

Kiel Policy Brief

Effectiveness of Central Bank Intervention on the Foreign Exchange Market

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Teaser

In contrast to academic recommendations monetary authorities all over the world intervene on the foreign exchange market to actively manage the exchange rate. Particularly in the aftermath of the global financial crisis the exchange rate is abused by some countries in a “currency war” to artificially improve the own competitiveness and thereby harming trading partners. Aside from these heavily debated activities a number of open economies try to shield their currency from irrational exuberance of international investors and use interventions to maintain exchange rates around their fundamental levels. This study shows theoretically and empirically how intervention operations can be effective in the latter sense.

Entgegen akademischer Empfehlungen intervenieren Währungsbehörden auf der ganzen Welt jeden Tag auf den Devisenmärkten um den Wert ihrer Währung zu beeinflussen. Besonders nach der globalen Finanzkrise wird der Wechselkurs von einigen Ländern dazu missbraucht, um die eigene Wettbewerbsfähigkeit in einem „Währungskrieg“ zu steigern und damit Handelspartnern zu schaden. Neben diesen intensiv diskutierten Maßnahmen versuchen einige Länder ihre Währung vor irrationalen Übertreibungen internationaler Investoren zu schützen und nutzen Interventionen, um Wechselkurse in der Nähe ihrer Fundamentalwerte zu halten. Diese Studie zeigt theoretisch als auch empirisch, wie Interventionen im letzteren Sinn effektiv sein können.

Introduction

The goal of monetary authorities (MA), e.g. central banks, is to stabilize output and inflation of the domestic economy. In general, stabilizing monetary policy is performed in a framework where exchanges are presumed to be determined by economic fundamentals and reflect an equilibrium value most of the time. Particularly in case of small open economies, however, the monetary policy strategy is repeatedly interfered by short-run capital flows adversely affecting exchange rates. Under these circumstances, interventions may be adopted to stabilize the exchange rate in order to restore

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the long-run equilibrium. So far, the empirical literature on the linear influence of foreign exchange intervention on exchange rates revealed mixed results whether such operations are effective or not. Among academics, this was taken as a case against official intervention of monetary authorities. In the following we outline a new approach using a real world microstructure model of the foreign exchange market, which is able to support the effectiveness of stabilizing interventions for several currency pairs.

The Bretton Woods system set fixed exchange rates between the industrial nations from 1949 onwards with the US-dollar as the reserve currency. In the following years the authorities in charge of monetary policy in the member countries, in most cases the central banks, were obliged to maintain their exchange rate in a small band of plus or minus 1 % of the agreed rate called the “peg”. The instrument used to achieve this goal was to intervene in the foreign exchange market buying or selling US-dollar to depreciate or appreciate their currency. The system was abandoned in March 1973 as persistent current account imbalances and a strong inflationary bias became unbearable for major participating economies. Since the breakdown of the Bretton Woods system it is the decision of the monetary authority (MA) of each country to choose the appropriate exchange rate regime. Based on the so-called open economy trilemma stating that it is impossible to have free capital movement, a fixed exchange rate and an independent monetary policy at the same time, economic theory prefers free floating exchange rates. So it is quite surprising that the IMF lists only 24 countries plus the Euro Area who are considered to have an independently floating currency.³ In addition, the number is shrinking further if one takes into account the ECB operations in 2000, heavy interventions of Japanese Ministry of Finance (JMF) in the last couple of years. The JMF bought on the 31st of October 2011 alone over 103 billion US dollar in order to prevent the Yen from further appreciation.⁴ Another very recent example was the announcement by the Swiss National Bank on September 6th 2011 to set a minimum exchange rate against the Euro and that it is ‘*prepared to buy foreign currency in unlimited quantities*’.⁵ The Brazilian Minister of Finance Guido Mantega even goes so far to announce that the world is in the middle of an ‘*international currency war*’.⁶ This refers to the common practice among many MA (e.g. China) to deliberately devalue the own currency in the aftermath of the financial crisis and can be considered as a comeback of the “beggar my neighbour” policy.

