When is foreign exchange intervention effective? Evidence from 33 countries

Marcel Fratzscher, Oliver Gloede, Lukas Menkhoff, Lucio Sarno and Tobias Stöhr

Abstract

This study examines foreign exchange intervention based on novel daily data covering 33 countries from 1995 to 2011. We find that intervention is widely used and an effective policy tool, with a success rate in excess of 80 percent under some criteria. The policy works well in terms of smoothing the path of exchange rates, and in stabilizing the exchange rate in countries with narrow band regimes. Moving the level of the exchange rate in flexible regimes requires that some conditions are met, including the use of large volumes and that intervention is made public and supported via communication.

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1 Introduction

Foreign exchange (FX) reserves of central banks have accumulated to the highest level ever seen in recent history, in absolute terms and in relation to GDP. This accumulation of FX reserves raises concerns about global imbalances in the world economy (e.g. Jeanne and Rancière, 2011) and about the potential for "currency wars" (see Eichengreen, 2013). At the same time, central bankers generally believe in FX intervention as a useful policy tool (Neely, 2008). The last global financial crisis has shifted the focus even more towards limiting exchange rate volatility (Mohanty and Berger, 2013; Blanchard et al., 2015), and recent theory claims that interventions may be welfare enhancing (Gabaix and Maggiori, 2015; Cavallino, 2016; Hassan et al., 2016).

We take these facts and policy concerns as motivation to examine the effectiveness of FX intervention in a systematic manner. We try to overcome the reliance of the extant empirical literature on small samples consisting of only a single country or a few countries. Due to this data limitation, lessons learned necessarily refer to specific circumstances which are difficult to compare across countries and thus tend to have low external validity. By contrast we examine a broad cross-section of countries in order to draw general lessons and detect the determinants of (more) effective FX interventions. Accordingly, we compile a new dataset on daily FX interventions by 33 central banks which comprise both actual interventions and communication about FX interventions.

This dataset is crucial for our study, because the bottleneck of research on FX intervention has long been data availability. Many studies have to rely on press reports about central bank intervention (Fischer, 2006) or use intervention data of single countries directly provided to the researcher (e.g., Fischer and Zurlinden, 1999). Only a few central banks publish their intervention data and therefore have been intensively studied by academics. However, this pool of available data is small and composed mainly of advanced economies. Thus studies either cover just few countries (such as three countries in the influential study by Dominguez and Frankel, 1993) or have to rely on lower quality data, such as weekly aggregates, or on proxies of actual intervention amounts, such as the change in foreign reserves (e.g., Adler and Tovar,

2011; Levy-Yeyati et al., 2013; Daude et al., 2014; Adler et al., 2015).

Our data come from 33 central banks, of which 21 central banks do not make their data publicly available. Reliable daily intervention data, covering only sterilized interventions, stretch over a maximum period from 1995 to 2011. This dataset has some overlap with a few other studies on single countries or small groups of countries; otherwise it opens a new universe that allows us to establish stylized facts, examine key differences across countries and exchange rate regimes, and distinguish the relative importance of FX intervention determinants across countries.

The first step of the analysis is the description of intervention behavior through the lens of our new data. Due to the broad coverage of the sample we have a more representative picture about intervention characteristics than is common in the literature. The dataset covers almost 114,000 trading days. On these days the sampled central banks intervened, on average, on 19.1% of days. This may be surprisingly frequent with the recent experience of the major advanced economies in mind, in particular when considering that the U.S. Federal Reserve and the European Central Bank hardly intervene in FX anymore. However, many central banks, in particular in emerging and developing economies, intervene frequently.

Our main finding is that exchange rate intervention is an effective policy tool according to different criteria used to judge the success of FX interventions. We use several different success criteria, building on the work by Fatum and Hutchison (2003) and Fratzscher (2008). These criteria look at the directional change of the exchange rate on the day of an intervention as well as the move, volatility and stabilization during subsequent days. Generally, we find fairly high success rates of FX interventions, contradicting those studies nurturing skepticism against the usefulness of interventions (e.g., Schwartz, 2000). Moreover, this finding is methodologically far from self-evident in a large cross-section of heterogeneous countries, given their different intervention objectives and operational implementations. Specifically, it is key to apply different success criteria that distinguish between currency regimes with more exchange rate flexibility and those with a narrow band of exchange rate variation to reflect the difference in policy objectives of the intervening authorities.

It is only for the more flexible regimes, dominating in advanced economies, that the conven-

tional effectiveness measures (e.g. moving the level of the exchange rate) are really appropriate. Regarding countries with narrow bands, however, a different stabilization effectiveness measure seems appropriate which reflects the fact that stable exchange rates constitute the intervention objective for these countries' authorities.

Based on this distinction we see that an 80% success rate of FX interventions is actually a fair description of past policy. The high effectiveness of interventions can most easily be recognized from the "smoothing" criterion, because such a dampening of earlier exchange rate changes works in about 80% of cases, basically independent of the exchange rate regime and the empirical specification. Regarding the stabilization criterion, the success across all countries and episodes would be clearly misleading because often – obviously in floating regimes – there is no ambition to keep exchange rates within narrow limits. Thus, focusing on narrow band regimes, the success rate is at least 80% and can be further improved under certain conditions.

Finally, regarding the conventional effectiveness criteria typically used for floating exchange rate regimes, i.e. moving the exchange rate at the "event" (or within a short window), the baseline success rate is only about 60%. Thus paying attention to the conditions of interventions is important. Interventions tend to be more effective (i) if they are large in size, (ii) are executed in line with the prior exchange rate trend, and (iii) towards longer run fundamental equilibrium. Moreover, we find that appropriate communication of authorities can enhance effectiveness. Intervention is more effective in terms of the "event" criterion (i) if it is noticed (i.e. not secret), (ii) if it is accompanied by oral intervention and (iii) if oral intervention occurs during turbulent times.[1]

We take some effort to deal with the endogeneity of interventions, regarding their existence and the termination of intervention episodes. Still, we may underestimate intervention success in periods where central banks intervene against strong exchange rate trends, to provide an obvious example; this is particularly important because most interventions are "leaning against the wind". More generally, we are aware that our procedures are better understood as reduced form rather than structural estimations.

Overall, our main contribution to the literature is the systematic analysis of determinants

[1] In further analyses we show other determinants of successful interventions, in particular regarding the use of oral interventions. Besides communication, also capital controls can be helpful for interventions.

of effective intervention, which should be informative to policy makers and the public debate.[2] We are the first to study such a broad cross-section of countries with different exchange rate regimes and at different stages of development, using data obtained on special request for this study from 33 central banks. The results suggest that intervention in currency markets is more common practice and effective than we would have expected, and that intervention size and the communication strategy of central banks are important factors in enhancing effectiveness.

The paper proceeds as follows. Section 2 introduces the dataset. Section 3 provides stylized facts about FX intervention, and Section 4 shows our basic results on the effectiveness of actual intervention. Results on the effectiveness of communication (including oral intervention) require data on press reports and are presented in Section 5. Section 6 discusses issues related to the identification of actual intervention. Section 7 mentions robustness tests, and Section 8 concludes.

2 Data

Actual intervention data are provided by 33 central banks issuing their own currencies in advanced, emerging and developing economies. This section provides details on data sources, sample countries, classification of exchange rate regimes, and representativeness of data.

Data sources. The dataset on actual, sterilized interventions comprises information from public sources and information received from bilateral data requests. To start with, we used all relevant data which have been previously published or used in other publications, such as Federal Reserve Economic Data (FRED) or central bank websites (see reference to sources in Table 1). We complemented the public data with data which we received from bilateral data requests. The countries which we approached were mainly from the members of the BIS Committee on the Global Financial System (CGFS). Further, we contacted those central banks which, according to the Annual Report on Exchange Arrangements and Restrictions published by the IMF (2010), collect daily intervention data. Overall, we approached 27 countries bilaterally of which 21 granted us access to their data. We collected data on sterilized FX interventions

[2] See surveys on FX intervention by Edison (1993), Sarno and Taylor (2001), Neely (2005), and the recent cross-country studies of Adler and Tovar (2011), Levy-Yeyati et al. (2013), Daude et al. (2014), Adler et al. (2015).

by the respective institution at daily frequency with break-down by size and currency, for the period from 1995 to 2011.

[Table 1 about here.]

Sterilized interventions. Our analysis of FX interventions focuses only on sterilized interventions and our data request to central banks was specifically designed to get data about sterilized interventions. These are interventions which do not impact on the net foreign asset position of the public sector, which is mostly proxied by the position of the central bank. Basically, this means that the monetary base is not affected by these interventions. However, different central banks may have different notions of sterilized intervention or different methods to sterilize, an issue to which we return later in the paper. Also, there may be other reasons for central banks to buy or sell foreign currency that are unrelated to their intentions to impact on FX rates, such as their foreign reserve management, in some cases their function as agent for central governments, and of course monetary policy operations. Therefore, we check later in the paper that our main results hold for the subsample of countries that publish their intervention data and that they hold when controlling for changes in monetary policy variables.

Interventions are almost exclusively conducted against a reference currency. This is usually the US dollar (USD) and, for European countries (and for the U.S.), the Euro (see Table 1). In a few cases we have recalculated interventions against another currency into the reference currency. Eliminating these cases from the sample does not change any result qualitatively.

Sample countries. The dataset includes Argentina, Australia, Azerbaijan, Bolivia, Canada, Chile, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, the European Monetary Union (EMU), Georgia, Hong Kong, Iceland, Israel, Japan, Kenya, Kyrgyzstan, Mexico, Moldova, New Zealand, Norway, Peru, Poland, Slovakia, South Africa, Sweden, Switzerland, Turkey, United Kingdom, United States and Venezuela. For nine countries the data cover the full period of 17 years from January 1995 to December 2011. For another nine countries we have at least 15 years, and for the remaining 15 countries data was supplied for at least ten years, with the exception of Switzerland with seven years (see details in Table 1). The sample covers advanced, emerging and developing countries. Specifically, following the IMF World Economic Outlook definitions (IMF 2014), the sample covers 83 percent of advanced countries (30/36

countries, i.e. 13 currencies plus the Euro, which represents 17 countries during our sample) and 40 percent of emerging economies (10/25, plus nine poorer developing countries such as Bolivia). The trading days covered by intervention data are split roughly in half among these groups (46.2% to 53.8%, respectively).

Exchange rate regimes. In order to classify countries into exchange rate regimes we use data on de facto (and not de jure) exchange rate arrangements by Reinhart and Rogoff (2004). Fortunately, most of our countries fall into just three (out of six) coarse categories, which makes it straightforward to explicitly consider these three exchange rate regimes in the main analyses. However, there are not enough observations to analyze these regimes in separate sub-samples. In most countries, i.e. 22 countries in our sample, the currency regime did not change over the observed period. The 11 exceptions are Argentina, Canada, the Czech Republic, Denmark, Georgia, Iceland, Kyrgyzstan, Moldova, Switzerland, Turkey and Venezuela, which reported interventions under more than one regime type.

The most populated regime in our sample is group "2" of Reinhart-Rogoff's currency regime classification ("coarse grid"), which includes pre-announced crawling peg, pre-announced crawling band that is narrower than or equal to $+/-2\%$, de facto crawling peg, and de facto crawling band that is narrower than or equal to $+/-2\%$: we name this regime "narrow band". Group "4" covers countries with "freely floating" exchange rates and group "3" comprises countries whose exchange rate regimes are in between the other two; we call this group "broad band". Whereas group "4" is dominated by advanced economies, group "2" is dominated by emerging and developing economies; group "3" is mixed in this respect. Beyond these three groups of regimes there are three others, coded "1", "5" and "6" in the "coarse" Reinhart-Rogoff classification which we do not analyze separately because they are rather special cases (definitions in Table 1), and because we only have few observations so that we cannot analyze these groups while ensuring anonymity of countries.

Representativeness. The sample of countries cannot be perfectly representative, because it is based on the willingness of central banks to provide data. In this respect, one could imagine that central banks conducting many secret interventions may not want to contribute to our study. However, we include a large number of interventions not being noticed in the press, many of

which may be intentionally secret. Thus we can analyze the effects of many secret interventions in our study. Considering also the realized high response rate among central banks, our data are unlikely to be distorted by some form of self-selection bias of the respondent central banks.

Minimum intervention size. Some of the interventions in our data are very small, too small to be meaningful, even though they belong to those operations that central banks themselves classify as interventions (which is the criterion in our data collection exercise). In fact, most of these tiny transactions may be motivated by market making activity. This leads to a trade-off between relevance (of considering larger interventions) vs. completeness (considering all cases). In order to mitigate this issue, we recode the intervention volumes for a total of 469 intervention days with intervention volumes smaller than 0.00001% of a country's GDP as zero, which corresponds to less than 0.001% of daily traded volumes even for little traded currencies (see Table 1). For a country of median size the chosen cutoff amounts to about 16,000 USD and average recoded interventions are well below 5,000 USD. The largest single value of a neglected intervention is 350,000 USD per day. These intervention days will henceforth be treated as days without intervention.[3]

3 Stylized facts about interventions

The broad coverage of countries in our sample allows us to identify some basic facts about FX interventions. We are also able to compare intervention behavior across three major exchange rate regimes, i.e. "free floaters", "broad bands" and "narrow bands," which cover more than 90% of the observations. These stylized facts refer to five dimensions, i.e. the incidence of interventions, their direction (purchase or sale), their size, their sequence, and characteristics of intervention days.

Incidence. FX interventions are remarkably common. All of the central banks we received data from intervened at some point between the beginning of 1995 and mid-2011, and a total of 113,844 trading days are covered in this period by these central banks. On average, actual activity was reported by central banks on 19.1% of trading days (see Table 2). Activity within

[3]The decrease in intervention days is driven by three countries which cover about three quarters of these interventions. However, we show in robustness tests that the reduced sample does not lead to qualitatively different results.

floating and broad band regimes is observed on about 8.7% of days, whereas within narrow band regimes central banks are active on about 34% of trading days. Figure 1 plots the share of central banks purchasing or selling FX on a given day during the sample period.

[Table 2 about here.]

Direction. On 76.1% of the intervention days we observe net purchases of foreign currency and on the remaining days foreign currency is sold on balance. While the share of purchases is expected to exceed 50% in a growing world, 76% seems to be beyond this expectation. Moreover, this result is surprising given the experiences from the Bretton Woods system and the many FX crises thereafter, where typically the exchange rate was defended by selling foreign currency (e.g. Eichengreen, 2008). By contrast, we find in our recent sample that the large majority of interventions are purchases of foreign currencies (see also Levy-Yeyati et al., 2013). This indicates a potential asymmetry in the objectives of the central bank, consistent presumably with a desire to support exports. Interestingly, there is not much of a difference across exchange rate regimes in this respect.

These aggregate statistics hide the fact that not all countries both buy and sell foreign currency. Among the 33 countries covered, eight countries never purchased foreign currency in the sample period, and eight others never sold foreign currency. This indicates substantial heterogeneity across countries and their policy objectives.

Size. The size of FX interventions, i.e. the daily net transaction volume, is on average 44.3 million USD, with higher volumes in free floating regimes. This pattern is related to the size of the respective economies as the share of advanced economies is highest in free floating regimes. For example, the larger advanced economies' central banks on average purchase (sell) an equivalent of USD 122.1 million (102.9) compared to USD 30.1 million (31.5) in emerging and developing countries.[4]

Thus it is advisable to also use relative intervention volumes. Table 2 shows that in GDP terms the average size of interventions in broad bands (0.03%) is between those in floating regimes (0.02%) and narrow bands (0.05%). However, floating regimes – mainly related to

[4]We use the exchange rate of the local currency with the USD or Euro to calculate the volume of the respective intervention in the foreign currency the country intervenes against. For countries targeting the Euro we then use the daily Euro-USD exchange rate to calculate the equivalent USD volume.

advanced economies – are not only characterized by larger economies but also by much larger financial markets. Thus, if we relate intervention size to the respective daily FX trading volume, relative intervention size in floating regimes is even smaller compared to the other regimes.[5]

Sequence. Typically, FX interventions take place in a repeated fashion. In the case of FX buying, 68.6% of intervention days are preceded by an intervention in the same direction from the same central bank on the day before (86.9% during the three days before). In the case of foreign currency sales, these shares are somewhat lower but still substantial (47.2% and 72.8%). Intervention days are thus typically part of a longer intervention period, which complicates the analysis of their effects. In line with other papers (e.g. Fratzscher, 2008), we apply a ten day gap between days with interventions to define a new episode. This reasonably long gap between episodes makes it more plausible that episodes constitute separate events.

Table 2 reports the total number of episodes and their average length. According to our definition, the average length of an episode is 6.1 and 2.8 days for buying and selling FX, respectively. The longest spell per country is on average 55.7 trading days for FX purchases and 14.5 for FX sales. However, these averages mask that the longest period of activity recorded in the sample was 345 trading days, i.e. almost 1.5 calendar years, in the case of FX purchases according to the 10-day definition.

Further intervention characteristics. We find that central banks are typically "leaning against the wind", i.e. against the trend of the ten trading days before the start of the intervention, in 66.5% of cases. Interventions go towards the fundamental exchange rate in 48.0% of cases, where we simply use a three-year moving average to approximate the fundamental value of a currency.[6] Alternatively we also use the IMF's Purchasing Power Parity (PPP) exchange rates as proxy for the fundamental value, leading to a share of interventions towards the fundamental of 51.4%. Finally, we observe interventions during periods of turbulence, de-

[5]Trading volume data are taken from the BIS triennial survey and interpolated linearly to yield values for the time between the survey years. Azerbaijan, Bolivia, Costa Rica, Croatia, Georgia, Iceland, Kenya, Moldova, and Venezuela are not included in BIS survey data and thus missing from statistics that feature traded FX volumes.

[6]Admittedly, this is a rudimentary measure of fundamental value and it is well documented that measuring a currency's fair value is a very complex task (e.g. Menkhoff et al., 2017, and the references therein). However, our simple measure has the advantage to capture mean reversion in a simple way that does not require macroeconomic data nor any econometric model while being easy to replicate. Results are not affected by using five-year or eight-year moving averages, as we show later.

fined as episodes when the VIX is more than two standard deviations above its median.[7] In turbulent times, central banks are active on 22.5% of days, slightly more than in tranquil times. This difference is mostly driven by narrow band regimes and translates into longer intervention episodes rather than frequently changing intervention directions, which would constitute new episodes. In the regressions below, we will also approximate the effect of volatility by including each country's exchange rate volatility on the first day of the intervention episode relative to the country's maximum during the sample. This variable is thus scaled between 0 and 1.

Summary. Considering all countries: FX interventions occur often (19.1% of trading days); they are mainly purchases of the foreign currency (in 76.1% of cases); the average transaction is about 44 million USD per day; interventions do not occur as single events but in sequences, and they occur most often in countries following a "narrow band" exchange rate regime, which is mainly chosen by emerging and developing economies.

4 Effectiveness of actual interventions

4.1 Effectiveness of intervention operations

The effectiveness of FX intervention policy is highly controversial and debated (see, e.g., BIS, 2013a). There are three main lines of arguments that are put forward by skeptics: the difficulty of changing the market outcome of the exchange rate; the small size of central banks in increasingly large currency markets; and the limited information in interventions as a policy signal.

Influencing market outcomes. FX interventions often run counter to prevailing market forces. Thus, interventions should bring new information to the markets, i.e. changing the market's information set, in order to be effective. This is no easy task because interventions take place when markets deliver outcomes which policy makers do not like. In this sense interventions have to overcome high hurdles, at least in market environments such as floating exchange rate regimes.

Huge FX markets. A second source of skepticism is rooted in the limited size of interven-

[7]The VIX is a widely used measure of expected short-term volatility of the S&P500 and it is based on the implied stock market volatility embedded in S&P500 stock options. It is often used by academics and practitioners to capture global risk aversion in financial markets.

tions in today's very large and liquid FX markets. FX transactions have substantially increased over the past decades, thus reducing the relative importance of central bank actions over the same time period. Taking, for example, FX reserves of all countries together the resulting amount of more than 4 trillion US dollars is in the same order of magnitude as daily transactions in FX markets (see BIS, 2013b). Moreover, the distribution of reserves is concentrated in a few countries. For example, China alone holds almost half of them and Japan contributes another 15%.[8]

Limited policy signals. The third line of argument against intervention is related to the ability of a central bank to signal its policy stance and provide new information to financial markets (Mussa, 1981; Vitale, 2003). The skeptical view here argues that it is in the interest of policy makers to signal intentions such as the likely course of future monetary policy to the markets anyway, and it is not clear what the additional contribution of FX intervention could be.

4.2 Measures of effectiveness

The effectiveness of any FX intervention should be assessed with respect to the intervention objectives. These objectives vary according to preferences and circumstances, and true objectives will be in many cases impossible to find out. In line with the literature, we proceed more modestly and aim to approximate intervention objectives. We follow established procedures which assume that FX interventions aim at moving the exchange rate level into the intervention direction. Due to our coverage of regimes of "narrow bands" we extend the standard set of success criteria by also considering that some central banks may be more interested in stabilizing the exchange rate within a certain band. Regardless of the effectiveness measure, we analyze intervention episodes in order to account for the fact that interventions tend to last longer than one day. The last day of an intervention event is defined as a day which is either followed by no similar intervention in the next 10 trading days or by an intervention in the opposite direction.

The aim of moving the exchange rate in the direction of intervention is often defined by various empirical measures of effectiveness which we apply below (see Humpage, 1999; Fatum

[8] On a more optimistic note, however, Fatum (2015) argues that, for the Japanese foreign currency interventions at the zero lower bound, intervention was effective. However, these interventions were evidently not fully sterilized as bank deposits at the Bank of Japan increased at the same time.

and Hutchison, 2003; Fratzscher, 2008, 2009). We present the criteria below from the one focusing on the most immediate success to that focusing on more longer-term oriented success.

First, using the "event criterion", we test whether the exchange rate moves in the intended direction during the intervention episode. If the central bank buys (sells) foreign currency, we code the event criterion "1" if – defining the exchange rate as the foreign currency price per one unit of domestic currency – the exchange rate decreases (increases) during that episode. Second, the post-intervention evaluation window is lengthened by the "direction criterion", which extends the event criterion to some days after the last intervention day. It thus also captures the exchange rate development immediately after the end of the intervention spell. In line with other studies, we choose a post-intervention window of five days (see Fatum and Hutchison, 2003; Fratzscher, 2008). Third, the direction criterion is further modified to the "smoothing criterion", which is coded "1" if the exchange rate change during and for five trading days after the intervention is smaller than during the five trading days leading up to the intervention. In order to make the criterion meaningful we define it only for interventions against the trend of the previous five trading days. Fourth, we complement the above standard criteria by also considering what we call the "stabilization criterion". This states that the exchange rate is kept within a narrow band of two percentage points during the whole intervention event and the two weeks after its end. With this measure we seek to approximate the objective of those central banks which are mainly concerned with stabilizing the exchange rate rather than with changing the exchange rate.

Table 3 reports the correlations between the different success criteria. The rather low correlation coefficients underline that the four criteria are able to capture different forms of effectiveness. In particular, stabilizing or moving the exchange rate can be conflicting objectives as the negative correlation highlights. It is only the direction criterion which has higher correlation coefficients (with the smoothing and, in particular, the event criterion). This motivates us to neglect the direction criterion in the coming main text, since results are qualitatively the same as for the event criterion. We report results for the direction criterion in our Internet Appendix.

[Table 3 about here.]

4.3 Unconditional outcomes of actual interventions

Having defined effectiveness criteria we first look at unconditional outcomes of interventions for each of the three exchange rate regimes considered. Indeed, using data for all countries regardless of the FX regime would not give justice to different intervention goals and practices. Thus, we distinguish between the three main exchange rate regimes that are present in the data, i.e. "freely floating" exchange rates, "broad bands" and "narrow bands". For each of these regimes we show results for the two most relevant criteria.[9]

Free floaters (columns 1 and 2 in Table 4) have some success in influencing the direction of exchange rates. In the short term more than 60% of FX interventions are successful at moving the exchange rate in the intended direction; this is significantly better than random as the placebo rates show success is around 48% in our data.[10] Smoothing is successful in 88% of cases.

[Table 4 about here.]

Countries pursuing narrow band regimes (columns 5 and 6) on the other hand are mainly interested in the stabilization criterion. They are highly effective at pursuing it, managing to keep the exchange rate within the narrow band in about 84% of intervention episodes. Of course, the benchmark of success – i.e. exchange rates within the narrow band – is higher than 50% for narrow band regimes; it is in fact 77%. These countries also succeed regarding the smoothing criterion, as do the broad band regimes (columns 3 and 4). However, the latter cannot stabilize the exchange rate in a narrow range, which does not seem surprising given the broad band target.

[9]However, we also report averages in the pooled sample across all regimes in Table A1 in the Internet Appendix. This table also includes "placebo" success rates for the counterfactual, i.e. the percentage of cases in the pooled sample of non-intervention periods where exchange rates behave in line with the effectiveness measures. Furthermore, average success rates when weighting each country equally as well as average success rates in turbulent times are reported.

[10]Placebo rates are calculated by creating intervention days in random directions on non-intervention days and calculating the success criteria for placebo intervention episodes with median country-specific intervention lengths. The simple averages above therefore do not assume any selection mechanism for intervention along the lines of a reaction function that takes into account market circumstances. Such extended analyses are presented later in the paper. Finally, note that we report p-values in Table 4 to formally document that the success rate in each column is statistically significantly different from placebo rates; this is always the case except for column 4, corroborating the interpretation that follows.

4.4 Determinants of effectiveness in actual interventions

Next, we calculate conditional intervention outcomes through regression analysis. To account for heterogeneity between regimes, we always include currency regime-specific intercepts (which are easier to interpret than classical fixed effects). However, due to the small number of observations in the floating regime, we cannot usefully run regressions for each regime separately. In the baseline regression we complement the intervention decision by four further considerations.

The first consideration is that "larger" interventions should improve the probability of success (Fatum and Yamamoto, 2014; indirectly in Dominguez et al., 2013). To capture this we control for the average intervention size during an event as a share of the GDP of the intervening country. Second, we test whether intervention occurs in line with a prior trend, which should ease its success. Third, we expect that intervention is more effective if it occurs in line with fundamentals. This is approximated by interventions occurring towards the fundamental exchange rate.[11] Fourth, we analyze whether volatility has any influence on intervention effectiveness. As the volatility over a period is not easily comparable across countries, for example because of regime differences and market size, we consider the degree of local volatility relative to the country's maximum.[12] Other covariates, such as the length of an intervention episode or the global market environment, are discussed in the robustness section (see Table A2).

Results are shown in Table 5 for the exchange rate regimes under consideration and three measures of effectiveness. We report OLS regressions; logit regressions yield qualitatively identical results, as we show in the later robustness section. However, OLS regressions allow adding up of the coefficients of the various intervention conditions. The left-hand-side variable is the respective effectiveness measure which is coded as a binary variable indicating success. The characteristics of intervention episodes are included in the vector X_i. We then estimate the

[11] The fundamental exchange rate is defined as the three-year moving average of the exchange rate. Results are qualitatively robust to various modifications, including those relying on PPP exchange rates.

[12] This is measured as the quarterly exchange rate volatility on the first day of the intervention episode as a share of the country's maximum during the sample period.

success criterion c_{ir} in intervention episode i in regime r as

$$c_{ir} = \theta_r + \gamma X_i + \epsilon_{ir},$$

where θ_r denotes currency regime fixed effects that are introduced as regime-specific intercepts and ϵ_{ir} is the error term.

[Table 5 about here.]

Free floating regime. We provide evidence on the effectiveness of intervention in Table 5. Looking at the "event criterion", which is key for free floating regimes and is used in specification (1), we see that the pure purchase or sale of FX has a probability of success of 0.53 in free floating regimes. This baseline success rate is well above the placebo success rate in Table 4 for free floaters but not for other regimes.[13]

Depending on the characteristics of an intervention, the likelihood of its success can increase further. Larger interventions are significantly more likely to move the exchange rate in the intended direction; large intervention sizes of, for example, 0.4% of a country's GDP increase success probability by about 13.2 percentage points. Also, interventions that are in line with markets, i.e. with the trend in the two weeks before the intervention, are significantly more successful. Intervening with a trend is associated with a 9.9 percentage point increase in the success rate. The probability that interventions towards the fundamental value succeed increases with the distance between exchange rate and its fundamental value. For the median misalignment of the exchange rate from its fundamental value, the increase in the success rate is 3.5 percentage points. Accordingly, the increase is much higher for severely misaligned currencies. We conclude that interventions are effective, and effectiveness increases under specific circumstances. Taking, for example, the above discussed measures and adding up coefficients, the success rate goes up to about 80% (53.2+ 13.2 + 9.9 + 3.5 = 80.0).[14]

Narrow band regime. For narrow band regimes it is relevant to look at the "stabilization

[13]Compared to the freely floating currency regime, the regime-specific intercepts show that narrow and also broad band regimes are significantly less successful according to the event criterion which makes sense given their targets. For an overview across all success criteria and regime types, see Table A3 in the Internet Appendix.

[14]We also note that, in line with unconditional results from Table 4, interventions in floating regimes are effective regarding smoothing in more than 80% of cases.

criterion" in specification (3). Interventions in volatile times (according to the local volatility measure) are less likely to restrict the exchange rate to the narrow two percent band we specified as a success. As interventions towards the fundamental are more likely to move the exchange rate, interventions occurring when exchange rates are further away from fundamental value are associated with a decrease of the likelihood of a stable exchange rate in the subsequent days. Most remarkable seems to be the very high regime-specific intercept for the narrow band regime (0.949), indicating that intervention works very well while high local volatility is the major hampering factor. Regarding other effectiveness criteria, it does not seem surprising that interventions create some smoothing of exchange rates, whereas they are not able to move it in a certain direction, as measured by the event criterion, but this criterion is not relevant for the narrow band regime.

Broad band regime. Broad band regimes are a heterogeneous category and thus it is difficult to do full justice to intervention policy in this regime. These regimes do not succeed, either in keeping the exchange rate in a narrow range, or in moving the exchange rate in a desired direction (event criterion). However, we can recognize that also under this regime the central bank is successful in decreasing the pace of an appreciation or a depreciation. Due to success rates of more than 70% there is not much scope for further improving performance. We only find that smoothing is more likely to be successful in highly volatile phases.

Discussion. Overall, we see that intervention effectiveness is systematically determined by several plausible characteristics: If in floating regimes the intervention objective is moving exchange rates as reflected by criterion (1), it is important to consider several determinants of success, such as intervening with large volumes. According to our evidence, then success can occur in 80% of cases. Interestingly, the probability of success in broad band regimes is limited to smoothing the exchange rate; however, smoothing due to interventions seems to work quite well, especially in more volatile periods. Finally, in narrow band regimes interventions effectively support exchange rate stabilization and are only endangered by very high exchange rate volatility.

Some caveats are in order. We use an event study approach which covers by construction relatively short time periods of analysis. The reason for applying an event window is to elim-

inate possibly rivaling influences on exchange rate behavior. Nevertheless, we cannot control for all policy measures which may occur at the same time. We aim to control for changes in interest rates and the monetary base as well as for capital controls, which we do later in the paper. However, we do not account for other policy measures that go beyond our approach, such as macro-prudential tools or communication about economic policy except communication with a direct link to exchange rates.

5 Effectiveness of central bank communication

In this section we consider the effect of authorities' communication on exchange rates. It is well known that communication can support monetary policy (Blinder et al., 2008) or non-sterilized FX intervention (Burkhard and Fischer, 2009). Fratzscher (2008) also provides evidence on effectiveness of oral intervention, which we extend here. Thus, in the next section we introduce the underlying press report data for analyzing the role of authorities' communication. Then, we provide our baseline results on oral intervention as well as further extensions.

5.1 Data about authorities' communication

In order to test the effect of communication we analyze press reports covered by the database Factiva. We use a standardized working procedure where news reports for each currency are searched including keywords such as "FX" and "intervention"; we also allow for different spelling and abbreviations. Before coding the resulting news reports we defined the criteria for different events such as rumors or confirmations. All news reports were then coded using double entry (see Table A4, and more details are available on request). In doing so, we assess (i) whether an actual intervention remains unnoticed or not. If it gets noticed in the press, we code (ii) whether notification is due to official confirmation or due to rumors in the press. Finally, we check (iii) whether officials (mainly from the central bank) have talked about intervention, i.e. whether an oral intervention in addition to an actual intervention takes place. In principle, an oral intervention could take place without an actual intervention, providing the interesting case of "isolated" oral intervention. However, there are just about 20 such cases in our sample. Thus, we cannot reliably work with this extremely small sample.

[Table 6 about here.]

Table 6 gives the respective categories and distribution of answers. As can be seen, 94.3% of intervention episodes remain uncovered in the press. This share differs widely by country, but not generally by regime type. An exception are free floaters where only 62.1% of intervention episodes remain unnoticed, probably because they are less frequent (see also Table A5). Moreover, in this regime a much larger share than in other exchange rate regimes (about a quarter of interventions) are officially confirmed.[15] Finally, the analysis of press reports reveals "oral interventions", i.e. the fact that the authorities talk to the market about interventions or currencies more generally. The aim is to influence markets by providing the viewpoint of authorities and this behavior occurs in 51.9% of all intervention episodes. As expected, the share is much higher in free floating regimes (with 96.8%) and broad band regimes (99.6%) than in narrow band regimes (30.9%).

5.2 The contribution of communication to intervention success

In the next step we add the information from these categories to our baseline regression on intervention effectiveness (see Table 5). Thus we report estimates about the importance of communication in various ways; in particular, we disentangle the relative effectiveness of notified (vs. unnoticed) interventions, and examine oral interventions.