The trend, at least until the recent crisis, to reduce financial market restrictions to foster global trade made economies not only choose between reducing exchange rate volatility and an independent monetary policy. In studies of central bank reaction functions it has consistently been revealed that MA also try to reduce misalignments of

³ <https://www.imf.org/external/np/mfd/er/2008/eng/0408.htm>.

⁴ http://www.mof.go.jp/english/international_policy/reference/feio/quarter/e2310_12.htm.

⁵ <http://www.bloomberg.com/news/2011-09-06/swiss-national-bank-sets-minimum-exchange-rate-of-1-20-against-the-euro.html>.

⁶ <http://www.guardian.co.uk/business/2010/sep/28/world-in-international-currency-war-warns-brazil>.

the exchange rate from a perceived fundamental level. For instance, the Reserve Bank of Australia states that *'There is an extensive literature on speculative bubbles, herding, fads, and other behaviour which can drive market prices away from their equilibrium values, even in a market which is deep and liquid. When such overshooting occurs, intervention may help in limiting the move or returning the exchange rate towards its equilibrium level, thus obviating the need for costly adjustment by the real economy to the incorrect signals which the exchange rate would otherwise give'* (Reserve Bank of Australia 2008).

While the incentives for intervening in the foreign exchange markets seem to be well established, it is far from clear how central banks' sales and purchases of foreign currency influence exchange rates. Indeed, it is common practice among MA to sterilise the impact of foreign exchange market interventions on the monetary base (e.g. Taylor 1992). Given, therefore, that the impact of intervention on the domestic money supply is typically neutralised, the question arises as to how sterilised intervention can affect exchange rates. On theoretical grounds three channels have been identified. (1) The portfolio-balance channel is arguing that interventions by the MA's change the relative demand and supply of imperfectly substitutable foreign and domestic assets. This can be regarded as the direct effect. (2) The signaling channel states that interventions by the MA are used to signal future changes in the monetary policy. The MA is "announcing" a monetary contraction in the future when selling foreign currency. Such an action is more credible than a simple statement, because the MA would lose money if it would come to a monetary expansion instead. Traditional empirical research based on these theoretical considerations provided mixed empirical results whether interventions are effective with respect to drive the exchange rate in the attended direction.

More recently, however, the move towards a more real-world market perspective was able to provide support for intervention effectiveness. Sarno and Taylor (2001) proposed an additional channel of influence, the coordination channel. The MA interventions are regarded as resolving a coordination failure in the foreign exchange market. Given the prevalence of non-fundamental influences in the foreign exchange market such as (backward looking) technical analysis (e.g. Allen and Taylor 1990), there may be periods in which the exchange rate moves strongly and persistently away from the FV. Under such circumstances traders who expect a reversion to the FV might lose confidence and therefore leave the market. The MA intervention could restore this confidence and therefore increase the speed of adjustment towards the FV. Another crucial point is that the effectiveness of the coordination channel should depend on the size of the misalignment, because only if the misalignment is strong the confidence should be affected. To investigate this idea it is necessary to look at the microstructure of foreign exchange markets and provide some empirical evidence. In the following part the trading environment on FX markets is characterized, before we analyze the empirical results.

Microstructure of FX markets

To study the effectiveness of intervention operations by the MA's the exchange rates are assumed to be determined in an order-driven market with heterogeneous agents (DeGrauwe and Grimaldi 2005, 2006). For simplicity and tractability only two groups of traders, chartists and fundamentalists are considered and they only deviate in their expectation of the future exchange rate. The demand for currency is expressed in terms of market orders, i.e. traders ask for an immediate transaction at the best available price. All orders are filled by the market maker at an exchange rate that is shifted from the previous exchange rate by an amount that depends on the excess demand of traders. Hence, the exchange rate depends on the net order flow from chartists and fundamentalists because the market maker does not observe them individually. The currency is appreciating if more traders intend to buy than to sell it and vice versa. Both groups are risk-neutral and their orders depend on expected excess returns. So they only buy/sell the currency if they expect to make money selling/buying it later.

The expected excess returns on foreign exchange markets depend on the expected change in the exchange rate and on the interest differential between the two countries. Since the agents are equal in respect to the interest differential and it is not the focus of this work, we neglect this aspect in the remaining part. The difference between the two groups is merely on how they forecast the exchange rate of "tomorrow".

Orders from chartists are not derived from a mathematically well-defined econometric or economic model and are perceived to be largely uninformative regarding the fundamental value. Although there exist a remarkable number of different chartist or technical trading rules, these forecasting devices generally rely on historical exchange rates and are therefore backward looking and incapable of using new information. Their practical importance is confirmed by e.g. the market survey study of e.g. Allen and Taylor (1992) which reveals that up to 30 % of traders are best characterised as technical traders. Practical examples are the technical analysis broadcasted on the television or found in newspapers, which mostly use tools like moving averages to determine the future development of financial assets. Given that an important element of technical trading relies on trend-following it is assumed that chartist believe that the latest price change will to some extent continue into the future.

Fundamentalists on the other hand base their expectations about future exchange rate changes on an analysis of exchange rate fundamentals. In general, this boils down to the calculation of a time-varying FV towards which the exchange rate is expected to revert over time. Important here is that in this model a confidence measure is attached to the expected return to determine the orders. It can be understood as the time varying reliability of fundamentals-based forecasting technique and is at the centre of our analysis. Depending on the confidence measure, fundamentalists want to trade and

these actions will amount to stabilizing speculation in the sense that their orders will drive the exchange rate towards its FV.

Traders' confidence on fundamental analysis depends on the gap in between the current exchange rate and the FV. If the exchange rate is persistently trending away from the fundamental equilibrium, fundamentalists realize that betting against the trend was associated with substantial losses. Hence, they become increasingly reluctant to submit orders, which is reflected by lower confidence in our setting. Conversely, if misalignments decrease, fundamental analysis delivers correct predictions and regains its popularity.

The central banks' trading activity in the foreign exchange market is able to influence the confidence of the fundamentalist, which is exactly how the coordination channel affects the exchange rate. If a central bank sells a currency that is widely perceived to be overvalued, it reveals its commitment to a lower exchange rate. MA's are perceived to have superior information about the FV, because they observe innovations in fundamental data series in advance and are able to assess their impact on future exchange rate returns (Sager and Taylor 2006). Thus, fundamentalists become more confident that the exchange rate will revert to its fundamental value and engage in trading. It is a prerequisite that the interventions are publicly announced to influence the behavior of traders. The market increasingly focuses on fundamentals again and so interventions may be viewed as a device with which to coordinate traders' expectations.

In addition, the influence of intervention operations on traders' confidence through the coordination channel should depend on the level of current misalignment. In the neighborhood of the FV, the potential stabilizing gains of interventions should be negligible because fundamentalists will interpret small misalignments as temporary phenomena exploitable for speculative purposes. They have already a high confidence and will intensively trade in the market. If the misalignment is large, however, intervention will tend to be more effective, because fundamentalists who have reduced their orders because of a loss in confidence in the fundamentals may be encouraged by the intervention.⁷ The stabilizing impact on the exchange rate increases therefore non-linearly with their confidence in fundamental analysis. This creates a role for the MA, due to its coordinating influence on fundamentalists confidence, to increase the speed of adjustment towards the FV by intervening in the market.

⁷ The increased effectiveness of intervention as the degree of misalignment grows also follows from a limits-to-arbitrage argument.

Empirical Analysis and Results

The aim is to investigate empirically the role of MA intervention through an investigation of the nonlinear theoretical exchange rate model briefly outlined in the previous section. The empirical results we refer to incorporate four currency pairs, one of which stems from an explicit target zone and one from a more informal target zone. For the cases without any (implicit or explicit) target zone arrangement, the question is how effective are interventions in regard to enhancing the speed of adjustment back towards the FV.