Notified interventions. Regarding the notification of interventions, there is a fairly common practice of central banks to intervene secretly, and the pros and cons of this approach have been debated (Sarno and Taylor, 2001). We add a dummy variable capturing "unnoticed interventions", i.e. those that are not noticed in press reports, to the benchmark specification, and obtain a largely consistent negative sign (Table 7). The coefficient becomes significant for the event criterion if we do not control for the other communication variables (see Internet Appendix Table A6). This cautiously indicates that actual interventions are more effective at moving the exchange rate if they are noticed by markets.

[Table 7 about here.]

[15] It seems plausible that the strong country fixed effects in the probability that an intervention episode remains unnoticed in Factiva news reports are partly due to less detailed media coverage of smaller currencies. Furthermore the longer intervention episodes last, the more likely they are to be noticed, and larger interventions relative to GDP are significantly more likely to be noticed. See also Table A5 in the Internet Appendix for further details.

Rumor or confirmation. In the next step we disaggregate notification by distinguishing between confirmation of intervention on the specific day by authorities and (correct) rumors on the intervention day. The analysis shows that confirmation has a strong effect, supporting the positive effect of authorities' communication (see Internet Appendix Table A6). Since confirmation is sometimes used jointly with oral interventions and because oral interventions may spark rumors, the dummy for unnoticed interventions turns insignificant in the combined specification of Table 7. Overall, this indicates the positive effect from notification (in various ways) on effectiveness.

Oral interventions. Whereas most interventions remain without explicit notion in the press, the relevant authorities talk about exchange rate-related issues in roughly half of all intervention episodes. As we are only using actual interventions in these estimations, the oral interventions we analyze here always go hand in hand with actual activity. In this sense the oral intervention is intended to reinforce the actual intervention. Empirically, we use the dummy variable "any oral intervention" in our specification and find that oral interventions – accompanying actual interventions – are associated with mixed effects (Table A6). Oral interventions support actual interventions according to the event criterion. Regarding effectiveness according to the other two success criteria, the coefficients are negative while the regime fixed effects become larger. This may indicate that communication helps moving the exchange rate but may occur at difficult times, in particular if, for example, the exchange rate is just expected to remain in a certain narrow band.[16]

Interventions in turbulent times. Oral intervention could have more potential also according to the smoothing and stabilization criterion in turbulent times, when authorities may provide useful guidance to markets. Evidence for this case is provided, for example, by Égert and Kočenda (2014) for three Eastern European exchange rates and by Born et al. (2014) for the effect of central bankers' speeches. The theoretical case for intervention at times of higher risk aversion is also made in the model of Gabaix and Maggiori (2015). Therefore, we consider the potential importance of communication in turbulent times by introducing an interaction term between turbulent times and oral intervention (Table A6). We find that oral interventions

[16]Table A7 furthermore indicates that oral interventions are associated with higher success rates when indicating higher intervention activity as well as when indicating lower activity.

substantially increase the success rate of interventions in turbulent times, according to the event and smoothing criterion. This seems to suggest that central bankers' communication is taken particularly seriously by markets in volatile phases. Regarding the stabilization criterion, oral interventions are still not effective.

On channels of intervention. Overall, we learn about the relevance of central bank communication in increasing intervention effectiveness: there are benefits of noticed interventions and of explicit oral interventions, in particular during turbulent times. These results have some implications for the potential channels by which interventions may impact on exchange rates. Most obvious is the relevance of the signaling channel because this is the main channel by which oral communication can have any effect. The portfolio balance effect may also be at work as larger intervention sizes have stronger impact in our data, which is consistent with the standard mechanism of portfolio balance models whereby larger interventions induce larger changes in private sector portfolios and thereby larger changes in exchange rates and risk premia. However, as a note of caution, we are mindful that our reduced-form regressions do not allow us to precisely disentangle the different channels of FX intervention, which in our view requires a more structural estimation approach than our event study methodology allows.

5.3 Further examinations on effectiveness of oral interventions

In this section we briefly report further analyses of the effectiveness of oral interventions, which are much less researched than actual interventions in the literature. These examinations cover three areas that are described below.

Characteristics of actual interventions. First, we analyze whether oral interventions are more effective if they occur in combination with specific actual intervention characteristics. Thus, we add interaction terms of oral intervention with other intervention characteristics such as size, leaning with the wind or intervention towards the fundamental (results available on request). These other characteristics do not affect the above mentioned (Section 5.2) positive significant interaction of oral intervention and intervention in turbulent times. The interaction terms are mostly insignificant, indicating that combined large actual and oral interventions are often conducted by central banks under unfavorable circumstances.

Effects in narrow band regimes. Next, we analyze oral interventions in narrow band

regimes. We do so both because considering this regime is relatively new to the literature and because we have enough observations (which are missing instead for floating regimes). In contrast to the result across all regimes we find that the positive effect of oral intervention in turbulent times does not apply to narrow bands and thus must stem from more flexible regimes. We also find that large actual interventions are particularly effective when combined with oral interventions (also different from the general case). However, oral interventions with the trend increase the probability that the narrow band will be violated. All this suggests that the details of successful FX interventions can also depend on the exchange rate regime.

Pre-announcement of regime. As we have seen that oral intervention can be a way to inform markets and thus to increase effectiveness of actual interventions, we study differences between cases where authorities do and do not make an announcement regarding their strategy. While typically using the coarse grid classification, Reinhart and Rogoff (2004) also offer a finer grid, which distinguishes between regimes that are pre-announced and not-pre-announced within the coarse categories. We construct a dummy variable which takes the value 1 if authorities have pre-announced their regime. This is then interacted with oral interventions in the specification of Table 7.[17] The estimates are reported in Table A8 and show that central banks that do not pre-announce their regime can use oral interventions to significantly increase their likelihood of successfully moving the exchange rate. In this case, a small and statistically significant effect is also found for the stabilization criterion. Hence, oral interventions seem to be particularly effective if the market is unsure about the exact policy of the central bank.

In summary, these extended analyses show that the general effect of oral intervention on making actual interventions more effective, in particular in turbulent times, is robust. Moreover, we learn that oral interventions can also be useful for narrow band regimes (when combined with large actual interventions) and when there is no pre-announcement about strategies.

6 On identification of FX interventions

The empirical analysis of FX intervention is often plagued by the problem of clearly isolating the causal effect of this policy instrument. There are at least three problems in this respect

[17] To take account of the use of the finer grid, we use finer grid currency-regime fixed effects instead of the coarse grid effects that are generally used in this paper.

which we address in this section. First, the use of FX interventions is often the result of specific circumstances in FX markets, potentially resulting in endogeneity (Section 6.1). Second, FX intervention is a policy measure which may be used in combination with monetary policy instruments. Our ambition of analyzing sterilized interventions is most affected if policy makers also change the monetary base leading to non-sterilized interventions (Section 6.2). Third, the use of capital controls – as another expression of policy activity – may influence the effectiveness of FX interventions, and thus also needs to be considered (Section 6.3).

6.1 On the endogeneity of FX interventions

The issue of isolating a causal effect of FX interventions against the potential influence from specific circumstances in the markets has been addressed in the literature using a variety of methods, which we fully discuss in the Internet Appendix. Here we simply present a qualitative discussion on the role of endogeneity in empirical work and apply a matching approach.

Qualitative reasoning. Let us start from noting the general point that FX interventions do not occur randomly. Rather, intervention decisions are typically motivated by unwanted market developments, implying that the circumstances for interventions are disadvantageous; this generates bias against intervention success. This effect may be reduced, however, by the experience of the central banks which select periods in which they see a good chance to realize their ambitions. An example in this direction is knowledge about intra-daily market circumstances which can increase intervention effectiveness (see Dominguez, 2003). This kind of endogeneity in favor of success, however, is rooted in the authorities' ability and thus represents a kind of missing determinant in our framework. More generally, omitted variables related to other macro policy actions that can impact on exchange rates, most obviously monetary policy actions, can generate bias that over-estimates the impact of intervention. Furthermore, independent of the timing, also the design of the intervention by the central bank may be co-determined by market circumstances, requiring some caution in interpreting the effects that are at the discretion of the central bank, namely intervention size and whether actual intervention is paired with oral intervention. In short, there are various aspects making the estimation of the effectiveness of FX intervention a difficult task, and various methods that can be used to investigate the importance of this issue, to which we now turn.

A matching approach. This approach involves selecting suitable counterfactuals by a matching mechanism to account for market circumstances (see Fatum and Hutchison, 2010). We build on this idea to match actual intervention events and placebo events, and yield a treatment and a control group. Actual and placebo success criteria are then used to create a joint outcome variable, taking the actual success rate for actual events and the placebo success rate for placebo events. We then use a nearest neighbor matching algorithm to match within country each actual episode with the most similar placebo episode using the characteristics that were most important according to Table A9 (this table reports results on a central bank reaction function approach which is described in detail in the Internet Appendix). These are the lagged absolute FX misalignment and the lagged absolute change in the exchange rate leading up to the day before the first (actual/placebo) intervention day. Furthermore we account for intervention length.[18] In Table 8 we report results for the treatment effect when basically reproducing Table 4 above. The results are consistent with those in Table 4, but the size of coefficients is larger, indicating that our earlier results may underestimate the true intervention effectiveness.[19]

[Table 8 about here.]

6.2 FX interventions and monetary policy

A natural concern about any analysis of FX interventions is whether interventions are fully sterilized; if not, the monetary base and / or the interest rate would change at times of intervention and make identification of pure interventions very difficult. Thus, we address this concern in three steps: first, we discuss limitations of any empirical examination in this case due to sterilization practices; second, we analyze the changes of interest rates during intervention times; and third, we also show results regarding changes in the monetary base.

Limitations of sterilization implementation. In practice, sterilization is implemented less perfectly than theoretically assumed. A first issue is that domestic monetary policy operations designed to offset the change in monetary base caused by the intervention can rarely be perfectly matched in volume and timing with the intervention. Thus it is in practice quite possible

[18] Matching is possible for most episodes. In a few cases matching fails, typically because there is no close enough equivalent placebo intervention regarding the FX misalignment. This requires some trimming of the data.

[19] Alternative matching estimates using different misalignment horizons are provided in Table A10.

that the monetary base changes temporarily at times of FX interventions. As a second issue, interventions create an open ended position on the central bank's balance sheet, which can last for long time periods. This creates a currency (and possibly maturity) mismatch which may by itself originate activities by the central bank. Finally, as a third issue, domestic sterilization operations designed to offset the intended amount require an attractive price to be implemented. However, many central banks are restricted by an upper bound, which is their target interest rate at which they provide central bank liquidity (otherwise arbitrage opportunities could arise). Consequently, it can occur that sterilization operations do not yield full allotment as was the case for the ECB with their sterilization operations of their Securities Markets Programme in 2014. Besides, in an environment of excess liquidity, any further increase of the domestic monetary base does not lower rates as they are already anchored at the lower bound of the central bank corridor. For the above reasons, we left it to the central banks to identify sterilized interventions. Central banks were specifically asked to supply data on sterilized intervention. In unclear cases we sought a dialogue with the central bank counterparts to get an understanding of their categorization. To shed additional light on this, we will also provide evidence that market interest rates and the monetary base do not show any of the systematic effects that one would expect without sterilization.

Interventions and changes in interest rates. Regarding interest rates we calculate the day-on-day change in the domestic interest rate (Δi) using the most widely available 3-month interbank rate. This is available at monthly frequency during most years for all but 5 countries (mostly narrow band regimes), and missing in the 1990s for three additional countries. After linearly interpolating the interest rate (usually available as end of month values) to yield daily values, we can use these series in regressions at the daily frequency. Table A11 reports OLS estimates for regressions of Δi on intervention: the results do not indicate any systematic change in interest rates on days with interventions. Note that the sign of FX interventions is positive and statistically insignificant, independent of the intervention direction; this is a bit surprising as congruence of interest rate policy and interventions suggests interest rate decreases if foreign currency is purchased in interventions, i.e. in these cases rather a negative coefficient sign.

Thus the results do not indicate that interventions and interest rate policy go hand in hand.[20]

In a second approach for capturing potential interrelations between FX intervention and interest rate policy, we reproduce the major results of Table 5 with daily data for interest rate changes. The best available proxies are daily deposit rates, which cover 27 out of 33 countries, however, often only starting in the mid-2000s. This decreases the sample size considerably and even more than in the first approach which uses monthly interbank data.

We calculate the percentage point change in 1-month deposit rates between the day before an intervention and the last day of an intervention episode. This is interacted with dummy variables for foreign exchange purchases and sales, since the sign in a regression explaining success depends on the intervention direction. The results show that all six estimated coefficients have the expected sign (see details in Table A12). However, there is no strong relationship between intervention success and changes in deposit rates in our sample. The one statistically significant coefficient (under the smoothing criterion) is only due to some very strong changes in the deposit rate during a few weeks in one particular country. Excluding these observations the coefficients are all very close to zero and statistically insignificant. Still, our estimates suggest that decreasing the deposit rate by 1 percentage point should increase the probability of successfully smoothing the exchange rate during a purchase of foreign currency by 1.1 percentage points.

Interventions and changes in the monetary base. As in the case of interest rates, there are also some data limitations regarding the relation between sterilization and changes in the monetary base for some smaller countries. Even though all countries are covered, data are missing in some years. Unfortunately, data are only available at quarterly frequency in some cases so we linearly interpolate it to make it available daily. Using OLS to estimate regressions for changes in the monetary base on intervention, we find that intervention is uncorrelated with changes in the monetary base, as Table A13 in the Internet Appendix shows. Specifically, consistent with the earlier analysis of interest rate changes, we find that both purchase and sale coefficients are negative and insignificant. This indicates that FX interventions tend to occur at

[20] As our above regressions use a smaller sample than the one of our main regressions, we repeat the examinations underlying our main Table 5. All coefficients remain qualitatively the same with one exception: the intervention size regressor turns statistically significant. We conclude that the smaller sample used here behaves similar to the full sample, so that results can plausibly be applied to the full sample too.

times when monetary policy is rather restrictive, indicated by increasing domestic interest rates and a shrinking monetary base.

To summarize, due to data limitations we cannot analyze the sterilization of our intervention sample perfectly well. However, our evidence is consistent with the assumption that interventions in our sample are sterilized.[21]

6.3 FX interventions and capital controls

As a final analysis to sharpen the identification of potential intervention effects we look at capital controls. The starting hypothesis is that a higher degree of capital controls reduces the actual and potential activities of traders in FX markets. This necessarily improves the influence of official authorities and thus interventions become more effective with tighter capital controls.

To examine empirically the role of capital controls, we match the data provided by Fernández et al. (2015) with ours. Their dataset covers all years and almost all countries in our sample. To measure capital controls, we create an aggregate index based on the broad spectrum of control activities applying equal weights to each kind of controls. The index is then standardized between 0 and 1, where 1 indicates that a country has every possible control in place at the time of the intervention. This index is added to the standard specifications (Table 5) as shown in Table A14 in the Internet Appendix. As expected, the correlation between capital controls and the effectiveness of interventions is consistently positive and statistically significant for the event and direction criteria.

This leads to the question whether particular types of controls are more important than others. Thus, we restrict the analysis to those four groups of controls which are probably most important for effective interventions: controls on money markets, bonds, equities, and funds (collective investment instruments). The results for these regressions are similar except for the coefficient on capital controls in the "stabilization" regression which doubles in size and turns highly significant (results are available on request).

Next, it seems interesting to learn which of the four groups of capital controls just considered may be most relevant for our results, and thus potentially most relevant for policy makers.

[21] We also estimate the regressions discussed in this section at the monthly frequency to avoid interpolation, and find qualitatively identical results.

We find, however, that controls across the four groups are very highly positively correlated (correlation coefficients around 0.8-0.9), which does not allow disentangling capital controls in this case. Overall, we conclude that the above introduced subset of (four groups of) capital controls is sufficient to support the effectiveness of FX interventions.

7 Robustness

The full robustness analysis is presented in the Internet Appendix. Here, we just mention what has been considered. (1) We start by justifying our interpretation of success rates, i.e. comparing a benchmark case of zero success vs. a benchmark of placebo success rates. (2) Then we show that logit regressions provide qualitatively the same result as OLS. (3) Another variation, i.e. shortening the somewhat arbitrary horizon of effectiveness measures, does not give any new insight. (4) Next, we again change the effectiveness measures by looking at quantitative effects, which gives a rough indication about the size of intervention effects (beyond the so far discussed probability of success). Further variations of our empirical approach refer to (5) modified definitions of the intervention period, (6) considering "stopping rules" for interventions, (7) modifications of the cut-off of tiny interventions (excluded from the sample), (8) exclusion of single countries from the sample and differences in effectiveness for countries that do not make their intervention data publicly available, (9) introduction of year fixed effects or sample splits, (10) other volatility measures than the VIX measure, (11) longer (i.e. 5-year and 8-year) moving averages in order to capture the longer-term fundamental exchange rate, (12) PPP-based moving averages, and (13) centered moving averages of nominal and PPP-exchange rates. None of the above empirical exercises affect qualitatively our results.