We assume that such a long-run equilibrium value exists and that it can be adequately described by a measure of the Purchasing Power Parity (PPP) based on relative consumer prices. This view is supported by recent empirical research that suggests that the exchange rate reverts to the PPP level in the long-run (e.g. Rogoff 1996). Furthermore PPP is suited to investigate MA interventions, because PPP is used by them as the target level.⁸

The sample sets analyzed in this manner are (a) US-dollar (US\$) against Deutsche mark (DM) from 1980-1992 (Reitz and Taylor 2008), (b) US\$ against Japanese yen (Yen) from 1980-2004 (Reitz et al. 2010). In the study (c) of the Australian dollar (AUS\$) against US\$ from 1984-2008 (Reitz et al. 2011) an informal target zone is assumed. The question for the target zone case is how effective are the interventions in holding the exchange rate within a specified target band. The application for the explicit target zone is (d) Danish krone (DKK) against the euro from 1999–2006 (Reitz and Rülke 2011). Therefore, the target exchange rate is used instead of the PPP to determine the FV. The official target rate for the Danish krone is 7.46038 to the Euro and the official deviation band is set to ± 2.25 percent by the ERM II. The EU accession treaty stipulates that successful participation in ERM II is a requirement for joining the European Monetary Union (EMU) and the adoption of the euro. The Danish exchange rate policy is motivated by a desire to maintain the option for joining EMU in the future. The four data sets are summarized below in Table 1.

In all applications daily data about the exchange rate is used. Moreover, only trades of the MA which should drive the current exchange rate towards its FV are considered as interventions. The empirical model belongs to the STR (smooth transition regression) family of models originally proposed by Ozaki (1985). To cope with the heteroscedastic properties of daily exchange rate returns a STR-GARCH procedure originally developed by Lundbergh and Teräsvirta (1998) is applied. The STR-GARCH model consists of a mean equation containing a smooth transition function and a standard GARCH(1,1) volatility equation. In addition, a Smooth Transition Autoregression Target Zone (STARTZ) model is estimated for the two studies in which a (implicit

⁸ An exception is Japan, where the Ministry of Finance had an implicit target value of 125 yen/US\$ according to Ito (2003, 2006). Since these preferences have not been communicated to the public, however, we do not expect this to be a problem in the corresponding analysis.

or explicit) target zone is investigated (Lundberg and Teräsvirta's 2006). In all studies several robustness checks have been conducted.

Table 1:
A short description of the data sets and the intervention policy of the corresponding MA

Exchange rate	Sample period	Summary of the intervention policy of the MA's
US\$ / DM	1980–1992	The Federal Reserve intervened on 0.13 percent of the trading days. After 1992 the Fed almost stopped intervening. The average intervention was US\$ –2.1 million, indicating a near balance between purchases and sales. The mean absolute value of an intervention was US\$ 112.1 million.
		The interventions of the Bundesbank are considered as secret and should therefore not work in respect to the signaling and coordination channel. The Bundesbank intervened on 0.25 percent of the trading days. The Bundesbank sold US\$, the average intervention being DM –26.6 million. The mean absolute value of an intervention was DM 158.3 million.
Yen / US\$	1980–1998	The Federal Reserve intervened only on 0.44 percent of the trading days and stopped completely after the sample period. The average intervention was 71,329 US\$, indicating a small amount (US\$ 343.95 mill.) of net buying home currency. The mean absolute value of an intervention was US\$ 151.3 million.
	1991–2004	The Japan Ministry of Finance intervened on 10.26 percent of the trading days. The average intervention was US\$ 159.07 million, accumulating to US\$ 539.6 billion worth of net selling home currency. The mean absolute value of an intervention was US\$ 1.769 billion.
AUS\$ / US\$	1984–2008	The RBA intervened on 44 percent of the trading days, which is very heavily compared to other MA. The intervention strategy has changed several times. Very frequent (small) interventions until 1993. No interventions between 1993(Nov)–1995(Jun). Afterwards change to less frequent but larger scale interventions, while 2000(Feb)–2002(Apr) was a relatively calm period. There were no Federal Reserve interventions in the market.
DKK / EURO	1999–2006	The National Bank of Denmark intervened on 13.7 percent of the trading days. The average intervention was EUR 3.06 million, indicating EUR 5.93 billion of net selling home currency. The mean absolute value of an intervention was EUR 186.68 million. Particular of this investigation is that the Danish krone is part of the ERM II and is therefore only allowed to fluctuate against the euro within an explicit target zone. There were no European Central Bank interventions in the market.