8 Conclusion

FX intervention is a controversial policy tool as much literature has not detected systematic evidence that intervention moves exchange rates in the intended way. This result is often supported by two lines of argument. First, the FX market is the largest financial market in the world by volume (BIS, 2013b) and over time central banks have become increasingly smaller players in terms of trading volume. Second, FX markets incorporate fundamental news quickly

(Andersen et al., 2003), and in the long-run they are anchored to fundamentals (Mark and Sul, 2001; Engel et al., 2008), which raises the question of what central banks can convey beyond available knowledge. In contrast to this view, survey evidence suggests that central bankers around the world believe in the usefulness of FX intervention (e.g., Neely, 2008). Thus, is FX intervention effective?

Using confidential data on FX intervention, we make a general assessment of intervention effectiveness for 33 central banks. First, this broad set of central banks has intervened, on average across countries and time, 19% of our daily observations, which suggests that this policy tool is widely and commonly used. Indeed all central banks in the sample intervene over the period from 1995 to 2011, irrespective of their exchange rate regime. Second, we find clear evidence that FX intervention is an effective policy tool. To give an order of magnitude, interventions in our sample tend to be effective in about 80% of cases under some criteria. Of course, intervention effectiveness depends on circumstances. Considering the effectiveness in various exchange rate regimes, intervention stabilizes exchange rates in more than 80% of cases if one looks at narrow band regimes. Also, if the objective is to smooth exchange rates, intervention works quite well in all major regimes, including broad bands. It is when authorities intend to move the level of exchange rates by interventions in floating regimes where conditions are most important: the baseline success rate is around 60% but it can increase to 80% if the intervention size is very large and if it follows the trend rather than leaning against it. Moreover, intervention is more effective if it is noticed (not secret) and accompanied by oral intervention.

Overall, given the difficulty of influencing financial markets and that our data are based on true intervention operations of central banks, the evidence reported in this paper indicates that authorities around the world master the art of FX intervention better than one might expect.

References

Adler, Gustavo, Noemie Lisack and Rui C. Mano. 2015. "Unveiling the Effects of FX Intervention: A Panel Approach." IMF Working Paper No. 15/130.

Adler, Gustavo and Camilo E. Tovar. 2011. "FX Intervention: A Shield against Appreciation Winds?" IMF Working Paper No. 11/165.

Almekinders, Geert J. and Sylvester C. W. Eijffinger. 1996. "A Friction Model of Daily Bundesbank and Federal Reserve Intervention," Journal of Banking and Finance, 20(8), 1365-1380.

Andersen, Torben G., Tim Bollerslev, Francis X. Diebold and Clara Vega. 2003. "Micro Effects of Macro Announcements: Real-Time Price Discovery in FX." American Economic Review, 93(1), 38-62.

Bank for International Settlements (BIS). 2013a. "Market Volatility and FX Interventions in EMEs: What Has Changed?" BIS Paper No. 73.

Bank for International Settlements (BIS). 2013b. Triennial Central Bank Survey FX Turnover in April 2013: Preliminary Global Results. Basel.

Blanchard, Olivier, Gustavo Adler and Irineude Carvalho Filho. 2015. "Can FX Intervention Stem Exchange Rate Pressures from Global Capital Flow Shocks?" NBER Working Paper No. 21427.

Blinder, Alan, Michael Ehrmann, Marcel Fratzscher, Jacob de Haan and David-Jan Jansen. 2008. "Central Bank Communication and Monetary Policy: A Survey of Theory and Evidence," Journal of Economic Literature, 46(4), 910-945.

Born, Benjamin, Michael Ehrmann and Marcel Fratzscher. 2014. "Central Bank Communication on Financial Stability," Economic Journal, 124(577), 701-734.

Burkhard, Lukas and Andreas M. Fischer. 2009. "Communicating Policy Options at the Zero Bound," Journal of International Money and Finance, 28(5), 742-754.

Cavallino, Paolo. 2016. "Capital Flows and Foreign Exchange Intervention." International Monetary Fund, mimeo.

Daude, Christian, Eduardo Levy Yeyati and Arne Nagengast. 2014. "On the Effectiveness of Exchange Rate Intervention in Emerging Markets." OECD Development Centre Working Paper No. 324.

Dominguez, Kathryn M.E. 2003. "The Market Microstructure of Central Bank Intervention." Journal of International Economics, 59(1), 25-45.

Dominguez, Kathryn M.E., Rasmus Fatum and Pavel Vacek. 2013. "Do Sales of FX Reserves Lead to Currency Appreciation?" Journal of Money, Credit and Banking, 45(5), 867-890.

Dominguez, Kathryn M.E. and Jeffrey A. Frankel. 1993. "Does FX Intervention Matter? The Portfolio Effect." American Economic Review, 83(5), 1356-1369.

Edison, Hali J. 1993. "The Effectiveness of Central-Bank Intervention: A Survey of the Literature after 1982." Special Papers in International Economics No. 18.

Égert, Balázs and Evžen Kočenda. 2014. "The Impact of Macro News and Central Bank Communication on Emerging European Forex Markets." Economic Systems, 38(1), 73-88.

Eichengreen, Barry. 2008. Globalizing Capital: A History of the International Monetary System. Princeton University Press, Second edition.

Eichengreen, Barry. 2013. "Currency War or International Policy Coordination?" Journal of Policy Modeling, 35(3), 425-433.

Engel, Charles, Nelson C. Mark and Kenneth D. West. 2008. "Exchange Rate Models Are not as Bad as You Think." NBER Macroeconomics Annual, 22, 381-441.

Fatum, Rasmus. 2015. "FX Intervention When Interest Rates Are Zero: Does the Portfolio Balance Channel Matter after All?" Journal of International Money and Finance, 57(C), 185-199.

Fatum, Rasmus and Michael M. Hutchison. 2003. "Is Sterilized FX Intervention Effective after All? An Event Study Approach." Economic Journal, 113(487), 390-411.

Fatum, Rasmus and Michael M. Hutchison. 2010. "Evaluating FX Market Intervention: Self-selection, Counterfactuals and Average Treatment Effects." Journal of International Money and Finance, 29(3), 570-584.

Fatum, Rasmus and Yohei Yamamoto. 2014. "Large versus Small FX Interventions." Journal of Banking and Finance, 43, 114-123.

Fernández, Andrés, Michael W. Klein, Allesandro Rebucci, Martin Schindler and Martín Uribe. 2015. "Capital Control Measures: A New Dataset." NBER Working Paper No. 20970.

Fischer, Andreas M. 2006. "On the Inadequacy of Newswire Reports for Empirical Research on FX Interventions," Journal of International Money and Finance, 25(8), 1226-1240.

Fischer, Andreas M. and Mathias Zurlinden. 1999. "Exchange Rate Effects of Central Bank Interventions: An Analysis of Transaction Prices." Economic Journal, 109(459), 662-676.

Fratzscher, Marcel. 2008. "Oral Interventions versus Actual Interventions in FX Markets – An Event Study Approach." Economic Journal, 118(530), 1079-1106.

Fratzscher, Marcel. 2009. "How Successful Is the G7 in Managing Exchange Rates?" Journal of International Economics, 79(1), 78-88.

Gabaix, Xavier and Matteo Maggiori. 2015. "International Liquidity and Exchange Rate Dynamics." Quarterly Journal of Economics, 130(3), 1369-1420.

Hassan, Tarek A., Thomas M. Mertens and Tony Zhang. 2016. "Currency Manipulation." Working Paper, Chicago.

Humpage, Owen F. 1999. "US Intervention: Assessing the Probability of Success." Journal of Money, Credit and Banking, 31(4), 732-747.

International Monetary Fund (IMF). 2010. Annual Report on Exchange Rate Arrangements and Exchange Restrictions. International Monetary Fund, Washington D.C.

International Monetary Fund (IMF). 2014. World Economic Outlook: Legacies, Clouds, Uncertainties. Washington D.C.

Jeanne, Olivier and Romain Rancière. 2011. "The Optimal Level of International Reserves for Emerging Market Countries: A New Formula and Some Applications." Economic Journal, 121(555), 905-30.

Kearns, Jonathan and Roberto Rigobon. 2005. "Identifying the Efficacy of Central Bank Interventions: Evidence from Australia and Japan." Journal of International Economics, 66(1), 31-48.

Levy-Yeyati, Eduardo, Federico Sturzenegger and Pablo Alfredo Gluzmann. 2013. "Fear of Appreciation." Journal of Development Economics, 101, 233-247.

Mark, Nelson C. and Donggyu Sul. 2001. "Nominal Exchange Rates and Monetary Fundamentals: Evidence from a Small Post-Bretton Woods Panel." Journal of International Economics, 53(1), 29-52.

Menkhoff, Lukas. 2010. "High-Frequency Analysis of FX Interventions: What Do We Learn?" Journal of Economic Surveys, 24(1), 85-112.

Menkhoff, Lukas, Lucio Sarno, Maik Schmeling and Andreas Schrimpf. 2017. "Currency Value." Review of Financial Studies, 30(2), 416-441.

Mohanty, Madhusudan S. and Bat-el Berger. 2013. "Central Bank Views on FX Intervention." in: Bank for International Settlements (2013a), 55-74.

Mussa, Michael. 1981. The Role of the Official Intervention. Group of Thirty Occasional Paper No. 6.

Neely, Christopher J. 2005. "An Analysis of Recent Studies of the Effect of FX Intervention." Federal Reserve Bank of St. Louis Review, 87(6), 685-717.

Neely, Christopher J. 2008. "Central Bank Authorities' Beliefs about FX Intervention." Journal of International Money and Finance, 27(1), 1-25.

Payne, Richard and Paolo Vitale. 2003. "A Transaction Level Study of the Effects of Central Bank Intervention on Exchange Rates" Journal of International Economics, 61(2), 331-352.

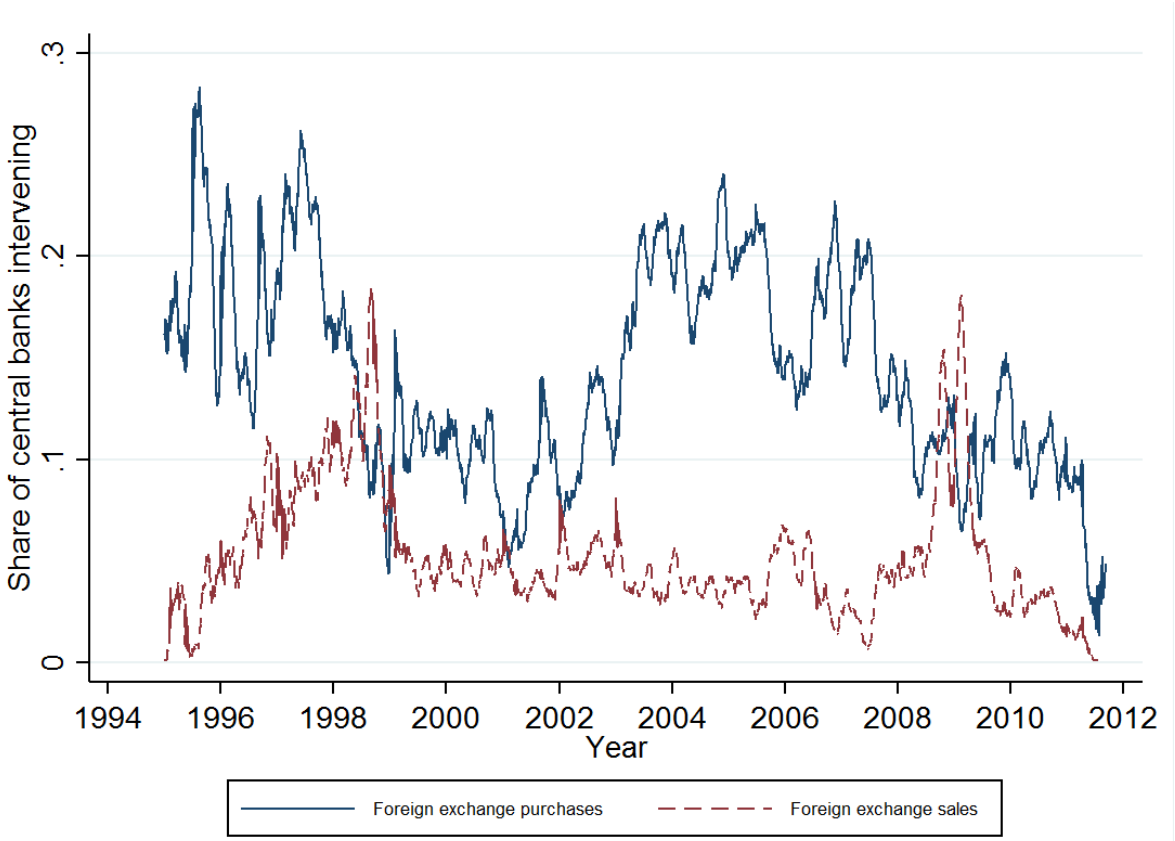
Reinhart, Carmen M. and Kenneth S. Rogoff. 2004. "The Modern History of Exchange Rate Arrangements: A Reinterpretation." Quarterly Journal of Economics, 119(1), 1-48.

Rossi, Barbara. 2013. "Exchange Rate Predictability." Journal of Economic Literature, 51(4), 1063-1119.

Sarno, Lucio and Mark P. Taylor. 2001. "Official Intervention in the FX Markets: Is It Effective and, If So, How Does It Work?" Journal of Economic Literature, 34(3), 839-868.

Schwartz, Anna J. 2000. "The Rise and Fall of FX Market Intervention as a Policy Tool." Journal of Financial Services Research, 18(2-3), 319-339.

Vitale, Paolo. 2003. "FX Intervention: How to Signal Policy Objectives and Stabilize the Economy." Journal of Monetary Economics, 50(4), 841-870.



Notes: The graph reports intervention activity smoothed using a rolling moving average including 20 lagged and forward trading days each.

Figure 1: Daily shares of foreign exchange purchasing and selling central banks in the sample

Table 1: *Descriptive characteristics of covered countries*

Country	Datasource	Reference currency	First year of coverage	Last year of coverage	Average GDP in bn. USD in sample period	Average GDP per capita in PPP USD in sample period	Average traded FX volumes[a] in mill. USD/day in sample period	FX regimes[b]
Argentina	Website	USD	2003	2011	235	12761	964	2.6
Australia	On request	USD	1998	2011	684	32910	45167	4
Azerbaijan	On request	USD	2001	2011	24	6108		2
Bolivia	On request	USD	2000	2011	12	3807		2
Canada	On request	USD	1995	2011	952	32745	30636	2,3
Chile	On request	USD	2001	2011	129	13508	3416	3
Colombia	On request	USD	1999	2011	158	7605	1385	3
Costa Rica	On request	USD	1996	2011	21	9237		2
Croatia	On request	EUR	1996	2011	38	14076		2
Czech Rep.	On request	EUR	1995	2011	110	19322	949	2,3
Denmark	On request	EUR	1995	2011	230	30819	3227	1,2
Georgia	On request	USD	2002	2009	6.9	3770		2,3
Hong Kong	Website	USD	1998	2009	178	33966	34435	1
Iceland	On request	USD	1995	2011	11	31177		2,3
Israel	On request	USD	1995	2011	137	24257	2492	3
Japan	FRED	USD	1995	2011	4534	28441	133987	4
Kenya	Website	USD	1999	2011	20	1381		2
Kyrgyz Rep	On request	USD	1998	2011	2.8	1759		2,5
Mexico	Website	USD	1997	2011	769	12136	13303	3
Moldova	Website	USD	1996	2011	2.9	2105		1,2,5
New Zealand	On request	USD	1995	2010	86	22395	4186	3
Norway	On request	EUR	1995	2011	253	43339	1504	3
Peru	On request	USD	1995	2011	77	6230	461	2
Poland	On request	EUR	1995	2010	267	12533	874	3
Slovakia	On request	EUR	1999	2008	42	15164	166	2
South Africa	On request	USD	1999	2010	169	7660	7536	4
Sweden	On request	EUR	1995	2006	288	26782	2412	3
Switzerland	FRED	USD	1995	2001	295	29516	17851	2,3
Turkey	Website	USD	2002	2011	510	11289	5268	4,5
UK	Website	EUR	1995	2011	1859	29020	36865	3
US	Website	EUR	1997	2011	11561	41377	170043	4
Venezuela	Website	USD	1997	2011	161	10028		2,6
EMU	On request	USD	1999	2011	9724	28813	47732	4

Notes: EUR indicates that reference currency was DEM before the introduction of the Euro. [a]: Source: BIS survey. Not available for all countries. [b]: According to Reinhart's and Rogoff's "coarse grid". The most rigid regimes are coded 1. Narrow bands (2) comprise preannounced crawling pegs, prennounced crawling bands that are narrower than or equal to $\pm 2\%$, de facto crawling pegs, de facto crawling bands that are narrower than or equal to $\pm 2\%$, as well as preannounced crawling bands that are wider than $\pm 2\%$. Broad bands (3) comprise de facto crawling bands that are narrower than or equal to $\pm 5\%$, noncrawling bands that are narrower than or equal to $\pm 2\%$ and managed floats. Freely floating is coded 4. Freely falling is coded 5 and dual markets in which parallel market data is missing is coded 6.

Table 2: *Descriptive characteristics of interventions by regime type*

Indicator	Total	Free Floaters	Broad bands	Narrow Bands	Other
Number of country-regime observations[a]	43	6	14	17	6
Trading days covered	113,842	19,330	41,604	42,961	9,947
Share of days with FX intervention	19.1%	7.3%	9.3%	33.6%	20.7%
Share of these with FX purchase	76.1%	94.8%	73.5%	73.2%	63.6%
Share of these with FX sale	23.9%	5.2%	26.5%	26.8%	36.4%
Average daily volume on intervention day in million USD	44.3	59.2	42.7	27.1	157.7
Average daily volume of FX purchases in million USD	44.4	52.7	45.8	24.9	190.6
Average daily volume of FX sales in million USD	44.1	177.1	34.2	33.3	100.2
Average daily intervention size as share of GDP	0.05%	0.02%	0.03%	0.05%	0.10%
Average daily intervention size as share of daily traded fx volume[b]	4.6%	1.0%	5.2%	5.1%	6.5%
FX purchasing episodes[c]	2,388	70	551	1,491	276
FX sale episodes[c]	2,161	25	511	1,402	223
Average length of episode in days	4.5	9.2	3.5	4.8	4.4
Share of intervention episodes leaning with the wind	35.5%	25.3%	47.1%	33.3%	25.6%
Share of intervention episodes towards the fundamental	48.0%	40.0%	48.8%	48.2%	46.6%
Trading days covered in turbulent times	5,638	949	1,975	2,178	536
Share of days with FX intervention in turbulent times	22.5%	2.7%	9.2%	43.5%	20.7%

Notes: [a]: Countries changing their regimes are counted more than once. No country returned to a previous regime after an interruption. Country-regime combinations are combined in "other", i.e. belong to other regime classifications such as pegs. [b]: Not available for all emerging markets, cf. Table 1. [c]: According to 10 day definition. Interventions leaning with the wind are defined as interventions that take the same direction as the previous two weeks' trend. Interventions towards the fundamental that aim into the direction of the three year moving average of the exchange rate. Turbulent times are defined as times when the CBOE VIX is 2 standard deviations above its median during the covered period.

Table 3: *Correlation between extended set of success criteria*

Success criterion	event	direction	smoothing	stabilization
event	1.00			
direction	0.52	1.00		
smoothing	0.31	0.45	1.00	
stabilization	-0.08	-0.07	0.05	1.00

Notes: The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks.

Table 4: *Unconditional success rates of intervention periods by regime*

	(1)	(2)	(3)	(4)	(5)	(6)
Regime	Free Floater		Broad Band		Narrow Band	
Criterion	Event	Smooth	Smooth	Stabilize	Smooth	Stabilize
Intervention episodes	61.1%	88.3%	79.1%	34.8%	78.1%	84.0%
Placebo rates	48.1%	40.1%	39.6%	49.5%	34.2%	76.8%
P-value (H0: equal effectiveness)	0.012	0.000	0.000	0.000	0.000	0.000
P-value (H0: actual $\leq$ placebo)	0.006	0.000	0.000	1.000	0.000	0.000
Actual events	95	77	561	1,062	1,010	2,893

Notes: The (unmatched, cf. Table 8) placebo effectiveness is calculated based on all days that do not belong to an intervention episode. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. For the direction criterion, see Table A3. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The panels are separated according to the "coarse grid" by Reinhart and Rogoff (2004). Broad bands comprise pre announced crawling bands of at least $\pm 2\%$, de facto crawling bands of up to $\pm 5\%$, moving bands of up to $\pm 2\%$ and managed floats. Narrow bands comprise more rigid arrangements. The p-values indicate tests with the H0 that actual intervention is equally likely to affect the success criteria as placebo intervention (top) and the one-sided hypothesis that actual intervention is more effective than placebo interventions.

Table 5: *Determinants of effectiveness*

Criterion	(1) Event	(2) Smoothing	(3) Stabilization
Regime-specific intercepts			
Free Floater	0.532***	0.798***	0.435***
	(0.053)	(0.043)	(0.044)
Broad Band	0.414***	0.712***	0.609***
	(0.024)	(0.028)	(0.024)
Narrow Band	0.213***	0.745***	0.949***
	(0.012)	(0.018)	(0.009)
Other Regime	0.133***	0.835***	1.004***
	(0.021)	(0.031)	(0.013)
Intervention characteristics			
Average daily intervention size in % of GDP	0.330***	0.115	0.104
	(0.104)	(0.077)	(0.064)
Intervention with prior 2 weeks' trend (0/1)	0.099***	-0.065**	0.011
	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.004***	0.001	-0.004***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	0.004	0.215***	-0.597***
	(0.041)	(0.050)	(0.039)
Observations	4,549	1,787	4,549
Adj. R-squared	0.373	0.800	0.810

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table 6: *News data coverage and affected events by country-regime combination*

News indicator	Total	Free Floaters	Broad Band	Narrow Band	Other
Number of affected events	4,549	95	1,062	2,893	499
Unnoticed intervention (0/1))	94.3%	62.1%	94.2%	94.8%	97.4%
Rumor of intervention (0/1)	4.6%	25.3%	5.3%	3.9%	2.6%
Confirmation of intervention (0/1)	1.8%	24.2%	1.0%	1.5%	0.8%
Any oral intervention (0/1)	51.9%	96.8%	99.6%	30.9%	63.5%

Notes: Noticing and not noticing is based on the criterion that a correct rumor or a confirmation by the central bank occur regarding at least one specific day of an episode. Retrospective confirmation is not counted here. Oral interventions are comments by the central bank or minister of finance that indicate increased or decreased likelihood of intervention or talking the currency into a particular direction.

Table 7: *Effectiveness, information, and central bank communication*

Criterion	(1) Event	(2) Smoothing	(3) Stabilization
Regime-specific intercepts			
Free Floater	0.496***	0.907***	0.466***
	(0.062)	(0.055)	(0.052)
Broad Band	0.387***	0.837***	0.640***
	(0.046)	(0.051)	(0.042)
Narrow Band	0.236***	0.832***	0.950***
	(0.036)	(0.038)	(0.032)
Other Regime	0.128***	0.931***	1.023***
	(0.044)	(0.048)	(0.035)
Intervention characteristics			
Average daily intervention size in % of GDP	0.258**	0.133*	0.151**
	(0.102)	(0.079)	(0.065)
Intervention with prior 2 weeks' trend (0/1)	0.095***	-0.064**	0.014
	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.004***	0.000	-0.005***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	-0.042	0.208***	-0.547***
	(0.042)	(0.052)	(0.042)
Communication			
Unnoticed intervention (0/1)	-0.044	-0.041	0.014
	(0.033)	(0.031)	(0.030)
Any oral intervention (0/1)	0.081***	-0.086***	-0.057***
	(0.018)	(0.025)	(0.014)
Turbulent time (0/1)	-0.058	-0.130*	-0.053
	(0.041)	(0.074)	(0.044)
Any oral intervention (0/1) x Turbulent time (0/1)	0.137**	0.175**	-0.065
	(0.060)	(0.085)	(0.054)
Observations	4,549	1,787	4,549
Adj. R-squared	0.377	0.802	0.811

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks. Unnoticed interventions are those that actual intervention that was not covered as rumor or confirm in news data. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification. See Table A15 for a this setup estimated by logit and Table A6 for specification with fewer *communication* controls.

Table 8: *Matching events and placebo events by country on misalignment and previous FX change*

	(1)	(2)	(3)	(4)	(5)	(6)
Criterion	Event	Smoothing	Smoothing	Stabilize	Smoothing	Stabilize
Regime	Free Floater	Free Floater	Broad Band	Broad Band	Narrow Band	Narrow Band
Estimator	nn-match	nn-match	nn-match	nn-match	nn-match	nn-match
Average Treatment Effect	0.250***	0.329***	0.267***	-0.001	0.347***	0.104***
on the Treated	(0.067)	(0.112)	(0.094)	(0.079)	(0.060)	(0.015)
Observations	18,533	9,556	25,940	28,376	17,671	25,556

Notes: Nearest neighbor matching with bias correction using, as suggested by Table A9, the lagged absolute misalignment from the 5, 3 and 1 year moving average (uncentered, previous year) of the exchange rate and the absolute change in the exchange rate leading to the previous day. Exact matching within country is used resulting in some observations that cannot be matched and which are excluded. The placebo intervention episodes are designed to have the country-specific median length of the intervention episodes and the length is accounted for in the matching procedure. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The number of observations indicates first days of intervention episodes plus the number of days that are not part of an intervention episode and for which placebo events are calculated.

Internet Appendix

to accompany

When is foreign exchange intervention effective?

Evidence from 33 countries

I. Robustness

We apply a host of robustness tests to our results (1) discussing the meaning of success, then varying (2) the regression method, (3) the effectiveness measures, (4) considering quantitative effectiveness, (5) the definition of intervention period, (6) the use of stopping rules, (7) the definition of tiny interventions, (8) the sample composition, (9) the sample periods, (10) variations of volatility measures, (11) redefinitions of the fundamental in terms of the horizon, (12) by using PPP exchange rates and (13) by using centered moving averages.

Interpretation of success rates. In line with the literature we interpret success rates against the implicit benchmark of having no success. Thus, an 80% success rate looks good within the range from 0% to 100%. Alternatively, however, one could also take the "success rate" of placebo exchange rate changes as the benchmark as they are documented in Table 4. Then, the interpretation is different: in case of the event criterion for floating regimes the placebo rate is 48%, thus realizing a conditional success rate of 80% means that the improvement is 32 percentage points, whereas there are 20 percentage points of unrealized potential success. Still, interventions do work but success from this perspective would be much lower. Nevertheless, we stick to the conventional interpretation because interventions do not occur in a "neutral" situation but they occur exactly when the exchange rate does not behave as desired by policy makers in unfavorable circumstances.

Regression method. The binary coding of intervention success according to the various effectiveness measures actually suggests to apply a logit / probit regression approach. These estimates yield qualitatively almost identical results, as Table A15 reports. The simplifying assumption of a linear probability model that we make to allow easier interpretation of effects with OLS is thus not crucial for the results.

Effectiveness measures. Decreasing the horizon of effectiveness measures means the results regarding the direction criterion approach those of the event criterion and the smoothing criterion becomes more short term. This naturally increases the baseline effectiveness of the stabilization criterion as it becomes less demanding. Other than that, results remain robust.

Quantitative effectiveness. In line with the event study literature we look at qualitative effects of interventions. However, it would be also interesting to learn how large an intervention has to be in order to move the market. Therefore, we repeat the benchmark specification in column 1 of Table A16 and then show two kinds of extensions. First, we redefine the success criterion by changing the event definition (0-1) to a threshold that has to be reached before success is claimed. Column 2 applies a threshold of 0.1% by which the exchange has to be moved, in column 3 the critical value is 0.2%. One can see that coefficient signs remain stable but coefficient sizes decrease as the degree of exchange rate volatility becomes important.

Second, in Table A17 we estimate a day-on-day (reduced form) elasticity of intervention for free floaters defined as

$$\begin{aligned}\Delta fx_{i,t} = \alpha + \beta_1 \cdot \text{fx sale (0/1)} \cdot ln|\text{Intervention volume in percent of GDP}_{i,t}| + \beta_2 \\ \cdot \text{fx purchase (0/1)} \cdot ln|\text{Intervention volume in percent of GDP}_{i,t}| + \gamma X_{i,t} + \epsilon_{i,t}.\end{aligned}$$

The number of observations is all observed days, the vast majority of which are without interventions. The covariates have to be adjusted from the event-setting for the simpler day-by-day-analysis, thus allowing using the FX trend instead of a dummy variable for intervention leaning with or against the trend. Results are shown in Table A17 for free floaters. The number of observations is all observed days, the vast majority of which are without intervention. The signs of the intervention coefficients are as expected. A sale of foreign currency (and purchase of domestic currency) leads to an appreciation of the domestic currency, whereas the purchase of foreign currency (and sale of domestic currency) is associated with the opposite effect. Both

estimated coefficients are heavily affected by the selection into intervention on that specific day. Not only may the market environment considerably vary between situations in which central banks decide to intervene in a particular direction, but also the central banks involved may differ because some of them intervene in one direction only. Thus, we hesitate to interpret the different coefficient size between purchases and sales.

As expected, the coefficients are considerably larger once only days are considered that did not have an intervention on the previous day, which reduces the numbers of intervention and non-intervention days.

Furthermore, the smoothing criterion can be adjusted. Any measure of the degree of smoothing that is not also a binary criterion is difficult to interpret because turning around the direction of the exchange rate has to be top-coded to yield a meaningful criterion. We therefore create two alternative smoothing criteria of a binary nature that indicate if an intervention lowered the slope of the exchange rate by 50 percent and 75 percent, respectively. Finally, we calculate a continuous smoothing criterion, which measures the percentage decrease in the slope and is limited to a range between 0 and 100 percentage point reductions. The results can be found in Table A18. The table shows that smoothing becomes more effective if interventions are larger, smoothing to a particular degree becomes more likely in volatile times and the regime-specific intercepts in column 5 suggest that in their typical intervention episode free floaters smooth significantly better than broad band or narrow band regimes.

Intervention periods. We test shorter definitions of the gap between intervention episodes. Using gaps between episodes of 1, 3, and 5 days instead of 10 days gives almost identical results. The only noteworthy difference is that the importance of the average intervention volume is lower (but still highly significant) for the event and direction criterion the shorter the gap between episodes is. This makes intuitive sense because longer gaps without intervention within an episode are likely to decrease the effectiveness of intervention and are reflected by a smaller average intervention volume throughout the intervention episode.

Stopping rule. There is the possibility that a central bank always intervenes until the exchange rate has moved in the intended way, i.e. following a stopping rule, even though the exchange rate may follow a random walk and the intervention may be completely useless. In such a case the success rate (of the event criterion) would be close to 100% by definition. However, the success rate in our sample is 61%. It is also unlikely that we observe a mix of countries that follow the stopping rule and some that do not follow it, because no single central bank in our sample has a success rate of (close to) 100% according to our criteria. Nevertheless, one might argue that patient central banks following the stopping rule would create a success rate which is increasing with the length of the intervention episode. Thus, Figure A1 plots the average success rate according to the event criterion for all regimes over different intervention lengths. The slope of the average line is very close to zero if using a linear fit. Next, further tentative evidence against the use of a stopping rule is provided by looking at realized changes in exchange rates within episodes. In fact in 45% of episodes that last more than one day, interventions continue after the exchange rate has moved in the (presumably) intended direction. Under a stopping rule, we would expect this share to be small. Finally, some of our success criteria measure the intended change in exchange rates not just until the last day of an intervention episode but include days beyond that last intervention day. Still FX intervention does seem to have a systematic impact. Overall, although the end of an intervention episode is (endogenously) determined by the change in exchange rate over the intervention episode, the empirical evidence provided is not consistent with central banks following a stopping rule in a world of randomly changing exchange rates.

Tiny interventions. Shifting the cutoff for "tiny interventions" from 0.00001 percent of GDP

by a factor of 100 up to 0.001 percent, or using an alternative threshold of 1% of a country's maximum intervention volume, does not affect estimates qualitatively. Increasing the threshold further leads to ever lower sample sizes and accordingly at some point starts to decrease the statistical significance of estimates. Furthermore, decreasing the cutoff to 0 increases the noise included in the estimation. Exemplary alternative thresholds are included in Table A19.

Sample composition. The results do not depend on particular countries. Systematically dropping individual countries does not change the results qualitatively (see also Table A1). Moreover, Table A20 shows that on average interventions by countries that make their intervention data freely available on the internet are more effective than interventions by countries which provided data on a confidential basis.

Sample periods. The results are robust to the inclusion of year fixed effects, which might pick up different levels of effectiveness for example due to global market environments. These results suggest that central banks were significantly less successful in stabilizing their exchange rates in the crisis year 2008. Splitting the sample in the median year of interventions (2004) and re-estimating Table A8 on the split samples suggests that the effectiveness of oral interventions in turbulent periods was higher in the instances coded "turbulent" before 2004 (in 1997, 1998, 2001, and 2002) rather than during the Great Recession in 2008 through 2011. In both samples, the finding that oral interventions in turbulent times are particularly effective holds for the event and the direction criterion. For the smoothing criterion, the point estimate is positive and insignificant in both groups with a large standard error.

Variations of volatility measures. Instead of using the VIX (for defining turbulent times), the Cleveland Fed Financial Distress Index or the St. Louis Fed Index (only available weekly) can be used. The Cleveland Fed Financial Distress Index yields near identical results while the St. Louis Fed Index has less explanatory power due to its lower frequency. The estimates for other variables are neither qualitatively nor quantitatively affected by this change.