The first two samples US\$ against DM and US\$ against Yen show very similar results in respect to the reported interventions and support the theoretical model. The important distinction between both studies is that in the first case the interventions of the Bundesbank are considered to be secret and therefore should not affect the exchange rate according to the coordination channel. Hence, we expect only significant influence on the confidence of the fundamentalists through the interventions by the Fed. In the second study interventions of the Fed as well as the Japanese Ministry of Finance are announced to the market participants.

In general, we find that the mean reversion of exchange rates diminishes the more the exchange rate deviates from PPP. Against the backdrop of the theoretical model, this is evidence of a decreasing confidence of fundamentalist analysis with the result that this trader type becomes more reluctant to submit orders. Solely reported interventions by the MA's are able to compensate for the lack of confidence caused by exchange rate misalignments thereby stabilizing the exchange rate around the

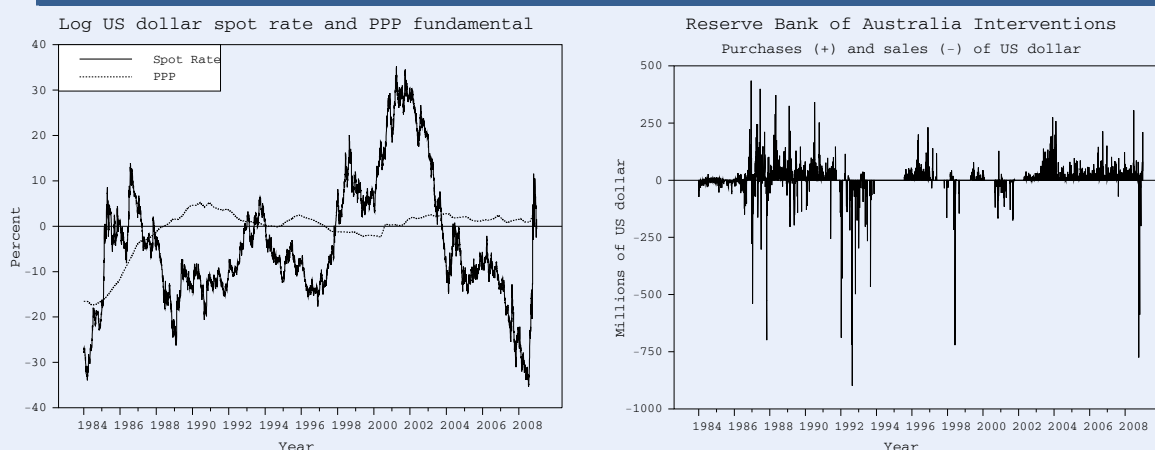
fundamental value. As suggested by the above model the effectiveness of intervention operations increases with the magnitude of the misalignment.

To get an intuitive understanding of the strength of these effects beyond the statistical significance we use an example for the interventions of the Fed in the US dollar against deutsche mark market. The parameters imply that, at the average level of exchange rate volatility, a 20 % misalignment results in a daily mean reversion towards fundamentals of 0.24 %, or well in excess of 1 % on a weekly basis. Under these circumstances an intervention operation of US\$ 200 million increases the mean reversion parameter to 0.5 %. The doubling of the mean reversion by a slightly larger than average intervention operation indicates that the effect is also economically significant. To further stress the nonlinearity of this effect we give another example that shows that the stabilizing influence of intervention increases as the real exchange rate moves away from its equilibrium level and misalignment grows. Using the above numbers, a US\$ 200 million intervention increases mean reversion from 0.76 % to 0.86 % if the misalignment is 5 % and from 0.04 % to 0.19 % if the misalignment is 40 %. Hence, such an intervention can quadruple the speed of adjustment towards the FV in the latter case. In summary the interventions encouraged traders to engage in fundamental speculation, thereby helping to bring the exchange rate back to the PPP level and this effect gets even stronger if the misalignment is larger. However, this is not the case for the secret interventions conducted by the Bundesbank. This is indirect evidence for the existence of the coordination channel, since it can only work if the interventions have been announced.