Lengthening the moving average exchange rate. In the main text of the paper we use a 3-year moving average of the exchange rate in order to proxy for a fundamental exchange rate. While three years seem to be rather short if one has longer-term swings in mind, we note that many countries in our sample have quite rapidly changing nominal exchange rate so that a trade-off arises between a long-term average and a realistic average. Accordingly, we find that result in Tables A21 and A22 tend to weaken with longer moving average. Whereas the change from three years to five years does not matter much, an extension to eight years means more noise, in the sense of the above made argument of a realistic moving average.

Using a PPP-based moving average exchange rate. We rely in the main text of the paper on simple moving averages of nominal exchange rates as a proxy for the fundamental exchange rate. From an economic point of view PPP-rates are more convincing than simple moving averages in order to capture a fundamental exchange rate. Thus we use PPP-rates of the IMF instead of nominal MAs and show the results in Table A23 and A24. Interestingly, the qualitative picture remains unchanged.

Using centered moving average exchange rate. While we use moving averages up to this point in the paper which are based on information that was available at each point in time, we also show results with moving averages that are centered around the time of intervention in Tables A24 and A25.

II. Further discussion about the endogeneity of FX interventions

While we have provided some material already in the main text (in Section 6.1), here we put this material into context and discuss further issues. Isolating a causal effect of FX interventions against the potential influence from specific circumstances in the markets has been addressed in the literature using a variety of methods, which we discuss below and relate to our context. We start from a simple qualitative discussion on the role of endogeneity in empirical work. Next, we discuss quantitative methods to deal with this issue by isolating the effect from interventions using controls for other state variables: here we distinguish approaches based on reaction functions and counterfactuals. Finally, we discuss two further empirical approaches that try to reduce the potential influence of confounding factors, an example being high-frequency studies.

Qualitative reasoning. In the main text we had presented our qualitative reasoning regarding the potential endogeneity of FX interventions. In short, while there are good reasons to believe that standard empirical approaches may underestimate the true effect of interventions, various aspects make the estimation of the effectiveness of FX intervention a difficult task, and there are various methods that can be used to investigate the importance of this issue, to which we now turn.

Central bank reaction functions. Working with central bank reaction functions is the most popular approach to deal with endogeneity. The motivation to apply central bank reaction functions is to control for the market environment as central banks react to past exchange rate developments with their interventions (Almekinders and Ejffinger, 1996; Adler and Tovar, 2011). The most basic step involves a model for explaining the intervention operation, i.e. the fact that a central bank intervenes in response to some driving factors. Using a dummy variable $IA_{i,t}$ taking the value 1 on intervention days, a reaction function has to be estimated to explain whether an intervention takes place. The model typically takes the form:

$$\text{IA}_{i,t} = \alpha_0 + \alpha_1 Z_{i,t} + \nu_{i,t} \quad \forall t$$

The interventions implied by this relatively simple model could then be called expected interventions. Thus, one could examine only unexpected interventions for identification, which will have a similar role as truly exogenous shocks in other contexts. Table A9 in the Internet Appendix shows that a typical reaction function model performs poorly, even if lagged interventions on a previous day are added to the model, which is problematic for the calculation of unexpected intervention. This is not very surprising because we know from previous literature that intervention is often secret and revealing an intervention is often an active decision by the central bank. The remarkably low R^2 in Table A9 indicates that such a model of "expected intervention" performs poorly across time and countries. Most interventions in our sample are thus unexpected according to the reaction function approach used here.

With these caveats in mind, the estimates in Table A9 suggest that intervention in free floating regimes and broad band regimes are more likely on days after strong movements in the currency. Furthermore, free floaters and narrow band regimes are more likely to intervene on days with a strong misalignment of the exchange rate from its 5 and 1 year moving average, respectively. The overall insignificance of monthly variables throughout the table nicely fits the results in Neely (2008), who finds that central bankers target longer term misalignments between the exchange rate and its fundamental value, but are less likely to react to shorter term misalignments.

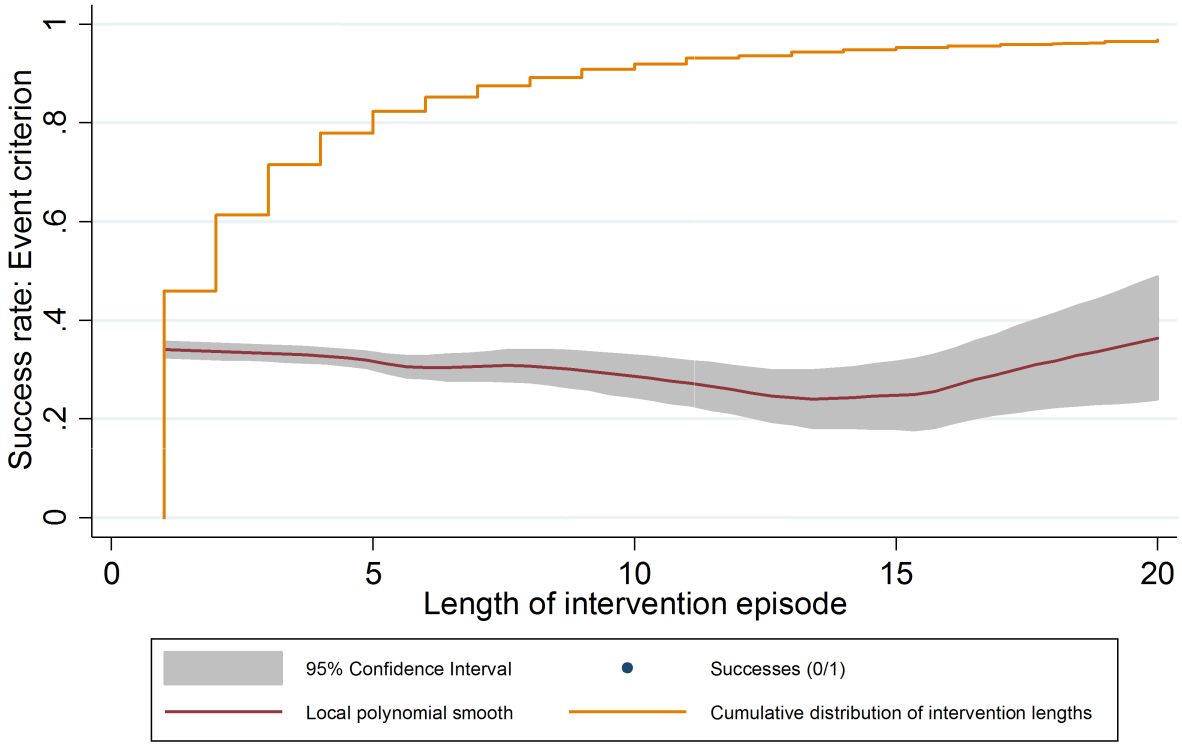
Studying counterfactuals. Within this line of literature there are three approaches, i.e. us-

ing forecasted exchange rates as counterfactuals, using non-intervention transactions as counterfactuals, and creating counterfactuals by a matching approach. Direct prediction of a counterfactual by forecasting from the last non-intervention day before the start of an intervention episode onwards may be, at first glance, the most straightforward approach. However, the likelihood of obtaining a good out-of-sample exchange rate model at the daily frequency is typically small, as indicated by the many studies that highlight the limitations of exchange rate models in out-of-sample forecasting (see Rossi, 2013). Another approach to get counterfactuals involves relying on other transactions of central banks which are not interventions. The first study in this respect is Fischer and Zurlinden (1999) who demonstrate for the Swiss case that only transactions which are classified and communicated to the market as interventions do impact exchange rates. What seems to be a clever way of identification unfortunately requires extremely scarce data so that there are just a few papers along this line (see Menkhoff, 2010, for a survey). Reassuringly, this approach indicates effectiveness of FX interventions. A third approach involves selecting suitable counterfactuals by a matching mechanism to account for market circumstances (see Fatum and Hutchison, 2010). We combine this idea with the reaction function approach and match actual intervention events and placebo events to yield a treatment and a control group. Details are described in the main text above and support the conclusion that our former results may underestimate the true intervention effectiveness.

Applying instrumental variables (IV). The application of an IV-approach is a standard procedure to eliminate or reduce the problem of endogeneity. However, it fully depends on having an appropriate instrumental variable. It seems difficult to imagine a variable which is highly related to interventions but otherwise unrelated to exchange rate changes. Dominguez and Frankel (1993) suggest using oral interventions as instrument but this does not work in today's world where oral interventions are used as policy measure themselves. Another IV-approach uses a combination with structural modeling. This approach assumes deep knowledge about the relations between exchange rates and interventions, and some clearly exogenous piece of information for identification. A prominent case is the study of Kearns and Rigobon (2005) about Japanese FX interventions, where a policy change in the size and frequency of interventions is used for identification. Obviously such an approach can hardly be applied to a broad cross-country study, such as ours, because it is difficult to find an IV that is valid for all countries. Thus, it may not be surprising that the IV-approach is not common in the FX intervention literature.

High-frequency approaches. The least demanding way in reducing unwanted effects from endogeneity is relying on high-frequency data. The idea is to eliminate as many disturbing influences as possible by narrowing the window of observation. Indeed, studies using intra-day data reveal clearly the impact of exchange rate interventions (see Menkhoff, 2010). The disadvantage is obviously the very short period of analysis and thus the question remains whether interventions may impact more permanently on exchange rates. A kind of compromise in this respect are event studies in FX, such as Fatum and Hutchison (2003) and Payne and Vitale (2003). They often use daily data, as in our case. Accordingly, we can interpret our results being based on about 4,500 single event studies, which should reduce the disturbing influence of confounding factors.

III. Figures



Notes: The figure plots the local polynomial smooth of the average success rate of episodes for all regimes over intervention length. Epanechnikov kernel and bandwidth of 2 days used.

Figure A1: Success rate of intervention episodes by intervention length in days

IV. Tables

Table A1: *Unconditional success rates of intervention periods, weights and sub-samples*

Panel A: Unweighted, equal weight to each intervention episode

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Actual intervention (buy FX)	36.0%†	40.8 %†	82.3 %†	71.6%
Actual intervention (sell FX)	29.2%	31.7%	77.1 %	72.8%
Observations	4,549	4,549	1,787	4,549

Panel B: Placebo success rates, no interventions*

Criterion	(5) Event	(6) Direction	(7) Smoothing	(8) Stabilization
Placebo intervention (any)	44.4%	45.0%	37.1%	57.2%
Observations	93,228	93,228	88,735	93,228

Panel C: Equal weight to each country

Criterion	(9) Event	(10) Direction	(11) Smoothing	(12) Stabilization
Actual intervention (buy FX)	50.5%†	54.6%†	89.2%†	64.6%†
Actual intervention (sell FX)	36.2%	39.2%	76.0%	53.5%
Observations	4,549	4,549	1,787	4,549

Panel D: Interventions in turbulent times, unweighted

Criterion	(9) Event	(10) Direction	(11) Smoothing	(12) Stabilization
Actual intervention (buy FX)	45.0%†	54.1%†	91.7%†	52.3%†
Actual intervention (sell FX)	31.7%	35.7%	75.7%	45.2%
Observations	235	235	118	235

Notes: †: Difference to mean effectiveness of FX sale statistically significant at the 10% level at least. *: Panel B reports success rates according to criteria on days without interventions. We assume that placebo intervention episodes last as long as an average intervention episode and the sign of the presumed intervention is random. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks.

Table A2: *Extended determinants of effectiveness*

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Intercepts				
FX purchase episode intervention period	0.539***	0.529***	0.836***	0.565***
	(0.055)	(0.056)	(0.046)	(0.045)
FX sale episode	0.509***	0.469***	0.794***	0.523***
	(0.055)	(0.056)	(0.048)	(0.045)
Regime fixed effects				
Free Floater	Baseline	Baseline	Baseline	Baseline
Broad Band	-0.115**	-0.108**	-0.081**	0.158***
	(0.053)	(0.053)	(0.041)	(0.043)
Narrow Band	-0.316***	-0.261***	-0.039	0.524***
	(0.051)	(0.052)	(0.041)	(0.042)
Other Regime	-0.394***	-0.303***	0.045	0.563***
	(0.055)	(0.056)	(0.048)	(0.043)
Intervention characteristics				
Average daily intervention size in % of GDP	0.318***	0.296***	0.096	0.087
	(0.103)	(0.104)	(0.078)	(0.062)
Length of intervention episode in days	-0.000	-0.000	-0.001	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Intervention with prior 2 weeks' trend (0/1)	0.098***	0.136***	-0.068**	0.008
	(0.015)	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.003***	0.002**	0.000	-0.005***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)	(0.001)
VIX	0.000	0.001	-0.001	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	-0.001	-0.001	0.233***	-0.515***
	(0.043)	(0.045)	(0.052)	(0.041)
Observations	4,549	4,549	1,787	4,549
Adj. R-squared	0.373	0.402	0.801	0.815

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks. Unnoticed interventions are those that actual intervention that was not covered as rumor or confirm in news data. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A3: *Long version: Unconditional success rates of intervention periods by regime*

Panel A: Freely floating

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Intervention episodes	61.1%†	60.0%†	88.3%†	21.1%
Placebo rates	48.1%	48.0%	40.1%	29.1%†
Actual events	95	95	77	95

Panel B: Broad band

Criterion	(5) Event	(6) Direction	(7) Smoothing	(8) Stabilization
Intervention episodes	48.3%	48.7%	79.1%†	34.8%
Placebo rates	49.1%	49.1%	39.6%	49.5%†
Actual events	1,062	1,062	561	1,062

Panel C: Narrow band

Criterion	(9) Event	(10) Direction	(11) Smoothing	(12) Stabilization
Intervention episodes	28.2%	32.6%	78.1%†	84.0%†
Placebo rates	38.9%†	40.4%†	34.2%	76.8%
Actual events	2,893	2,893	1,010	2,893

Notes: †: Statistically significantly higher mean effectiveness than the relevant comparison in the cell directly above or below (at least at the 5% level). The placebo effectiveness is calculated based on all days that do not belong to an intervention episode. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The panels are separated according to the "coarse grid" by Reinhart and Rogoff (2004). Broad bands comprise pre announced crawling bands of at least $\pm 2\%$, de facto crawling bands of up to $\pm 5\%$, moving bands of up to $\pm 2\%$ and managed floats. Narrow bands comprise more rigid arrangements.

Table A4: *Coding the news*

Coding generally considers only foreign exchange interventions and no other policy measures of central banks or governments.

Rumors capture the immediate rumors of market participants of central bank interventions on the same day.
Oral interventions are interventions by the central bank or minister of finance in favor or against a currency. Oral intervention means that either the likelihood of an intervention increases or the currency is talked into a particular direction. The announcement is tied to the specific day it occurred but the intention can be general and forward looking.
Confirmations are announcements by the central bank that foreign exchange has been purchased or sold on the same day.

Table A5: *Likelihood that events remain unnoticed*

	(1)	(2)	(3)
Dependent variable	Unnoticed	Unnoticed	Unnoticed
Average daily intervention size in % of GDP	-0.437***	-0.188***	-0.188***
	(0.080)	(0.056)	(0.056)
Length of episode in days	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)
Log GDP of country			-0.002
			(0.005)
Regime fixed effects	yes	yes	yes
Country fixed effects	no	yes	yes
Observations	4,549	4,549	4,549
R-squared	0.112	0.377	0.377

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The outcome variable indicates that an intervention episode is not reported in Factiva news.

Table A6: *Effectiveness and central bank communication*

Panel A: Unnoticed intervention

	(1)	(2)	(3)	(4)
Criterion	Event	Direction	Smoothing	Stabilization
Unnoticed intervention (0/1)	-0.073**	-0.116***	-0.018	0.033
	(0.033)	(0.033)	(0.030)	(0.029)
Specification otherwise as in Table 5	yes	yes	yes	yes
Observations	4,549	4,549	1,787	4,549

Panel B: Rumors vs. confirmations

	(5)	(6)	(7)	(8)
Criterion	Event	Direction	Smoothing	Stabilization
Intervention rumor (0/1)	0.020	0.072**	0.004	-0.038
	(0.035)	(0.036)	(0.034)	(0.033)
Intervention confirmed (0/1)	0.192***	0.133**	0.062	-0.013
	(0.062)	(0.064)	(0.043)	(0.050)
Specification otherwise as in Table 5	yes	yes	yes	yes
Observations	4,549	4,549	1,787	4,549

Panel C: Oral interventions

	(9)	(10)	(11)	(12)
Criterion	Event	Direction	Smoothing	Stabilization
Any oral intervention (0/1)	0.093***	0.074***	-0.067***	-0.062***
	(0.018)	(0.018)	(0.024)	(0.013)
Specification otherwise as in Table 5	yes	yes	yes	yes
Observations	4,549	4,549	1,787	4,549

Panel D: Oral interventions in turbulent times

	(13)	(14)	(15)	(16)
Criterion	Event	Direction	Smoothing	Stabilization
Any oral intervention (0/1)	0.087***	0.066***	-0.079***	-0.059***
	(0.018)	(0.018)	(0.024)	(0.013)
Turbulent time (0/1)	-0.057	-0.051	-0.128*	-0.053
	(0.041)	(0.046)	(0.074)	(0.044)
Oral intervention (0/1) x Turbulent time (0/1)	0.133**	0.185***	0.170**	-0.063
	(0.060)	(0.064)	(0.085)	(0.055)
Specification otherwise as in Table 5	yes	yes	yes	yes
Adj. R^2	0.377	0.403	0.802	0.811
Observations	4,549	4,549	1,787	4,549

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables for each relevant value (1 to 6) of the Reinhart and Rogoff (2004) classification. The split date of the bottom variables in Panel D is based on the median year of the intervention episodes covered in the sample.