The two remaining studies additionally employ an econometric technique to identify a target zone band of exchange rates (STARTZ model). In case of the Australian dollar against the US dollar this is particularly interesting, because the exchange rate policy of the Royal Bank of Australia cannot be considered as an *explicit* target zone arrangement. The STARTZ model is used to successfully detect that the exchange rate dynamics behave like an implicit target zone and show the according nonlinearities. In a target zone, the persistence of shocks depends nonlinearly on the misalignment from the target value. Is the current exchange rate close to the upper or lower band of the target zone shocks are less persistent and exhibit simple white noise behavior. In the absence of a publicly announced target rate purchasing power parity is a reasonable proxy for the target rate of the MA. Again, the results support the existence of a coordination channel and the effectiveness of interventions in speeding up the mean reversion towards the FV by strengthening the confidence of the fundamentalists. The model tests also for how long the interventions have a significant effect on the exchange rate and finds that five lags are necessary. This is important to answer the question of whether the aforementioned effect is persistent or not. The results support the effectiveness further by showing that not only the single effect on the day of the intervention has the right sign and is significant, but also the overall effect adding the following four days.

These results are especially valuable, because they hold true for the long time period from 1984 to 2008, while the RBA changed their intervention strategy several times. Figure 1 illustrates these changes and gives a general idea of a stabilizing intervention policy. On the left the (log) exchange rate and the PPP fundamental are compared for the sample period.⁹ In this graph the misalignment of the exchange rate is simply the vertical distance between these two lines at any given point in time. In addition, it is obvious that there are strong and persistent deviations from the FV, which are the reason for the MA to intervene in the first place. On the right graph the interventions of the RBA are displayed, while the different intervention strategies over the years are clearly visible. However, the most interesting aspect is that even by eyeballing it is obvious that heavier interventions in terms of quantity and/or size are undertaken alongside strong misalignments. Moreover, these interventions are mostly sales (purchases) of US\$, if the AUS\$ is undervalued (overvalued) to drive back the current exchange rate to the FV.

Figure 1: On the left are the log exchange rate and the PPP, on the right are the magnitude and the direction of the interventions by the RBA



In the study of the Danish krone against the euro exists an explicit target zone set by the ERM II. Therefore the target exchange rate is used instead of the PPP to define the FV. The application of the STARTZ model reveals that the Danish Nationalbank (DN) managed to keep the exchange rate within a narrow band of approximately 0.4 percent around its mean against the euro. This exceeds the goal set by the ERM II for Denmark of 2.25 percent. The narrower informal target zone is identified by the fact that exchange rate shocks become less permanent as misalignments grow, implying a regime transition from autoregressive to white-noise behavior of the exchange rate. There seems to be no trend following close to the borders of the informal target zone anymore. Moreover, the estimates show that the DN interventions also exert a nonlinear mean reversion effect on the exchange rate. After introducing the model and

⁹ The PPP was normalized to be equal to the nominal exchange rate at the beginning of January 1994.

summarizing the most important results of the four studies we are ready to draw a conclusion.

Conclusion

The microstructural model with heterogeneous agents is capable of explaining the exchange rate dynamics much better than simple representative agent rational expectations models. Given the real-world financial market complexity, such a modelling strategy seems to be a promising route in research. However, one must not understand the different market participants as fixed set of traders or financial players. It is more likely that some traders employ different strategies at different points in time.

With regard to the effectiveness of central bank interventions the empirical results provide strong support for the idea that monetary authorities are able to influence the exchange rate by coordinating stabilising speculation based on fundamentals. This is achieved by improving the confidence of the fundamentalist traders and therefore speeding up the reversion towards the FV. This transmission mechanism works in a nonlinear fashion and gets stronger the further away the current exchange rate is from the fundamental value. In fact, this implies that the coordination channel is by no means a tool for fine-tuning exchange rates. In addition, it is crucial for the interventions to work in this manner to be announced to market participants. The results are confirmed on the grounds of four completely different data sets each covering a long sample period and different intervention strategies.

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