Table A7: *Effectiveness, information, and the signal communicated with oral interventions*

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Regime-specific intercepts				
Free Floater	0.421***	0.417***	0.842***	0.497***
	(0.057)	(0.058)	(0.049)	(0.046)
Broad Band	0.342***	0.348***	0.784***	0.671***
	(0.029)	(0.030)	(0.035)	(0.027)
Narrow Band	0.190***	0.231***	0.783***	0.972***
	(0.013)	(0.013)	(0.020)	(0.010)
Other Regime	0.083***	0.173***	0.884***	1.053***
	(0.025)	(0.026)	(0.032)	(0.016)
Intervention characteristics				
Average daily intervention size in % of GDP	0.235**	0.252**	0.104	0.143**
	(0.103)	(0.105)	(0.080)	(0.065)
Intervention with prior 2 weeks' trend (0/1)	0.096***	0.135***	-0.066**	0.012
	(0.015)	(0.016)	(0.028)	(0.012)
Intervention towards fundamental	0.004***	0.003***	0.000	-0.005***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	-0.028	-0.026	0.204***	-0.585***
	(0.042)	(0.044)	(0.050)	(0.040)
Communication				
Rumor (0/1)	-0.014	0.043	0.027	-0.014
	(0.035)	(0.037)	(0.035)	(0.033)
Confirmation (0/1)	0.157**	0.100	0.081*	0.010
	(0.062)	(0.063)	(0.043)	(0.050)
Oral intervention indicating higher activity (0/1)	0.080***	0.033	-0.086***	-0.086***
	(0.020)	(0.020)	(0.025)	(0.016)
Oral intervention indicating lower activity (0/1)	0.087***	0.092***	-0.048*	-0.044***
	(0.021)	(0.022)	(0.027)	(0.017)
Observations	4,549	4,549	1,787	4,549
Adj. R-squared	0.378	0.404	0.802	0.811

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks. Unnoticed interventions are those that actual intervention that was not covered as rumor or confirm in news data. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A8: *Oral intervention and the pre-announcement of regimes*

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Intervention characteristics				
Average daily intervention size in % of GDP	0.188**	0.194**	0.105	0.071
	(0.093)	(0.095)	(0.082)	(0.068)
Intervention with prior 2 weeks' trend (0/1)	0.041***	0.072***	-0.065**	0.009
	(0.015)	(0.016)	(0.028)	(0.012)
Intervention towards fundamental	0.000	-0.000	0.001	-0.004***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	0.109**	0.072	0.137**	-0.497***
	(0.044)	(0.046)	(0.055)	(0.045)
Communication				
Unnoticed intervention (0/1)	-0.044	-0.097***	-0.017	0.024
	(0.034)	(0.034)	(0.031)	(0.030)
Any oral intervention (0/1)	0.117***	0.122***	-0.062**	0.005
	(0.021)	(0.023)	(0.031)	(0.017)
Turbulent time (0/1)	-0.067	-0.070	-0.114	-0.059
	(0.041)	(0.045)	(0.075)	(0.043)
Any oral intervention (0/1) x Turbulent time (0/1)	0.122**	0.179***	0.161*	-0.052
	(0.060)	(0.063)	(0.085)	(0.054)
Any oral intervention (0/1) x Preannounced regime (0/1)	-0.340***	-0.423***	-0.048	-0.082***
	(0.043)	(0.044)	(0.074)	(0.031)
"Fine grid" currency regime fixed effects	yes	yes	yes	yes
Observations	4,549	4,549	1,787	4,549
Adj. R-squared	0.412	0.442	0.804	0.823

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. "Fine grid" currency regime fixed effects are dummy variables for each relevant value (1 to 14) of the Reinhart and Rogoff (2004) classification. They are not reported due to confidentiality requirements.

Table A9: *Determinants of intervention days*

Panel A: Modelling intervention, including lagged intervention

	(1)	(2)	(3)	(4)	(5)
Estimator	OLS	Logit			
Regimes	All	All	Free Floater	Broad Band	Narrow Band
Lagged absolute change in exchange rate (1 day)	-0.001	-0.021	0.383**	0.078**	-0.079
	(0.003)	(0.103)	(0.156)	(0.039)	(0.133)
Absolute misalignment from monthly MA	-0.001	-0.033	0.018	0.023	-0.014
	(0.001)	(0.045)	(0.062)	(0.047)	(0.052)
Absolute misalignment from 1y-MA	0.000	0.012	0.042	0.031	0.033***
	(0.001)	(0.017)	(0.028)	(0.040)	(0.012)
Absolute misalignment from 3y-MA	-0.001	-0.016	0.001	-0.060***	0.012
	(0.001)	(0.017)	(0.021)	(0.020)	(0.019)
Absolute misalignment from 5y-MA	0.002	0.036**	0.029**	0.033	0.021
	(0.001)	(0.015)	(0.011)	(0.028)	(0.017)
Intervention on previous day (0/1)	0.270***	2.526***	perfect	3.513***	1.841***
	(0.036)	(0.332)	prediction= 0	(0.363)	(0.277)
Monthly FX volatility	-0.952	-24.250	-12.884	54.256**	-39.242
	(0.700)	(27.726)	(47.221)	(23.615)	(33.202)
Constant	0.019**	-3.732***	-6.275***	-4.552***	-3.217***
	(0.009)	(0.315)	(0.515)	(0.516)	(0.389)
Observations	112,059	112,059	19,226	40,994	41,871
R-squared	0.086	0.124	0.037	0.202	0.103

Panel B: Modelling intervention, without lagged intervention

	(6)	(7)	(8)	(9)	(10)
Estimator	OLS	Logit			
Regimes	All	All	Free Floater	Broad Band	Narrow Band
Lagged absolute change in exchange rate (1 day)	-0.001	-0.024	0.378**	0.159**	-0.105
	(0.004)	(0.146)	(0.151)	(0.062)	(0.176)
Absolute misalignment from monthly MA	-0.002	-0.044	0.018	0.028	-0.014
	(0.002)	(0.066)	(0.061)	(0.052)	(0.064)
Absolute misalignment from 1y-MA	0.000	0.012	0.042	0.055	0.043***
	(0.001)	(0.020)	(0.028)	(0.071)	(0.013)
Absolute misalignment from 3y-MA	-0.001	-0.017	0.002	-0.087**	0.014
	(0.001)	(0.021)	(0.021)	(0.037)	(0.023)
Absolute misalignment from 5y-MA	0.002	0.045**	0.029**	0.043	0.025
	(0.002)	(0.020)	(0.011)	(0.032)	(0.020)
Monthly FX volatility	-1.336	-38.820	-12.477	63.139	-52.168
	(0.935)	(44.303)	(46.743)	(46.617)	(46.695)
Constant	0.026*	-3.454***	-6.278***	-4.197***	-3.016***
	(0.013)	(0.400)	(0.513)	(0.560)	(0.462)
Observations	112,059	112,059	19,320	40,994	41,871
R-squared	0.014	0.033	0.036	0.028	0.043

Notes: This table reports day-level estimates of simple reaction functions that test whether interventions can be expected based on spot rate movements on previous days, misalignment of the exchange rate from its short or long term moving average or volatility. Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively.

Table A10: *Matching events and placebo events by country on different misalignment horizons and previous FX change*

Criterion Regime Estimator	(1) Event Free Floater nn-match	(2) Smoothing Free Floater nn-match	(3) Smoothing Broad Band nn-match	(4) Stabilize Broad Band nn-match	(5) Smoothing Narrow Band nn-match	(6) Stabilize Narrow Band nn-match
Matching on 1 year misalignment						
Average Treatment Effect	0.170**	0.449***	0.239**	-0.006	0.347***	0.104***
on the Treated	(0.083)	(0.072)	(0.096)	(0.075)	(0.060)	(0.015)
Matching on 3 year misalignment						
Average Treatment Effect	0.359***	0.857***	0.267***	-0.001	0.495***	0.055***
on the Treated	(0.106)	(0.190)	(0.094)	(0.079)	(0.040)	(0.015)
Matching on 5 year misalignment						
Average Treatment Effect	0.250***	0.329***	0.307***	0.000	0.350***	0.129***
on the Treated	(0.067)	(0.112)	(0.103)	(0.080)	(0.043)	(0.022)
Sample size	18,542	9,563	25,953	28,394	17,716	26,632

Notes: Nearest neighbor matching with bias correction using the lagged absolute misalignment from the 1/3/5 year moving average (uncentered, previous year) of the exchange rate, the absolute change in the exchange rate leading to the previous day for free floaters and broad bands and an exact match by country (cf. Table A9). Exact matching within country results in some observations that cannot be matched and which are excluded. The placebo intervention episodes are designed to have the country-specific median length of the intervention episodes and the length is accounted for in the matching procedure. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. Note that the alternative matching variables are used here to provide evidence of robustness, not necessarily because they are supported by our analyses. For the summary of matching estimates supported by Table A9, see Table 8 in the main text.

Table A11: *Foreign exchange intervention and interest rates*

	(1) Δi	(2) Δi	(3) Δi	(4) Δi
Purchase FX	0.026	0.025	0.025	0.047
	(0.030)	(0.029)	(0.029)	(0.049)
Sell FX	0.076	0.074	0.075	0.099
	(0.056)	(0.054)	(0.054)	(0.075)
Constant	-0.009	-0.030	-0.034	-0.094
	(0.006)	(0.024)	(0.025)	(0.074)
Weekday FE	No	Yes	Yes	Yes
Year FE	No	No	Yes	Yes
Country FE	No	No	No	Yes
Observations	90,365	90,365	90,365	90,365
R-squared	0.001	0.002	0.002	0.002

Notes: Δi is the change in the linearly interpolated 3-month interbank rate on a given day. Purchase FX and Sell FX are dummy variables indicating intervention days. A basis point is denoted as 0.01. Heteroskedasticity-robust standard errors that cluster at the country level in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively.

Table A12: *Determinants of effectiveness and the role of interest rate changes*

Criterion	(1) Event	(2) Smoothing	(3) Stabilization
Regime-specific intercepts			
Free Floater	0.721***	0.889***	0.437***
	(0.075)	(0.052)	(0.065)
Broad Band	0.554***	0.754***	0.620***
	(0.049)	(0.050)	(0.042)
Narrow Band	0.444***	0.790***	0.984***
	(0.039)	(0.040)	(0.028)
Other Regime	0.429***	0.912***	1.077***
	(0.059)	(0.035)	(0.023)
Intervention characteristics			
Average daily intervention size in % of GDP	-0.101	0.162**	0.352**
	(0.203)	(0.084)	(0.150)
Intervention with prior 2 weeks' trend (0/1)	-0.038	-0.056	-0.018
	(0.029)	(0.039)	(0.025)
Intervention towards fundamental	0.005**	0.002	0.006***
(based on distance to 3Y-MA)	(0.003)	(0.003)	(0.002)
Share of max. local volatility	-0.111	0.096	-0.701***
	(0.099)	(0.091)	(0.077)
FX purchase (0/1) x Day on day change	-0.005	-0.012**	-0.001
in deposit rate (in percentage points)	(0.007)	(0.005)	(0.005)
FX sale (0/1) x Day on day change	0.002	0.006	0.002
in deposit rate (in percentage points)	(0.004)	(0.006)	(0.005)
Observations	1,225	669	1,225
Adj. R-squared	0.500	0.825	0.652

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. Daily data one month deposit rates used where available. Data availability is far better for bigger currencies and in the 2000s. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A13: *Foreign exchange intervention and the monetary base*

Panel A: Daily analysis

	(1) ΔMB	(2) ΔMB	(3) ΔMB
Purchase FX (0/1)	-0.002	-0.001	-0.007
	(0.012)	(0.012)	(0.013)
Sell FX (0/1)	-0.011	-0.009	-0.022
	(0.014)	(0.015)	(0.018)
Constant	0.008	0.014	-0.010
	(0.012)	(0.009)	(0.023)
Year FE:	No	Yes	Yes
Country FE:	No	No	Yes
Observations	113,806	113,806	113,806
R-squared	0.000	0.000	0.000

Panel B: Quarterly analysis

	(4) ΔMB	(5) ΔMB	(6) ΔMB
Net intervention purchases	-0.243	-0.227	-0.288
in percent of GDP	(0.204)	(0.223)	(0.257)
Constant	0.202	-0.068	1.529***
	(0.203)	(0.113)	(0.410)
Year FE	no	yes	yes
Country FE	no	yes	yes
Observations	1,231	1,231	1,231
R-squared	0.001	0.015	0.024

Notes: ΔMB is the change in the monetary base on the day (Panel A) or during the quarter (Panel B) in percentage points relative to the monetary base of the previous day/quarter. Purchase FX and Sell FX are dummy variables indicating intervention days. In Panel B, the purchase and sales volumes are added up by quarter. Estimated using OLS. Heteroskedasticity-robust standard errors that cluster at the country level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table A14: *Determinants of effectiveness and capital controls*

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Regime-specific intercepts				
Free Floater	0.429***	0.470***	0.869***	0.412***
	(0.069)	(0.070)	(0.069)	(0.059)
Broad Band	0.369***	0.421***	0.789***	0.495***
	(0.056)	(0.058)	(0.070)	(0.051)
Narrow Band	0.173***	0.263***	0.788***	0.902***
	(0.043)	(0.045)	(0.053)	(0.039)
Other Regime	0.062	0.187***	0.923***	1.010***
	(0.052)	(0.054)	(0.061)	(0.042)
Intervention characteristics				
Average daily intervention size in % of GDP	0.184	0.186	0.234**	0.086
	(0.124)	(0.129)	(0.093)	(0.087)
Intervention with prior 2 weeks' trend (0/1)	0.097***	0.161***	-0.044	0.008
	(0.018)	(0.019)	(0.033)	(0.015)
Intervention towards fundamental	0.005***	0.004***	-0.000	-0.005***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	-0.108**	-0.088*	0.263***	-0.455***
	(0.047)	(0.050)	(0.062)	(0.047)
Communication				
Unnoticed intervention (0/1)	-0.024	-0.079*	-0.028	0.025
	(0.040)	(0.042)	(0.040)	(0.037)
Any oral intervention (0/1)	0.071***	0.045**	-0.084***	-0.064***
	(0.022)	(0.023)	(0.031)	(0.017)
Turbulent time (0/1)	-0.106**	-0.127***	-0.166*	-0.105*
	(0.041)	(0.047)	(0.096)	(0.061)
Oral intervention (0/1) x Turbulent time (0/1)	0.205***	0.276***	0.191*	0.018
	(0.063)	(0.067)	(0.105)	(0.070)
Capital controls				
Aggregate index	0.170***	0.174***	0.021	0.071***
	(0.033)	(0.034)	(0.041)	(0.027)
Observations	3,233	3,233	1,235	3,233
Adj. R-squared	0.394	0.425	0.801	0.788

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A15: *Effectiveness, information, and central bank communication (logit estimates)*

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Regime-specific intercepts				
Free Floater	-0.082	0.169	2.160***	0.097
	(0.274)	(0.276)	(0.473)	(0.344)
Broad Band	-0.536**	-0.213	1.596***	1.062***
	(0.211)	(0.208)	(0.348)	(0.261)
Narrow Band	-1.192***	-0.737***	1.611***	2.436***
	(0.163)	(0.160)	(0.265)	(0.206)
Other Regime	-1.764***	-1.032***	2.332***	3.335***
	(0.216)	(0.204)	(0.378)	(0.281)
Intervention characteristics				
Average daily intervention size in % of GDP	1.247***	1.076**	1.008	1.379**
	(0.470)	(0.463)	(0.691)	(0.564)
Intervention with prior 2 weeks' trend (0/1)	0.448***	0.609***	-0.385**	0.102
	(0.069)	(0.067)	(0.156)	(0.085)
Intervention towards fundamental	0.020***	0.017***	0.003	-0.032***
(based on distance to 3Y-MA)	(0.003)	(0.003)	(0.008)	(0.004)
Share of max. local volatility	-0.234	-0.260	1.461***	-3.357***
	(0.214)	(0.211)	(0.419)	(0.258)
Communication				
Unnoticed intervention (0/1)	-0.199	-0.428***	-0.268	0.158
	(0.147)	(0.145)	(0.217)	(0.181)
Any oral intervention (0/1)	0.409***	0.252***	-0.551***	-0.400***
	(0.091)	(0.087)	(0.161)	(0.114)
Turbulent time (0/1)	-0.367	-0.286	-0.784**	-0.428
	(0.284)	(0.261)	(0.386)	(0.315)
Any oral intervention (0/1) x Turbulent time (0/1)	0.710**	0.878***	1.148**	-0.456
	(0.337)	(0.320)	(0.527)	(0.395)
Observations	4,549	4,549	1,787	4,549

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks. Unnoticed interventions are those that actual intervention that was not covered as rumor or confirm in news data. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A16: *Determinants of moving the exchange rate*

	(1)	(2)	(3)
		Movement	
Criterion	Event	$> 0.1\%$	$> 0.2\%$
Subsample	All	All	All
Free Floater	0.518***	0.474***	0.417***
	(0.053)	(0.052)	(0.053)
Broad Band	0.406***	0.311***	0.267***
	(0.024)	(0.023)	(0.022)
Narrow Band	0.205***	0.096***	0.054***
	(0.012)	(0.010)	(0.009)
Other Regime	0.124***	0.000	-0.046***
	(0.022)	(0.016)	(0.012)
Intervention characteristics			
Average daily intervention size in % of GDP	0.311***	0.188**	0.152*
	(0.103)	(0.088)	(0.081)
Intervention with prior 2 weeks' trend (0/1)	0.095***	0.058***	0.043***
	(0.015)	(0.013)	(0.012)
Intervention towards fundamental	0.003***	0.003***	0.003***
(based on distance to 3Y-MA)	(0.000)	(0.000)	(0.000)
Share of max. local volatility	0.024	0.195***	0.247***
	(0.041)	(0.040)	(0.038)
Observations	4,549	4,549	4,549
Adj. R-squared	0.376	0.333	0.311

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. "Movement $> 0.2\%$" and accordingly "$> 0.1\%$" indicate that only interventions that move the exchange rate by at least 0.2 and 0.1 percent in the expected direction are coded as success. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A17: *Day-on-day movements of the exchange rate*

	(1)	(2)	(3)	(4)	(5)
Subsample	All	All	All	No intervention on previous day	
FX purchase (0/1) x Average daily	-0.008**	-0.008**	-0.008**	-0.011***	-0.012***
intervention size in % of GDP	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
FX sale (0/1) x Average daily	0.118*	0.112*	0.114*	0.238***	0.228**
intervention size in % of GDP	(0.064)	(0.063)	(0.063)	(0.091)	(0.089)
FX misalignment (from MA-1y) in % of MA		0.000***	0.000***		0.000***
		(0.000)	(0.000)		(0.000)
FX misalignment (from MA-3y) in % of MA	0.000***	-0.000***	-0.000***	0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FX trend (weekly MA)		-0.126***	-0.084**		-0.051
		(0.037)	(0.036)		(0.035)
FX trend (monthly MA)			-0.196***		-0.209***
			(0.064)		(0.067)
Constant	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	19,325	19,325	19,325	17,925	17,925
R-squared	0.005	0.017	0.018	0.008	0.020

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The outcome variable are day-on-day changes in the log exchange rate. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A18: *Determinants of smoothing the exchange rate*

Criterion	(1) Event criterion	(2) Smoothing criterion	(3) Decrease absolute slope by 50%	(4) Decrease absolute slope by 75%	(5) Percentage point decrease in slope
Free Floater	0.532***	0.798***	0.672***	0.607***	63.038***
	(0.053)	(0.043)	(0.053)	(0.057)	(5.362)
Broad Band	0.414***	0.712***	0.583***	0.487***	54.490***
	(0.024)	(0.028)	(0.033)	(0.035)	(3.142)
Narrow Band	0.213***	0.745***	0.594***	0.499***	48.316***
	(0.012)	(0.018)	(0.021)	(0.021)	(1.876)
Other Regime	0.133***	0.835***	0.738***	0.660***	53.938***
	(0.021)	(0.031)	(0.037)	(0.041)	(3.856)
Intervention characteristics					
Average intervention size in % of GDP	0.330***	0.115	0.176*	0.150	30.940***
	(0.104)	(0.077)	(0.097)	(0.119)	(10.382)
Intervention with prior 2 weeks' trend	0.099***	-0.065**	-0.037	-0.014	1.862
	(0.015)	(0.028)	(0.031)	(0.032)	(2.908)
Intervention towards fundamental	0.004***	0.001	0.001	0.002	0.250**
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)	(0.001)	(0.119)
Share of max. local volatility	0.004	0.215***	0.281***	0.301***	9.186
	(0.041)	(0.050)	(0.060)	(0.065)	(6.014)
Observations	4,549	1,787	1,787	1,787	1,781
R-squared	0.373	0.800	0.691	0.612	0.629

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event and smoothing criteria are identical to above. The "decrease in slope" criteria take the value of 1 if the absolute slope decreases by at least the indicate percentage number and if the smoothing criterion is defined for this intervention episode. The "percentage point decrease in slope" criterion take the value 0 if smoothing is unsuccessful, 1 if the direction of the exchange rate is changed succesfully and values between 0 and 100 for the percentage point decrease in the slope relative to the reference period that is also used for the smoothing criterion. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A19: *Effectiveness under alternative noise canceling thresholds*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Threshold: 1% of largest intervention				Threshold: none			
Criterion	Event	Direction	Smoothing	Stabilization	Event	Direction	Smoothing	Stabilization
Regime-specific intercepts								
Free Floater	0.529***	0.563***	0.936***	0.523***	0.505***	0.543***	0.893***	0.460***
	(0.063)	(0.064)	(0.053)	(0.057)	(0.061)	(0.063)	(0.054)	(0.052)
Broad Band	0.411***	0.479***	0.842***	0.684***	0.394***	0.448***	0.825***	0.627***
	(0.049)	(0.049)	(0.052)	(0.044)	(0.046)	(0.047)	(0.050)	(0.041)
Narrow Band	0.261***	0.340***	0.834***	0.940***	0.246***	0.333***	0.819***	0.953***
	(0.037)	(0.038)	(0.039)	(0.032)	(0.035)	(0.037)	(0.037)	(0.031)
Other Regime	0.153***	0.278***	0.921***	1.022***	0.134***	0.269***	0.920***	1.027***
	(0.045)	(0.046)	(0.049)	(0.036)	(0.044)	(0.045)	(0.048)	(0.035)
Intervention characteristics								
Average daily intervention size in % of GDP	0.263***	0.275***	0.096	0.125**	0.221**	0.209**	0.145*	0.127**
	(0.100)	(0.103)	(0.079)	(0.062)	(0.098)	(0.100)	(0.078)	(0.064)
Intervention with prior 2 weeks' trend (0/1)	0.101***	0.143***	-0.063**	0.014	0.090***	0.141***	-0.068**	0.017
	(0.016)	(0.017)	(0.031)	(0.013)	(0.014)	(0.015)	(0.027)	(0.011)
Intervention towards fundamental	0.005***	0.004***	0.001	-0.005***	0.004***	0.004***	0.001	-0.005***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	-0.066	-0.071	0.210***	-0.541***	-0.038	-0.041	0.206***	-0.486***
	(0.044)	(0.047)	(0.057)	(0.044)	(0.040)	(0.042)	(0.048)	(0.039)
Communication								
Unnoticed intervention (0/1)	-0.075**	-0.118***	-0.041	0.019	-0.042	-0.098***	-0.040	0.017
	(0.033)	(0.034)	(0.031)	(0.030)	(0.033)	(0.034)	(0.031)	(0.030)
Any oral intervention (0/1)	0.075***	0.046**	-0.083***	-0.053***	0.074***	0.051***	-0.074***	-0.071***
	(0.019)	(0.019)	(0.026)	(0.014)	(0.018)	(0.018)	(0.024)	(0.013)
Turbulent time (0/1)	-0.056	-0.068	-0.128	-0.058	0.004	0.015	-0.072	-0.017
	(0.044)	(0.048)	(0.081)	(0.048)	(0.039)	(0.042)	(0.060)	(0.030)
Any oral intervention (0/1) x Turbulent time (0/1)	0.157**	0.217***	0.216**	-0.078	0.072	0.111*	0.117	-0.116***
	(0.067)	(0.071)	(0.090)	(0.063)	(0.058)	(0.060)	(0.073)	(0.043)
Observations	3,945	3,945	1,521	3,945	4,877	4,877	1,908	4,877
Adj. R-squared	0.365	0.397	0.809	0.815	0.373	0.401	0.799	0.826

Notes: Columns 1-4 are based on a sample trimmed by setting intervention days that are smaller than 1 percent of the respective country's largest daily intervention in absolute value. Columns 5-8 are based on all intervention volumes provided by the central banks. For additional notes see Table 5.

Table A20: *Effectiveness and the public availability of intervention data*

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Regime-specific intercepts				
Free Floater	0.478***	0.530***	0.912***	0.469***
	(0.060)	(0.063)	(0.056)	(0.052)
Broad Band	0.435***	0.489***	0.833***	0.633***
	(0.047)	(0.048)	(0.051)	(0.042)
Narrow Band	0.218***	0.318***	0.836***	0.953***
	(0.036)	(0.037)	(0.038)	(0.031)
Other Regime	0.052	0.211***	0.937***	1.034***
	(0.046)	(0.047)	(0.049)	(0.035)
Intervention characteristics				
Average daily intervention size in % of GDP	0.247**	0.225**	0.130*	0.153**
	(0.102)	(0.103)	(0.079)	(0.065)
Intervention with prior 2 weeks' trend (0/1)	0.088***	0.133***	-0.065**	0.015
	(0.015)	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.002***	0.002**	0.001	-0.004***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	0.017	-0.009	0.201***	-0.555***
	(0.042)	(0.045)	(0.052)	(0.043)
Communication				
Unnoticed intervention (0/1)	-0.047	-0.101***	-0.040	0.014
	(0.034)	(0.035)	(0.031)	(0.030)
Any oral intervention (0/1)	0.020	0.007	-0.081***	-0.048***
	(0.020)	(0.020)	(0.025)	(0.015)
Turbulent time (0/1)	-0.062	-0.057	-0.129*	-0.052
	(0.042)	(0.047)	(0.074)	(0.043)
Any oral intervention (0/1) x Turbulent time (0/1)	0.134**	0.191***	0.175**	-0.064
	(0.061)	(0.064)	(0.085)	(0.054)
Data availability				
Central bank publishes intervention data (0/1)	0.160***	0.122***	-0.016	-0.023
	(0.020)	(0.021)	(0.023)	(0.015)
Observations	4,549	4,549	1,787	4,549
Adj. R-squared	0.387	0.410	0.802	0.811

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks. Unnoticed interventions are those that actual intervention that was not covered as rumor or confirm in news data. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A21: *Determinants of effectiveness with alternative 5 year fundamental*

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Regime-specific intercepts				
Free Floater	0.520***	0.500***	0.793***	0.435***
	(0.053)	(0.054)	(0.044)	(0.044)
Broad Band	0.406***	0.391***	0.710***	0.611***
	(0.024)	(0.025)	(0.028)	(0.024)
Narrow Band	0.205***	0.236***	0.743***	0.947***
	(0.012)	(0.013)	(0.018)	(0.010)
Other Regime	0.122***	0.187***	0.832***	1.000***
	(0.022)	(0.023)	(0.031)	(0.013)
Intervention characteristics				
Average daily intervention size in % of GDP	0.305***	0.292***	0.109	0.110*
	(0.103)	(0.105)	(0.077)	(0.064)
Intervention with prior 2 weeks' trend (0/1)	0.096***	0.135***	-0.066**	0.007
	(0.015)	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.003***	0.003***	0.001	-0.002***
(based on distance to 5Y-MA)	(0.000)	(0.001)	(0.001)	(0.000)
Share of max. local volatility	0.019	0.022	0.216***	-0.613***
	(0.041)	(0.043)	(0.050)	(0.039)
Observations	4,549	4,549	1,787	4,549
Adj. R-squared	0.375	0.402	0.800	0.809

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A22: *Determinants of effectiveness with alternative 8 year fundamental*

Criterion	(1) Event	(2) Direction	(3) Smoothing	(4) Stabilization
Regime-specific intercepts				
Free Floater	0.495***	0.474***	0.781***	0.440***
	(0.053)	(0.054)	(0.044)	(0.044)
Broad Band	0.395***	0.379***	0.705***	0.613***
	(0.024)	(0.025)	(0.029)	(0.024)
Narrow Band	0.194***	0.224***	0.739***	0.947***
	(0.012)	(0.013)	(0.018)	(0.010)
Other Regime	0.115***	0.179***	0.831***	0.996***
	(0.021)	(0.023)	(0.031)	(0.013)
Intervention characteristics				
Average daily intervention size in % of GDP	0.265***	0.249**	0.092	0.118*
	(0.101)	(0.103)	(0.078)	(0.065)
Intervention with prior 2 weeks' trend (0/1)	0.090***	0.128***	-0.068**	0.007
	(0.015)	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.003***	0.003***	0.001**	-0.001***
(based on distance to 8Y-MA)	(0.000)	(0.000)	(0.001)	(0.000)
Share of max. local volatility	0.040	0.044	0.220***	-0.622***
	(0.041)	(0.043)	(0.050)	(0.040)
Observations	4,549	4,549	1,787	4,549
Adj. R-squared	0.379	0.406	0.801	0.809

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The direction criterion extends the relevant period by one week after the intervention episode. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A23: *Determinants of effectiveness with PPP-exchange-rate-based uncentered 3Y-MA*

Criterion	(1) Event	(2) Smoothing	(3) Stabilization
Regime-specific intercepts			
Free Floater	0.523***	0.788***	0.413***
	(0.053)	(0.046)	(0.044)
Broad Band	0.403***	0.703***	0.600***
	(0.024)	(0.029)	(0.024)
Narrow Band	0.198***	0.732***	0.927***
	(0.013)	(0.020)	(0.011)
Other regime	0.128***	0.827***	0.973***
	(0.021)	(0.032)	(0.014)
Intervention characteristics			
Average daily intervention size in % of GDP	0.316***	0.097	0.076
	(0.104)	(0.077)	(0.065)
Intervention with prior 2 weeks' trend (0/1)	0.100***	-0.067**	-0.003
	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.001***	0.001**	0.000
(based on distance to uncentered PPP 3Y-MA)	(0.000)	(0.000)	(0.000)
Share of max. local volatility	0.023	0.221***	-0.610***
	(0.041)	(0.050)	(0.040)
Observations	4,548	1,787	4,548
Adj. R-squared	0.372	0.800	0.808

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A24: *Determinants of effectiveness with PPP-exchange-rate-based centered 3Y-MA*

Criterion	(1) Event	(2) Smoothing	(3) Stabilization
Regime-specific intercepts			
Free Floater	0.523***	0.787***	0.411***
	(0.053)	(0.046)	(0.044)
Broad Band	0.403***	0.702***	0.599***
	(0.024)	(0.029)	(0.024)
Narrow Band	0.200***	0.731***	0.925***
	(0.013)	(0.020)	(0.011)
Other regime	0.131***	0.826***	0.973***
	(0.021)	(0.032)	(0.013)
Intervention characteristics			
Average daily intervention size in % of GDP	0.320***	0.098	0.075
	(0.104)	(0.077)	(0.065)
Intervention with prior 2 weeks' trend (0/1)	0.104***	-0.066**	-0.003
	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.001***	0.001**	0.000*
(based on distance to centered PPP 3Y-MA)	(0.000)	(0.000)	(0.000)
Share of max. local volatility	0.021	0.221***	-0.611***
	(0.041)	(0.050)	(0.040)
Observations	4,549	1,787	4,549
Adj. R-squared	0.372	0.801	0.808

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.

Table A25: *Determinants of effectiveness with centered 3Y-MA*

Criterion	(1) Event	(2) Smoothing	(3) Stabilization
Regime-specific intercepts			
Free Floater	0.546***	0.822***	0.439***
	(0.053)	(0.044)	(0.044)
Broad Band	0.418***	0.735***	0.625***
	(0.024)	(0.029)	(0.024)
Narrow Band	0.226***	0.764***	0.947***
	(0.012)	(0.018)	(0.010)
Other regime	0.153***	0.862***	1.009***
	(0.021)	(0.030)	(0.013)
Intervention characteristics			
Average daily intervention size in % of GDP	0.349***	0.092	0.064
	(0.106)	(0.077)	(0.064)
Intervention with prior 2 weeks' trend (0/1)	0.109***	-0.062**	0.006
	(0.015)	(0.028)	(0.011)
Intervention towards fundamental	0.001	-0.008***	-0.010***
(based on distance to centered PPP 3Y-MA)	(0.002)	(0.002)	(0.001)
Share of max. local volatility	0.016	0.218***	-0.596***
	(0.041)	(0.050)	(0.040)
Observations	0.369	0.802	0.810
Adj. R-squared	0.373	0.798	0.806

Notes: Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2% band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification.