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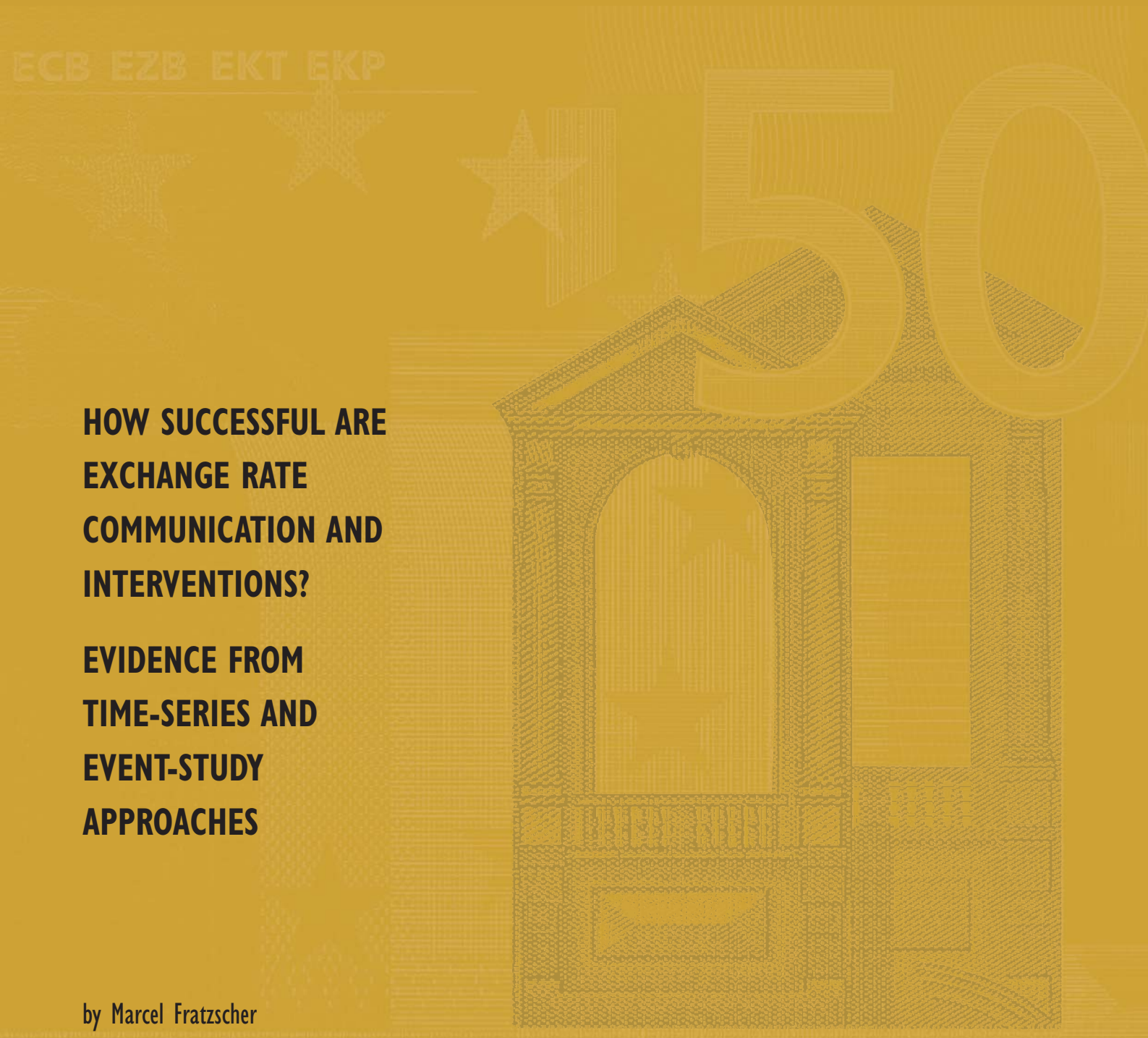

HOW SUCCESSFUL ARE EXCHANGE RATE COMMUNICATION AND INTERVENTIONS?

EVIDENCE FROM TIME-SERIES AND EVENT-STUDY APPROACHES

by Marcel Fratzscher

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In 2005 all ECB publications will feature a motif taken from the €50 banknote.

1 I would like to thank Terhi Jokipii for excellent research assistance. The views expressed in this paper are those of the author and do not necessarily reflect those of the European Central Bank.
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Abstract

The paper analyses whether communication and actual interventions in FX markets are successful in moving exchange rates over the medium- to long-run. It compares empirical evidence based on time-series analysis with that obtained from an event-study approach. Both the time-series approach based on option contracts and the event-study methodology yield compelling evidence that communication and actual interventions tend to be successful in moving exchange rates in the desired direction contemporaneously as well as over the medium- to long-term. This finding is consistent with recent work on microstructure models that emphasises the importance of dynamic effects of news and fundamentals on exchange rates.

JEL: E61; E58; F31.
Keywords: communication; exchange rate; intervention; policy; time-series analysis; event-study methodology; United States; euro area; Japan.

Non-Technical Summary

Many monetary authorities have moved away from conducting actual interventions and have used communication as their primary policy instrument to influence exchange rates when deemed necessary and desirable. But is exchange rate communication an effective policy tool? Although the literature has found evidence that communication and actual interventions may be effective in the short-run, e.g. on the days they occur, from a policy perspective the key question is whether such policies prove successful by inducing a permanent, long-term effect on exchange rates.

The objective of this paper is to tackle this issue by comparing two different methodological approaches, one based on standard time-series tools, and the second employing an event-study methodology, to analyse the long-term effectiveness of communication and actual intervention policies by the United States, Japan and the euro area since 1990.

Conceptually there are several reasons why such policies may have dynamic effects on FX markets. In particular, the rapidly evolving literature on microstructure-based exchange rate models suggests that there may be dynamic effects of how exchange rates incorporate new information. For instance, Evans and Lyons (2005) show that macroeconomic news have a dynamic effect that may take several days to be fully priced into foreign exchange markets. Similarly, Sarno and Taylor (2001) argue that monetary authorities may affect markets over a prolonged period of time as their interventions may function as a coordination device for market participants.

For the time-series approach, the paper uses an EGARCH framework to analyse the dynamic effects of interventions. It focuses on forward-looking indicators of exchange rates, in particular implied volatilities, risk reversals and strangles obtained from over-the-counter (OTC) option contracts to gauge the longer-term effectiveness of communication and actual interventions. A key result is that in particular exchange rate communication has a statistically significant effect on forward rates for a horizon up to 6 months, whereas actual interventions by most authorities have a significant effect on forward contracts only over a shorter horizon.

As to the alternative methodology, the paper then analyses the effectiveness of interventions using an event-study approach, which is based on the premise that exchange rate communication and actual interventions form clusters – i.e. some periods are characterised by frequent oral or actual interventions while other extended periods have none – and thus should be treated as such. In essence, this event-study approach reduces the dimensionality of measuring the effectiveness of events into a single dimension by distinguishing whether an event was ultimately a “success” or a “failure” in achieving a particular objective. The advantage of the event-study approach is

that it avoids the problem of "noise" affecting the precision of time-series estimates by transforming the variable of interest into such a binomial setting of "success" and "failure", but with the drawback of ignoring the information about the magnitude of exchange rate movements.

Based on four different success criteria for the event-study approach, the results show that communication and actual intervention events were successful and moved the G3 exchange rate in the desired direction in the five-day post-event period in 65% to 77% of the cases. This directional effect also proves highly persistent and shows a similar rate of "success" as many as 40 days after the events. Based on a non-parametric sign test, this rate of "success" is significantly higher than the unconditional rate of success. Finally, the paper shows that in the large majority of events – in all cases more than 80% – interventions succeeded in smoothing the exchange rate development, i.e. in reducing the strength of the exchange rate movements that took place prior to the event.

The results prove robust to a number of extensions and robustness tests. Most importantly, communication and actual interventions are successful in moving exchange rates in the desired direction mostly independently of whether they are supported by monetary policy. Moreover, the evidence suggests that communication and actual intervention events tend to be more successful when they go in the same direction as the pre-event exchange rate trend, if they occur in periods of large volatility and uncertainty and when exchange rates are misaligned. They are also more successful if they are coordinated domestically and with communication or actual interventions of foreign authorities.

Overall, the evidence based on both methodological approaches suggests that exchange rate communication, and to some extent also actual interventions may indeed be an effective policy tool by have a permanent effect on exchange rates.

1. Introduction

Are exchange rate communication and actual interventions effective policy tools? The literature is very much split on this issue with several studies finding evidence that actual interventions tend to help monetary authorities move exchange rates in the desired direction, while other papers show that such interventions usually tend to merely raise volatility in foreign exchange markets.[1] An important development over the past decade has been that many central banks have moved away from trying to manage exchange rates through actual purchases and sales of foreign exchange. Most notably, both the US and the euro area authorities basically abandoned actual interventions in August 1995 – with two exceptions in September and November 2000. Instead, many authorities increasingly use communication as their primary tool to influence exchange rates when deemed necessary. Policy-makers (Rubin and Weisberg 2003) have argued and recent empirical work (e.g. Jansen and de Haan 2005, Fratzscher 2004) has found that communication may indeed have a significant impact on exchange rates, though the literature on this issue is still very much in its infancy.

From a policy perspective, a key question is whether oral interventions and actual interventions prove to be successful by inducing a permanent, long-term effect on exchange rates. The premise of standard macroeconomic models of exchange rates is that efficient markets should price in all relevant information instantaneously so that the contemporaneous effect of any type of news, such as interventions, should also constitute the permanent effect. The great majority of the work in the literature uses a time-series approach, usually based on a GARCH-type framework at a daily or intra-daily frequency, and partly finds some evidence for a contemporaneous effect of actual interventions on the conditional mean and in particular on the conditional variance of the exchange rate, though such effects cannot be found beyond one or at most a few days (e.g. Baillie and Osterberg 1997, Beine, Bénassy-Quéré and Lecourt 2002, Dominguez 2003). Very similar conclusions emerge when analysing the effects of important macroeconomic news on exchange rates (e.g. Andersen et al. 2003, Ehrmann and Fratzscher 2005). This finding does not come as a surprise as so many different types of news affect foreign exchange markets every day that the true permanent, or long-term effect of interventions cannot be measured accurately. This does not necessarily imply that interventions are ineffective, but only that exchange rates are sufficiently volatile so as to make it impossible to measure their permanent, long-run effects.

On the contrary, the rapidly evolving literature on microstructure-based exchange rate models, building on the work by Peiers (1997), Evans and Lyons (2002) and Osler (2002), suggests that there may be dynamic effects of how exchange rates incorporate new information. For instance, Evans and Lyons (2005) show that macroeconomic news have a dynamic effect that may take several days to be fully priced into foreign exchange markets. They relate this dynamic effect to

[1] See the Edison (1993) and Sarno and Taylor (2001) for surveys of the different evidences.

the fact that news change the signed transaction volume, or order flow, for a sustained period of time, thereby affecting exchange rate for a number of days. Similarly, in their review of the literature on foreign exchange interventions, Sarno and Taylor (2001) argue that monetary authorities may affect markets over a prolonged period of time as their interventions may function as a coordination device for market participants, or through what they call a coordination channel. The question of key policy relevance is therefore precisely how permanent and long-lasting the effects of oral and actual interventions are. The objective of this paper is to tackle this issue by taking two different methodological approaches, one based on standard time-series tools, and the second employing an event-study methodology, to analyse the effectiveness of actual and oral interventions by the United States, Japan and the euro area since 1990.[2] Figure 1 illustrates the fundamental differences between these two methodologies. Figure 1 shows the evolution of the US dollar – euro exchange rate in the 40 days before the start and in the 40 days after the end of each of the oral intervention events by US and euro area authorities, which will be explained in detail below. Note that interventions that aim at reducing the US dollar – euro exchange rate have been inverted so that a positive change in the exchange rate after the event in Figure 1 implies that the exchange rate has moved in the direction desired by the interventions.

Figure 1 indicates that in around 75-80% of the events the exchange rate indeed moved in the desired direction in the post-event periods, and only in 20-25% in the undesired direction. Does this imply that oral intervention events by US and euro area authorities were "successful" in moving the exchange rate in the desired direction? The answer to this question depends on which methodological approach one takes to measuring "success". In essence, time-series approaches take into account the precise evolution of exchange rate movements after the events. Figure 1 shows how highly volatile exchange rates were after as well as before the events. This implies that although there is a marked positive mean return to exchange rate movements after the events – shown by the fat solid line– statistically one may not be able to reject the hypothesis that the changes after the events are different from zero – the fat dotted lines show +/- one standard deviation around the mean exchange rate change, with the lower band being continuously below zero. By contrast, an event-study approach, in essence, reduces the dimensionality of the analysis by transforming exchange rate movements into distinguishing solely between whether an event was a "success" or a "failure" and then testing whether the number of "successes" is higher than the number of "failures".

[2] Strictly speaking, also the time-series approaches are event-study approaches. However, for clarity I only refer to this alternative approach as event-study approach throughout the paper.

For the time-series approach, the paper uses an EGARCH framework to analyse the dynamic effects of interventions. Communication, and to some extent also actual interventions are found to have a significant contemporaneous impact on exchange rates on the days when these interventions take place. However, using cumulated impulse responses obtained from an EGARCH model specification shows that the effect of oral and actual interventions cannot be shown to be statistically significant beyond two or three days. The paper argues that this finding cannot be interpreted as evidence against long-term effectiveness of interventions, but only implies that the effect of individual interventions is not sufficiently large to dominate all other factors that influence exchange rates. In fact, I show that also the impact of important macroeconomic news, such as announcements of US non-farm payroll employment and of the German Ifo business confidence index, is not statistically significant beyond a few days.

To gauge the longer-term effectiveness of communication and actual interventions, the final part of the paper turns to forward-looking indicators of exchange rates, in particular implied volatilities, risk reversals and strangles obtained from over-the-counter (OTC) option contracts. Two key results emerge. First, in particular exchange rate communication has a statistically significant effect on forward rates for a horizon up to 6 months, whereas actual interventions by most authorities have a significant effect on forward contracts only over a shorter horizon. Second, a fundamental difference between communication and actual interventions exists for their impact on volatility. Communication mostly reduces historical volatility of spot rates, based on the EGARCH specification, as well as the implied volatility of OTC option contracts, whereas actual interventions mostly increase both types of volatility.

As the alternative methodology, the paper then analyses the effectiveness of interventions using an event-study approach in sections 4 and 5. This approach is based on the key premise that exchange rate communication and actual interventions form clusters – i.e. some periods are characterised by frequent oral or actual interventions while other extended periods have none – and thus should be treated as such.[3] In essence, this event-study approach then reduces the dimensionality of measuring the effectiveness of events into a single dimension by distinguishing whether an event was ultimately a "success" or a "failure" in achieving a particular objective. The advantage of the event-study approach is that it avoids the problem of "noise" affecting the precision of time-series estimates by transforming the variable of interest into such a binomial setting of "success" and "failure", but with the drawback of ignoring the information about the magnitude of exchange rate movements.

Based on four different success criteria, the results show that these oral intervention and actual intervention events were successful and moved the exchange rate in the desired direction in the five-day post-event period in 65% to 77% of the cases. This directional effect also proves highly

[3] MacKinlay (1997) provides a detailed overview of the use of this type of event-study methodology in different fields of the literature.

persistent and shows a similar rate of "success" as many as 40 days after the events. Based on a non-parametric sign test, this rate of "success" is significantly higher than the unconditional rate of success. Finally, the paper shows that in the large majority of events – in all cases more than 80% – interventions succeeded in smoothing the exchange rate development, i.e. in reducing the strength of the exchange rate movements that took place prior to the event.

The results prove robust to a number of extensions and robustness tests. Most importantly, communication and actual interventions are successful in moving exchange rates in the desired direction mostly independently of whether they are supported by monetary policy. Moreover, for US and euro area authorities the results indicate that communication against the prevalent policy mantra, i.e. statements that attempt to weaken the domestic currencies, have a substantially larger rate of success than those that merely re-affirm the mantra. A formal test using odds ratios in a logit-model framework confirms these results and suggests that communication events and actual intervention events are more successful in an environment of market uncertainty, when exchange rates deviate from equilibrium and when they are coordinated domestically as well as internationally with foreign monetary authorities.

The paper is structured as follows. Section 2 outlines the data on communication and actual intervention before Section 3 presents the empirical results for the time-series methodology. Section 4 then discusses the event-study methodology and its caveats. The empirical results of the event-study methodology as well as several extensions and robustness tests are given in Section 5. Section 6 concludes.

2. Data on Communication and Interventions

The starting point is to present the data on oral and actual interventions by the monetary authorities of the United States, Japan and the euro area, and to discuss some of the caveats. The data set for oral and actual interventions is identical to that presented and discussed in detail in Fratzscher (2004). This section provides a brief overview of the data and of some of the underlying caveats.

Data on *actual interventions* is nowadays mostly directly available from the respective central banks.[4] A look at the data – a more detailed analysis of which follows below – shows that US and euro area authorities basically stopped conducting actual interventions in August 1995, with the mentioned exception of September and November 2000, while Japanese authorities intensified actual interventions in 2003 and early 2004 (Table 1).

[4] The European Central Bank is the exception, as it has acknowledged the dates of its interventions in September and November 2000, but has not made public the amounts of intervention. In these four cases, the data on the intervention amounts used are those reported by financial market participants, or more precisely as reported by Reuters News.

Turning to *exchange rate communication*, the first issue is how to measure such communication. In principle, one would like to obtain a complete list of all statements in which policy-makers express a view about the domestic exchange rate. Since the objective of the paper is to measure whether such communication is successful in moving foreign exchange markets in the intended way, one should look in particular at all those statements that become available to market participants. The newswire service *Reuters News* was therefore chosen as the source from which to extract all headline statements that occurred by relevant policy-makers since 1990 because such a newswire service provider is the most likely source of information for market participants. A further challenge is that one statement may be followed by several newswire reports. The extraction of the newswire reports was therefore done so as to include only the first of these reports. In most cases, such reports are posted within minutes of a policy-maker's statement. This allows conducting the empirical analysis using a daily frequency, with all exchange rate quotes used throughout the paper at 18.00 US Eastern Standard Time (EST).

A second issue who the relevant policy-makers are that should be included in the analysis. In the United States and in Japan, exchange rate policy is in the realm of the Treasury and the Ministry of Finance, respectively. However, officials at the Federal Reserve and the bank of Japan also occasionally make statements about the exchange rate, so that the list of policy-makers includes the Treasury Secretary, his deputy and the members of the FOMC for the United States; and the Minister of Finance and his deputy plus the Governor and two Vice Governors of the Bank of Japan for the analysis of Japan. For the United States, the great majority of statements extracted indeed comes from the Treasury officials, while relatively few come from the Federal Reserve. For instance, only seven statements were extracted for Chairman Greenspan for the entire 1990-2003 period.

By contrast, exchange rate policy in Europe has traditionally been the responsibility of the respective central banks with finance ministry officials usually providing relatively few statements on the exchange rate overall. Moreover, exchange rate communication is de facto mostly conducted by members of the ECB Governing Council (ECB Monthly Bulletin 2001, page 59). For the period since monetary union in the euro area in 1999, the 18 members of the Governing Council are included in the analysis, whereas the members of the Bundesbank Zentralbankrat are the ones included for the period 1990-1998.

Given this list of policy-makers two sets of search criteria were used to extract all statements that fulfil these criteria. The search word is the word "exchange rate" or the name of the exchange rate – e.g. US dollar for the United States. The second word is the title or the name of the relevant policy-maker. This is followed by the third and most difficult step, which is to classify the content of the statements. The analysis of the content of language is often referred to as content analysis (e.g. Holsti 1969, Kassarjian 1977). The objective is to provide a systematic classification of the meaning of statements. For the purpose of this paper, one would like to know whether a statement

is supporting a stronger domestic currency, a weaker one, or whether the policy-maker is neutral, so that the classification is:

$$IO_t = \begin{cases} +1 & if\ "strengthening"\ oral\ statement \\ 0 & if\ "ambiguous"\ oral\ statement \\ -1 & if\ "weakening"\ oral\ statement \end{cases}$$

Table 2 provides some summary information for the period 1990-2003. One important part of such content analysis is to provide clear rules by which to classify the statements. In most cases it has been straightforward to classify, but in some cases it was unclear. The way we chose to approach this issue is that two people looked over the statements, and those that wee not unanimous were discarded from the analysis. The more difficult statements to classify were often those by US policy-makers that attempted to weaken the US dollar, and those by euro area policy-makers that intended to weaken the euro or Deutsche mark. As explained by Robert Rubin (Rubin and Weisberg 2003), policy-makers often tend to use very subtle and slight changes in their language to indicate a shift in policy. However, the advantage in the case of the newswire service is that a lot of the interpretation of the statements is provided by professionals who are aware of these nuances and most experienced in interpreting such changes.

Nevertheless, these points also provide some of the caveats for using such an analysis for extracting a communication database. A first caveat is that newswire reports may not reflect the true intention of the policy-maker. Moreover, a further potential drawback is that not all statements may be reported and thus that the list of statements extracted is not a complete list of all statements made. However, the objective of the present paper is to analyse the market reaction to communication; hence it seems sensible to focus only on those statement that actually become available to market participants, and again *Reuters News* is among those providers who receive the greatest attention among traders and investors.

Finally, comparing communication and actual interventions shows some marked differences across authorities over the past 15 years. In particular, the almost complete cessation of actual interventions by US and euro area authorities since 1995 is contrasted by the frequent use of actual interventions by Japanese authorities, which in particular have increased in magnitude over the years.

3 Time-Series Approach: Methodology and Evidence

I first turn to the time-series evidence for analysing the long-term effectiveness of oral and actual interventions. Do communication and actual interventions move exchange rates? And if so, does this imply that the oral and actual interventions have a long-run effect? This section addresses this

issue by analysing the contemporaneous and dynamic effects of interventions in an EGARCH framework, first for the spot exchange rate, and then by using forward-looking exchange rates based on OTC option contracts and other asset prices.

3.1 Empirical methodology and hypotheses

As the starting point, the evolution of the exchange rate (s_t) is modelled as a function of fundamentals, or more precisely as a function of agents' expectations of future fundamentals f_{t+i}:

$$s_t = (1-\theta)\sum_{i=0}^{\infty}\theta^i \; E_t(f_{t+i}\,|\,\Omega_t) \tag{1}$$

where θ is the discount factor and Ω_t the information set at time t. Oral interventions (IO_t), as classified and explained in section 2, and actual intervention (IA_t), measured as the intervention amounts in US dollars, are part of the information set Ω_t, but also other relevant fundamentals X_t are part of this set. In the empirical framework, the change in the log spot exchange rate (Δs_t) is therefore modelled as a function of the difference in interest rates between the two countries (i^*-i), both types of interventions, fundamentals and day-of-the-week effects (W_t):

$$\begin{aligned}\Delta s_t^{USD/EUR} &= \alpha + \delta\left(i_t^{US} - i_t^{EA}\right) + \sum_d \eta^d W_t^d + \sum_l \chi^l X_t^l \\ &\quad + \sum_j \left(\beta^j IA_t^j + \gamma^j IO_t^j\right) + \varepsilon_t \qquad j = US, EA\end{aligned} \tag{2}$$

which constitutes the estimation equation for the conditional mean of the US dollar – euro exchange rate, and an analogous model applies to the yen – US dollar exchange rate. For daily data, the change in the log exchange rate exhibits strong non-normality, in particular significant heteroskedasticity with $\varepsilon_t \sim (0,h_t)$, excess kurtosis and skewness. A commonly employed way to correct for this is to model the conditional second moment explicitly using some form of a GARCH (1,1) model. Here I use an EGARCH(1,1) specification of Nelson (1991) which has the advantage that no non-negativity constraints on the coefficients of the conditional second moments need to be imposed:

$$\begin{aligned}\log(h_t) &= \tau + \omega\left(\left|\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{2/\pi}\right) + \phi\,\log(h_{t-1}) + \kappa\left(\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right) \\ &\quad + \sum_j \left(\mu^j\left|IA_t^j\right| + \lambda^j\left|IO_t^j\right|\right) + \sum_d \xi^d W_t^d \qquad j = US, EA\end{aligned} \tag{3}$$

The model is estimated using a standard log likelihood function. Finally, it is worth noting that part of the literature has focused on the effects of interventions on FX market volatility using related GARCH or other frameworks.[5] The results shown below, however, are largely robust to using alternative specifications of the model.

3.2 Evidence from spot exchange rates

I now turn to the empirical results of the model based on spot exchange rates for daily data over the period 1990-2003. The parameters β and γ in the conditional mean equation (2) measure the contemporaneous effect of oral and actual interventions by the respective authorities. Table 3 presents the results for these contemporaneous effects when controlling for the macroeconomic news X_t, day-of-the-week effects W_t and the interest rate differential.[6]

The key result is that both oral interventions and actual interventions by the three authorities have a highly significant contemporaneous effect on the exchange rate on the day they occur. On average, an oral intervention moves the daily exchange rate by between 0.14% and 0.22%. By contrast, the impact of actual interventions varies substantially. An actual intervention by German authorities of USD 1 billion moved the exchange rate by about 1.1%, whereas US actual interventions only had a significant effect on the yen – US dollar exchange rate. The smallest effect of actual interventions are those by the Bank of Japan where a USD 1 billion purchase or sale moved the exchange rate by a mere 0.087%. This is very similar to the contemporaneous effect found by Ito (2002).

However, it should be stressed again at this point that US and euro area authorities basically stopped actual interventions in August 1995, whereas Japanese authorities continued and even intensified actual interventions in 2003 and early 2004, purchasing around USD 180 billion in 2003 and about USD 140 billion in the first quarter of 2004. Hence the smaller effect of Japanese interventions may merely reflect the fact that the rapid rise in financial integration and in trading volumes in FX markets require larger actual interventions to move the exchange rate by the desired magnitude. As an order of magnitude, the purchase of USD 180 billion by Japanese

[5] See for instance Bonser-Neal and Tanner (1996), Baillie and Osterberg (1997), Dominguez (2003) and Frenkel, Pierdzioch and Stadtmann (2003). Moreover, Beine, Bénassy-Quéré and Lecourt (2002) argue that a fractionally integrated GARCH (FIGARCH) model could be a more appropriate model to formulate the conditional variance. However, using a standard FIGARCH specification did not yield qualitatively different results from the EGARCH(1,1) model employed here.

[6] The results for these control variables are not shown in Table 3 for reasons of brevity. A detailed discussion of macroeconomic news and calendar effects for exchange rates can be found e.g. in Andersen, Bollerslev, Diebold and Vega (2003).

authorities in 2003, and given a point estimate of 0.087, implies that Japanese interventions helped to weaken the yen by more than 15% on a cumulative basis.

A potentially important caveat to all estimations about the effect of interventions in the literature is that interventions may inherently be endogenous, i.e. they may not only alter current and future exchange rate movements, but they may react to past exchange rate movements or trends. Kearns and Rigobon (2004) suggest a methodology for correcting for such an endogeneity bias by modelling directly the potential behaviour and reaction of central banks on the days when they conduct interventions. However, it is not clear to what extent and over what horizons policy-makers react to past exchange rate developments.

More importantly, if endogeneity was a significant issue for the estimation of the impact of oral and actual interventions, it most likely induces a *downward* bias of the empirical estimates. The reason is that there is a broad consensus in the literature (see e.g. Sarno and Taylor 2001) that in particular actual interventions tend to be of the leaning-against-the-wind type. This implies that if endogeneity really constituted a bias, it would be a downward bias, and the true effect of communication and actual interventions may even be somewhat larger. The same argument applies to cases when oral or actual interventions are anticipated and hence the impact of the interventions may at least in part occur *before* the intervention event takes place.

Given the contemporaneous effect shown in Table 3, the central question is how permanent and long lasting this effect is. One way of analysing the permanence of the effect is to formulate the mean equation in a dynamic context so as to test whether oral and actual interventions have a lagged effect on future exchange rate movements:

$$\begin{aligned} \Delta s_t^{USD/EUR} &= \alpha + \delta\left(i_t^{US} - i_t^{EA}\right) + \sum_d \eta^d W_t^d + \sum_l \chi^l X_t^l \\ &+ \sum_{k=0}^{T} \sum_j \left(\beta_k^j IA_{t-k}^j + \gamma_k^j IO_{t-k}^j\right) + \varepsilon_t \qquad j = US, EA \end{aligned} \tag{4}$$

which is identical to the model of equation (2), only that now it is tested whether interventions have a significant effect on the exchange rate up to an order of T=40 days. I then estimate the cumulated impulse responses, i.e. whether there are dynamic, lagged effects of interventions on the exchange rate:

$$H_0: \sum_k \beta_k = 0 \quad , \quad \sum_k \gamma_k = 0$$

Figures 2 and 3 show the responses of the US dollar – euro and the yen – US dollar exchange rates to different types of interventions, starting from their contemporaneous response and up to 40

lags, and their 90% confidence bands. Two key results stand out from the cumulated impulse responses. First, for several interventions the point estimate of the effect remains relatively stable and changes little over time. In other words, the largest effect of interventions on exchange rates is the contemporaneous one, while exchange rates seem to be unaffected by interventions thereafter. This suggests that markets are indeed efficient in incorporating the information from interventions into prices on the day interventions occur. Moreover, the effects of interventions on exchange rates appear *economically* meaningful, as discussed above for Table 3.

The second key result is that *statistically* the effect of interventions becomes insignificant after a few days, usually after two to three days, in those cases where the contemporaneous effect is significant. This does not seem surprising as many different pieces of news affect exchange rates every day, so that interventions clearly cannot be said to be dominant but are only one source of important factors driving exchange rates.

An alternative way of testing the duration of the effects of oral and actual interventions on exchange rates is to use different time windows for the model (2)-(3), i.e. to use 2-day returns, 3-day returns etc. for the change in the log spot exchange rate (Δs_t). The results, however, are qualitatively very similar to those using cumulated impulse responses, and are not shown here for reasons of brevity.

To allow for a comparison with other factors driving exchange rates, Figure 4 shows the cumulated impulse responses for two of the most important macroeconomic news, the US non-farm payroll employment releases and the Ifo business confidence indicator for the euro area.[7] The same pattern as for the intervention variables is also present for these macroeconomic news, i.e. while they have a statistically significant contemporaneous effect on exchange rates, the significance disappears beyond a few days after their release.

In summary, the evidence based on time-series analysis suggests the presence of a significant contemporaneous effect of both oral interventions and actual interventions on exchange rates. However, statistically this effect becomes insignificant after a few days. This does not necessarily imply that interventions do not have a permanent, long-run effect, but merely that other pieces of news occurring in the days after interventions do not allow measuring empirically the permanent effect precisely.

[7] Andersen, Bollerslev, Diebold and Vega (2003) and Ehrmann and Fratzscher (2005) test for the impact of a broad set of US and European macroeconomic news on exchange rates, also showing that these two are particularly important news, among others.

3.3 Evidence from forward rates and OTC option contracts

Clearly, the problem of obtaining the true permanent or long-run effect of oral and actual interventions of equation (2) is that other pieces of news that occur in the days after an intervention introduce "noise" that render the point estimates statistically insignificant after a few days. An alternative way of approaching the question of the long-run effectiveness of interventions is to look at purely forward-looking asset prices. This section analyses the effect of oral and actual interventions on over-the-counter (OTC) option contracts, where these contracts range from 1 day to 1 year in their horizon. Thus the effect of communication and of actual interventions on such contracts over various horizons provides an indirect measure of their long-term effectiveness.

In more detail, the option contracts for the US dollar – euro and the yen – US dollar options come from Citigroup, who is one of the largest players in these OTC markets. Moreover, OTC currency markets are substantially larger, with a substantially higher trading volume than that of exchange traded option contracts. An additional advantage of the OTC contracts comes from the fact that their daily quotes are based on fixed moneyness, i.e. the distance between the strike price of the option and the corresponding forward rate. By contrast, quotes from exchange traded options are usually based on the distance between fixed strike prices and time-varying forward contracts so that the time horizon of the quotes varies.

Finally, this section looks at different types of OTC contracts. In addition to forward rates, the OTC contracts analysed are implied volatilities, risk reversals and strangles. In contrast to the backward-looking volatility measure obtained from conditional variance equation (3) of the EGARCH model, the implied volatility is a purely forward-looking measure that reflects the degree of uncertainty among market participants about the exchange rate outlook. Risk reversals and strangles are contracts that combine different types of options. A risk reversal is a simultaneous sale of an out-of-the-money put option and purchase of an out-of-the-money call option. It provides a positioning indicator about market expectations about the future direction of the exchange rate. As an example, a positive price of a US dollar – euro risk reversal contract indicates that markets are long in euro and thus put a larger probability on a euro appreciation. By contrast, a strangle is a contract that combines the simultaneous purchase of an out-of-the-money call option and an out-of-the-money put option. It provides a proxy for expectations about large future exchange rate movements.[8]

In short, these option contracts provide different and mutually complementary information about how communication and actual interventions may affect expectations of exchange rate movements

[8] Galati and Melick (2002) provide a detailed discussion of the OTC market and also offer an empirical analysis of the effect of actual interventions on exchange rates. Castrén (2004) uses OTC options data to analyse the effect of Japanese actual interventions on the different moments of the derived risk neutral densities of the contracts.

and underlying risks over the medium- to long-run. As a starting point, Figures 5 and 6 show the response of forward contracts with horizons ranging from 1 day to 1 year to oral interventions and actual interventions in the US dollar – euro market (Figure 5) and the yen – US dollar market (Figure 6). In all cases do the forward rates of contracts with shorter maturities react more strongly to oral and actual interventions than those with longer maturities. A key finding of the analysis is that forward rates of up to and including 6 months react statistically significantly to communication for US and euro area authorities. By contrast, actual interventions affect forward rates only at most 1 month for the yen – US dollar exchange rate, and even only 1 week for the US dollar – euro exchange rate.

Overall, a first key finding therefore is that communication affects forward rates over a longer horizon than actual interventions. The finding thus may be interpreted as evidence in favour of the long-term, or at least medium-term effectiveness of exchange rate communication. However, as a caveat it should be stressed that actual interventions tend to lean against the exchange rate trend relatively more often than exchange rate communication. Hence at least part of this difference may be explained by these differences in environment under which oral and actual interventions take place.

The next step of the analysis focuses on the different option contracts – implied volatility, risk reversal and strangle – as outlined above. Table 4 shows the results for both types of interventions and for both the US dollar – euro and the yen – US dollar exchange rates. The central finding is that communication tends to *reduce* implied volatility in most cases whereas actual interventions *raise* implied volatility. This implies that communication tends to lower market uncertainty, whereas actual interventions increase it. This finding is consistent with the finding of Table 3 on historical volatility from the EGARCH model. It underlines a fundamental difference between communication versus actual interventions.

One possible explanation for this finding may arise from the very different ways official statements about the exchange rate and actual interventions are made. On the one hand, communication is available to all market participants in the same way and the great majority of market participants may interpret a statement in the same way. Hence exchange rate communication that is considered to offer relevant information tends to reduce the heterogeneity of beliefs among market participants and thus lowers market volatility. On the other hand, actual interventions are mostly conducted in secret without policy-makers announcing that such

interventions have taken place. Although many market participants may have an indication that an actual intervention by a central bank has occurred, views about the scale, frequency and likelihood of future interventions may differ widely across market participants. Hence one may indeed expect such actual interventions to raise the degree of market uncertainty.

Finally, Table 5 shows the response of other asset prices – equity returns, short-term and long-term interest rates – to communication and actual interventions. While there is some modest reaction of equity markets to US oral and actual interventions, neither short-term nor long-term interest rates respond significantly to either communication or actual interventions. One interpretation of this finding is that market participants do not see either communication or actual intervention to provide a signal for future monetary policy decisions so that interest rates remain broadly unchanged.

4. Event-Study Approach: Methodology

As to the alternative methodology, I now turn to the event-study approach. The rationale for taking an event-study approach to the analysis of interventions is the fact that both communication and actual interventions tend to occur in clusters, i.e. in certain periods several interventions take place within a few days while there are no interventions over other, extended periods of time (e.g. MacKinlay 1997). The reasons for why monetary authorities conduct interventions in such clusters may be manifold, but one of the possible reasons is that authorities may decide to continue conducting interventions until they have achieved a certain objective or they have realised that the efforts are in vain. Whatever the precise reason for the duration and magnitude of the interventions, the key premise of the event-study approach is to treat each cluster of interventions as a separate event and to test their effectiveness.

Fatum and Hutchison (2003) and Humpage (1999) use similar approaches to analyse interventions in the DEM-USD market in the period 1985-1995 and in 1987-1990, respectively. Based on various criteria to measure the effectiveness or "success" of actual interventions but using different empirical methodologies to test for effectiveness, the two studies find quite different results. The study by Fatum and Hutchison shows that intervention events helped move the exchange rate in the desired direction in the great majority of the cases. For instance, even 15 days after the end of intervention events the DEM-USD exchange rate had moved in the intended direction in as many as two thirds of the cases. The results for the shorter time sample by Humpage, however, finds much less evidence in favour of effectiveness of interventions, though the study analyses only the contemporaneous reaction of the exchange rate.

4.1 Defining an event

A first important issue is to define the length of the event window, i.e. the maximum number of days that can lie between two interventions so that these two are still to be considered as part of the same event. On the one hand, the longer this time window is chosen, the more interventions will be clustered and defined to be part of the same event, but for a given number of interventions taking a longer window also reduces the overall number of events that can be analysed. The danger of taking a very long window is that it may put together interventions that belong to different intervention episodes or may even have pursued different objectives.

On the other hand, the shorter the time window the more events are obtained, but at the danger of separating interventions into different events that were part of the same effort by monetary authorities. Moreover, a further disadvantage of choosing a shorter time window is that it does not allow an analysis for a long pre-event period and post-event period in isolation from other events.

The chosen time window is 10 days, which implies that an intervention or a set of interventions is defined as an event if there is no other intervention in the 10 days before the first and no other intervention during the 10 days after the last intervention of the event. Other event windows were also tested in order to check for the robustness of the results. Using a window definition based on as few as 5 days and as many as one month shows very similar results to the ones presented below.

Tables 6-9 show summary statistics for the events obtained from this event definition. For Table 6, 86 events of oral interventions by US and euro area authorities in the US dollar – euro market are identified for the period 1990-2003. They are fairly evenly spaced over these 14 years, although there are periods when oral interventions are much more intense than in other periods. The "event type" in the table indicates whether the majority of the oral interventions in the respective event intended to strengthen the US dollar (+1) or weaken the US dollar vis-à-vis the euro (-1). The final three columns in the table show the exchange rate movement during the 5 days before the respective event, during the event, and during the 5 days after the event. Table 7 presents the list of 95 events and summary statistics for Japanese and US oral interventions in the yen – US dollar market.

Tables 8 and 9 show the event definitions and summary statistics for actual interventions in the two FX markets. For US and euro area interventions, there are merely 22 events since 1990. Table 8 clearly shows that actual interventions by US and euro area authorities basically stopped in August 1995. After this date, actual interventions in the US dollar – euro market occurred only on 22 September 2000 with a coordinated intervention of the ECB, the Federal Reserve and the Bank

of Japan, and a unilateral intervention by the ECB in early November 2000. Moreover, with the exception of a substantial number of interventions in late 1990 and early 1991, most intervention events comprised one or two isolated intervention days.

By contrast, Table 9 shows that with 45 actual intervention episodes there have been far more interventions in the yen – US dollar market since 1990. 1992-93 and 2003 were periods with particularly heavy actual intervention activity in this market. The table also reveals the distinct changes in the direction of intervention: interventions in 1990-92 and in late 1997-early 1998 were exclusively those in which selling US dollar intended to strengthen the yen. In all other periods interventions aimed at weakening the yen vis-à-vis the US dollar, and in almost all intervention events after 1995 interventions were undertaken unilaterally by the Japanese authorities.

Finally, comparing the events of oral interventions with the corresponding events for actual interventions reveals a high degree of consistency between these two types of events. In other words, most periods were characterised by oral interventions that were in line with those conducted through actual interventions. However, in some periods the two may deviate, which when checking in more detail proved to be periods when the objectives and interventions of the respective two monetary authorities were not always in line with one another. Nevertheless, overall both have been consistent for most of the time since 1990.

4.2 Defining the "success" of an event

The central question is: what constitutes a "successful" event? The definition adopted here is that a "successful" intervention event is one in which the intervention *moves the exchange rate in the desired direction* on the day of the intervention and possibly also in subsequent days. However, a number of important caveats should be stressed. First, in principle a successful event should be one that achieves the *objective* of the policy-maker that undertakes it. However, objectives may be manifold and cannot be observed directly. For instance, it has been conjectured that the objective of several episodes of intervention after the Louvre Accord in 1987 was not necessarily to weaken the US dollar further, but merely to stabilise and to reduce uncertainty and volatility in the markets (e.g. Edison 1993). Nevertheless, it may be fair to assume that many intervention episodes since 1990 had an objective also in terms of the level of the exchange rate and thus the adopted definition of "success" here seems to be the most appropriate one.

A second caveat is that assessing whether an intervention episode succeeded in moving the exchange rate in the desired direction requires knowing *what the counterfactual is*, i.e. what would have happened to the exchange rate if no interventions had taken place. On the one hand, the efficient market hypothesis implies that expected exchange rate movements, in particular for daily frequency, follow a random walk, i.e. the null hypothesis of the expected exchange rate change being zero cannot be rejected. On the other hand, exchange rates tend to follow trends,

which implies that there is a positive relationship of exchange rate changes in particular at daily frequency, although statistically it cannot be rejected that exchange rate changes are white noise.

4.3 Measuring the "success" of an event

The event-study approach in essence reduces the dimensionality of the exchange rate evolution into a discrete variable of whether or not an intervention even moved the exchange rate in the desired way. For measuring the "success" of events, this sub-section follows an approach as outlined in MacKinlay (1997) for event-study approaches in general, and builds also on the work by Humpage (1999) and by Fatum and Hutchison (2003) on actual interventions in the DEM – USD market.

Four alternative and partly complementary criteria are used to evaluate the success of intervention events. The precise definitions of the four success criteria are shown in the table below, indicating the exchange rates changes Δs before ("pre"), after ("post") and during the event ("eve") and the event type or objective of the intervention event (*I*), with *I<0* indicating an attempt to weaken the domestic currency and *I>0* to strengthen it.

Success criteria of event-study approach

	Definition of "success":
"event" criterion:	$\left(\Delta s^{eve} > 0\,,\, I > 0\right) or \left(\Delta s^{eve} < 0\,,\, I < 0\right)$
"direction" criterion:	$\left(\Delta s^{post} > 0\,,\, I > 0\right) or \left(\Delta s^{post} < 0\,,\, I < 0\right)$
"reversal" criterion:	$\left(\Delta s^{post} > 0\,,\, I > 0 \; iff \; \Delta s^{pre} < 0\right) or \left(\Delta s^{post} < 0\,,\, I < 0 \; iff \; \Delta s^{pre} > 0\right)$
"smoothing" criterion:	$\left(\Delta s^{post} > \Delta s^{pre}\,,\, I > 0 \; iff \; \Delta s^{pre} < 0\right) or \left(\Delta s^{post} < \Delta s^{pre}\,,\, I < 0 \; iff \; \Delta s^{pre} > 0\right)$

First, the "event" criterion tests whether the direction of the exchange rate change during the event is consistent with the interventions themselves, i.e. whether an intervention to e.g. strengthen the US dollar indeed leads to such a change during the event. Second, the "direction" criterion tests whether the exchange rate movement over the post-event window is in the desired direction.

As discussed earlier on, many interventions are of the "leaning-against-the-wind" type, i.e. they try to reverse or at least to smooth the pre-event exchange rate movements. The third and fourth criteria are therefore defined only for these types of interventions. The third criteria is the

"reversal" criterion that tests whether the intervention event succeeds in appreciating the currency after the event if it was depreciating before, or in depreciating the exchange rate when it was appreciating prior to the event. Fourth, the "smoothing" criterion is less demanding in its definition of "success" by investigating merely whether intervention events manage to reduce or smooth the strength of the pre-event exchange rate movements.

Under the condition that the exchange rate change is never exactly zero – which holds for all the different event-study windows – the sign test is used to test whether the number of "successes" (n_+) is larger than 50%, or equivalently larger than the number of "failures" (n_-), with the null hypothesis as $n_+ \sim binomial\ (n,\ p = 0.5)$, and with n as the total number of events. A key point to stress is that each of the success criteria makes an implicit assumption about the underlying counter-factual. The first three criteria take a change of zero as counter-factual, and indeed the unconditional probability in the data, when excluding periods of interventions, of observing a positive change in the exchange rate is 50.4% and the mean daily exchange rate change at 0.0030%. However, the issue is different for the "smoothing" criterion as the unconditional probability of observing a change in the daily exchange rate that is consistent with this criterion is 75%. Hence the null for the "smoothing" criterion is $n_+ \sim binomial\ (n,\ p = 0.75)$.

5. Event-Study Approach: Empirical Results

I now turn to the empirical results for communication and for actual interventions for the different success criteria. The first part of this section presents the benchmark results, while section 5.2 discusses robustness tests and extensions. The final sub-section then analyses the determinants of the success of interventions events.

5.1 Benchmark results

The first set of columns of Table 10 presents the results for the different success criteria for the combined US and euro oral interventions and actual interventions in the US dollar – euro market while the second set of columns shows the corresponding results for the yen – US dollar market. The first columns indicate the percentage of successes in all events for each of the success criteria, the second column the corresponding p-values, and the third column the mean difference in the exchange rate change under the different criteria. The pre- and post-event windows in the benchmark specification are chosen to be five days, although section 5.2 also shows the sensitivity of event "successes" to different pre- and post-window lengths.

Overall, there is overwhelming evidence that both oral intervention events as well as actual intervention events have been successful. Turning first to *oral* interventions in the US dollar – euro market, 75% of the events succeeded in moving the exchange rate in the desired direction during the event ("event" criterion) and still almost two thirds of the events managed in doing so after the event ("direction" criterion). Both of these success criteria are statistically significantly higher than p=50% at the 99% significance level. The success rate of the "reversal" criterion is somewhat lower at around 63%, although it is still statistically significantly at the 95% level. The highest rate of "success" is obtained by the "smoothing" criterion where 88% of the events managed to at least reduce the exchange rate movement in the five-day pre-event period. Finally, the results for oral interventions in the yen – US dollar market are very similar, with the only exception that the success rate based on the "event" criterion fares worse.

The success of *actual* interventions is mostly comparable to that of oral interventions although there are also some remarkable differences. Most strikingly, and maybe surprisingly, the success rate of actual interventions during intervention events is less than 50%, i.e. they more often fail to move the exchange rate in the desired direction during the event as compared to after the event. There are several possible explanations for this. One may be related to the fact that actual interventions are usually conducted in secret and hence may take some days to be fully priced into the market. Moreover, this finding may provide support for the argument that interventions should be analysed as events and not individually in isolation, i.e. intervention events may stop only when policy-makers have achieved their objective, thus explaining why the post-event success rate is substantially higher than the event success rate for both the US dollar – euro and the yen – US dollar markets.

In summary, the evidence suggests that both oral interventions and actual interventions by G3 authorities have been very effective in achieving their desired objectives. Oral interventions appear to be more successful during the events, while actual interventions have a somewhat higher success rate than oral interventions when they are of the "leaning-against-the-wind" type and attempt to reverse the previous exchange rate trend.

5.2 Extensions and robustness tests

As the next step, various extensions and robustness checks are conducted. A first important issue is how robust the results are to changing the length of the pre- and post-event time window. Figure 7 shows the evolution of the direction, reversal and smoothing criteria for pre- and post-event windows ranging from 1 to 40 days and for the oral interventions in the US dollar – euro market. The solid lines indicate the success rate of the different criteria and the dotted lines the corresponding p-values. Figure 8 presents the same analysis for actual interventions in the yen – US dollar market.

The key finding of this analysis is that the success rate remains relatively stable and falls only moderately when extending the time window. The p-values reveal that intervention events are statistically successful at the 90% level for all time windows from 1 to 40 days, while only the reversal criterion of the oral interventions in Figure 7 becomes insignificantly different from 50% between 15 and 30 days. Similar results apply to Figure 8 for US and Japanese actual interventions, although such actual interventions are statistically effective in inducing a reversal of the exchange rate only up to around 30 days.

It should be stressed that a potential problem with such an analysis of up to 40 days after each event is that it may overlap with future intervention events as the definition of the event window requires only that there are no interventions of 10 days or more to separate two events. However, as Tables 6-9 show, most events using this definition nevertheless have at least one month of no interventions in between so that this problem is minor. Moreover, using different even-window definitions of up to 40 days yields a smaller number of events but essentially very similar results to the ones presented in Tables 10-14 and Figures 7-8.

Second, are there differences in the *type* of interventions, i.e. are interventions that go against the prevalent policy mantra, more effective than those that merely re-state the usual policy position? As discussed in section 2, US and euro area authorities have traditionally pursued a policy supporting a strong domestic currency although there have been periods when this was not the case. Table 11 shows that oral interventions are indeed substantially more effective if they aim at weakening the domestic currency as compared to when they try to strengthen it. In some cases this difference is substantial. For example, oral interventions aiming at a stronger domestic currency have only a slightly higher success ratio than 50% in reversing the exchange rate trend, whereas oral interventions against the mantra by US and euro area authorities have success ratios of reversal of 70.4% and 77.8%, respectively.

Third, the signalling hypothesis entails the conjecture that oral interventions may be used by authorities to signal future monetary policy changes or actual interventions. This argument is analogous to the one for actual interventions made in the literature (Mussa 1981, Lewis 1995, Kaminsky and Lewis 1996, Bonser-Neal, Roley and Sellon 1998). The signalling hypothesis therefore implies that oral interventions *alone* may have little effect on the exchange rate, but they are effective mainly because they signal and help markets anticipate future monetary policy changes or actual interventions.

Two tests are conducted to investigate the role of the signalling channel. First it is tested whether oral interventions are more effective when they coincide with or precede by 10 days or less any actual intervention events. Comparing Table 10 for all oral intervention events with Table 12 only for those that are accompanied with actual interventions reveals that the latter events are generally not more successful by US and euro area authorities for the US dollar – euro market. By contrast, oral intervention events by Japanese and US authorities in the yen – US dollar market are in some cases substantially more successful when they are accompanied by actual interventions.

This different evidence seems convincing for a number of reasons. Most importantly, it should be recalled that US and euro area authorities have basically stopped conducting actual interventions in 1995 whereas the majority of oral interventions occurred thereafter. Hence it seems convincing that oral interventions by the two authorities are unlikely to have functioned via signalling actual interventions. By contrast, Japanese authorities continued to intervene, intensifying actual interventions in 2003 and early 2004, so that it seems credible that oral interventions by Japanese policy makers may have been effective at least in part by having been understood to signal or at least raise the probability of actual interventions.

Finally, Table 13 shows the results when analysing only those interventions that have not been supported or been followed by monetary policy changes. Comparing the success ratios of these intervention events with the overall group shown in Table 10 reveals that overall oral intervention episodes are generally not less effective when they are not supported or followed by monetary policy changes. In most cases, the success ratios are little changed from those for all oral interventions presented in Table 10.

In summary, this sub-section has shown that the effectiveness of both oral and actual interventions is quite robust to altering the length of the pre- and post-event windows. In fact, the event-study methodology suggests that both types of interventions are still fairly successful even 40 days after the end of intervention events. Moreover, the evidence indicates that the effectiveness of communication on exchange rates is not related to the signalling channel, at least for US and euro area authorities, and that it is an effective policy tool in is own right. Moreover, oral interventions that deviate from the prevalent policy mantra are in many cases substantially more effective than those that merely re-affirm it.

5.3 Determinants of success

What explains why some intervention events are successful while others are not? The final part of the analysis is to test which factors explain the success of intervention events. As discussed above, one hypothesis is that intervention events are more successful if they signal future monetary policy changes. Alternatively, for instance Humpage (1999) found that interventions tend to be

more successful if they are coordinated internationally. Moreover, a further hypothesis is that oral and actual interventions tend to be more successful if they occur in periods of large uncertainty.

To test these hypotheses, I take a logit model with a logistic density function that expresses the odds of a successful event P as

$$\ln\left(\frac{P}{1-P}\right) = X_i\ \beta + \varepsilon_i \tag{5}$$

with X_i as a vector of explanatory variables, β the vector of coefficients and ε the unexplained disturbance. Rearranging (5) yields the conditional probability of success as

$$P(X_i\ \beta) = \frac{e^{X_i\beta}}{1+e^{X_i\beta}} \tag{6}$$

To obtain parameter estimates for the vector of coefficients β, it is useful to express the conditional probability in terms of the *odds ratios* of success:

$$\frac{P(X_1\ \beta)}{P(X_0\ \beta)} = e^{(X_1-X_0)\beta} \tag{7}$$

such that the odds ratio is larger than one if events are more likely to be successful if X=1 as compared to X=0. In the analysis, I express all explanatory variables as discrete variables, such that X=1 e.g. if interventions are coordinated and X=0 if they are not coordinated. In this case the odds ratio simplifies to e^{β}. Measuring X as a continuous variable, where possible, yields qualitatively very similar results to the ones presented below.

Table 14 shows the results for various explanatory factors related to exchange rates, monetary policy and coordination for all combined interventions in the US dollar – euro and the yen – US dollar markets. For oral interventions, the estimates of the odds ratios indicate that oral intervention events are more successful if they are leaning with the trend, i.e. go in the same direction as the exchange rate trend during the pre-event period. The odds ratio for oral interventions is, however, statistically significant at the 95% level only for the event criterion. The odds ratio of 1.99 implies that an oral intervention event is twice as likely to be successful if it goes in the same direction as the pre-event exchange rate trend.

Oral intervention events are also more likely to be successful if exchange rates were volatile before the event (model 2) and if they were strongly misaligned, i.e. if deviation from PPP are above average (model 3). Here the odds ratios are statistically significant for the event and the

direction criteria and lie between 2.4 and 3.2. Moreover, oral intervention events are more likely to be successful if they are coordinated, i.e. if they occur in clusters (model 6), if they are supported through actual interventions during the event (model 7) and if they coincide with supportive oral interventions by foreign monetary authorities (model 8). The success criteria for which this is the case are again the event and the direction criteria.

By contrast, oral intervention events do not seem to be more successful if they are supportive of the existing monetary policy trend or supported by monetary policy decisions during or after the events (models 4 and 5) as the odds ratios are mostly close to one and none of them is statistically significant. This result is fully consistent and supports the finding of the previous sub-section and suggests that the success of communication does not seem to be related to the signalling channel of communication with regards to monetary policy.

Turning to *actual interventions*, the results are in some regards similar and other very different to those for exchange rate communication. The results are similar in that actual intervention events tend to be more successful if they are leaning with the pre-event exchange rate trend and occur in periods of large exchange rate volatility and uncertainty. They are also more likely to be successful if they are coordinated domestically and internationally.

A key difference, however, is that actual intervention events tend to be more successful if they coincide with or are followed by monetary policy changes that are consistent with the intervention event (model 5). In those cases, actual interventions are more than four times as likely to be successful for the direction and reversal success criteria.

In summary, the evidence presented suggests that communication and actual intervention events tend to be more successful when they go in the same direction as the pre-event exchange rate trend, if they occur in periods of large volatility and uncertainty and when exchange rates are misaligned. They are also more successful if they are coordinated domestically and with communication or actual interventions of foreign authorities. However, there is no evidence that the success of communication is related to monetary policy.

6. Conclusions

Many monetary authorities have moved away from conducting actual interventions and have used communication as their primary policy instrument to influence exchange rates when deemed necessary and desirable. While the literature provides evidence that both oral interventions and actual interventions have a contemporaneous effect on exchange rates, the open question that remains is how permanent these effects are and whether monetary authorities can succeed in altering the path of the exchange rate over the medium-term.

The objective of this paper has been to address this question by comparing two alternative empirical methodologies. The evidence based on a standard time-series approach, using

cumulated impulse responses from a GARCH-type of model with daily exchange rate and intervention data, suggests that there is a strong contemporaneous effect, but that statistically this effect cannot be shown to persist for more than a few days. The paper has argued that the lack of statistical evidence may not prove that interventions have no medium- to long-term effect, but simply that the large number of news that affect foreign exchange markets every day does not allow measuring the medium- to long-term effect of interventions. In fact, evidence based on forward-looking, over-the-counter option contracts suggests that both oral and actual interventions are indeed affecting exchange rates over the medium-run.

The paper has then presented an alternative methodology, an event-study approach, to analyse the long-term effectiveness of interventions. The key premise of the event-study approach is that both oral interventions and actual interventions occur in clusters, i.e. several interventions often occur in a short time span while no interventions are made in other periods, and thus that empirically interventions should be analysed as events and not in isolation from one another. Based on four criteria and non-parametric sign tests for the "success" of interventions, the empirical findings provide strong evidence for the long-term effectiveness of both oral interventions and actual interventions by US, Japanese and euro area authorities since 1990.

The results also reveal that exchange rate communication is effective in influencing exchange rates mostly independently of actual interventions and of monetary policy. Perhaps with the exception of oral interventions by Japanese authorities, the evidence suggests that communication may exert a lasting influence on exchange rates not by signalling future monetary policy or actual interventions, what is generally referred to as the signalling channel, but rather at least in part by providing relevant information to market participants and possibly by coordinating private sector beliefs and actions, as consistent with the functioning of a coordination channel of interventions. This finding is consistent with recent work on microstructure models that emphasises the importance of dynamic effects of news and fundamentals on exchange rates.

The literature on analysing and understanding the importance of communication for asset prices, and in particular for exchange rates, is still in its infancy. However, from a policy perspective it is important to understand the role communication may play as a policy tool and what its limitations are. The objective of the paper has been to contribute towards a better understanding of this role of communication, though many open issues, in particular concerning the channels through which communication works, remain for future work.

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Appendix:

Table 1: Actual interventions, 1990-2003

	USA			Japan			euro area		
	all interventions			all interventions			all interventions		
	all	buy FX	sell FX	all	buy FX	sell FX	all	buy FX	sell FX
Magnitude of interventions (average, USD million)									
1990 - 2003	284	202	323	1554	1697	223	1591	2589	617
1990 - 1994	203	125	242	385	427	223	1709	2811	634
1995 - 1998	821	833	819	1706	1706	--	419	419	--
1999 - 2003	1500	1500	--	3192	3192	--	n/a	--	n/a
Number of intervention days									
1990 - 2003	84	27	57	278	251	27	87	43	44
1990 - 1994	74	25	49	131	104	27	79	39	40
1995 - 1998	9	1	8	59	59	0	4	4	0
1999 - 2003	1	1	0	88	88	0	4	0	4

Sources: US Federal Reserve, Bank of Japan, Bundesbank, Reuters.
Note: Amounts for the actual interventions of the ECB were not announced. The numbers used here are those reported by Reuters News, based on financial market reports.

Table 2: Exchange rate communication, 1990-2003

	USA		Japan		euro area	
	strengthen	weaken	strengthen	weaken	strengthen	weaken
Number of interventions						
1990 - 2003	125	30	66	71	77	37
1990 - 1994	18	15	34	16	13	4
1995 - 1998	31	5	16	4	3	15
1999 - 2003	76	10	16	51	61	18

Source: Reuters News, author's categorization.

Table 3: Impact effect of interventions on spot exchange rate

	cond. mean eq.[1]		cond. variance eq.[1]	
	coef.	*std.error*	coef.	*std.error*
A. US dollar - euro exchange rate				
US oral intervention IO^{US}	-0.144 **	*0.072*	-0.026 *	*0.014*
Ge/EA oral intervention $IO^{GE/EA}$	0.216 **	*0.101*	-0.031 **	*0.014*
US actual intervention IA^{US}	-0.505	*0.309*	0.044	*0.052*
Ge/EA actual intervention $IA^{GE/EA}$	1.125 ***	*0.286*	0.556 ***	*0.134*
Interest rate differential[2]	-0.002	*0.006*		
LR test[3]	8.356 ***			
B. Yen - US dollar exchange rate				
US oral intervention IO^{US}	0.143 ***	*0.067*	-0.016 *	*0.008*
Ja oral intervention IO^{JA}	-0.142 ***	*0.051*	-0.007	*0.016*
US actual intervention IA^{US}	1.150 ***	*0.390*	0.398	*0.298*
Ja actual intervention IA^{JA}	-0.087 ***	*0.012*	0.822 ***	*0.119*
Interest rate differential[2]	0.014	*0.072*		
LR test[3]	8.200 ***			

Notes: ***,**,* indicate significance at the 99%, 95%, 90% levels, respectively.
[1] Results are based on EGARCH model with controlling for macroeconomic news, as outlined in the text.
[2] Interest rate differential for US dollar - euro exchange rate is the difference of 3-month money market rates in the United States minus the one in the euro area, and correspondingly for the yen - US dollar exchange rate.
3 LR test is test whether model with intervention variables has a higher explanatory power than the model without intervention variables.

Table 4: Impact effect of interventions on forward-looking (1-month) exchange rate indicators

	forward rate		implied volatility		risk reversal		strangle	
	coef.	*std.error*	coef.	*std.error*	coef.	*std.error*	coef.	*std.error*
A. US dollar - euro exchange rate								
US oral intervention IO^{US}	-0.137 **	*0.064*	-0.235 ***	*0.098*	-1.569	*5.465*	-0.184	*0.690*
Ge/EA oral intervention $IO^{GE/EA}$	0.167 *	*0.086*	-0.606 ***	*0.198*	-2.380	*3.213*	0.529	*0.648*
US actual intervention IA^{US}	-0.291	*0.224*	0.057 ***	*0.017*	-0.985	*0.926*	0.188	*0.236*
Ge/EA actual intervention $IA^{GE/EA}$	0.691	*0.483*	0.237 ***	*0.035*	-0.466	*0.696*	0.228	*0.199*
B. Yen - US dollar exchange rate								
US oral intervention IO^{US}	0.152 *	*0.079*	-0.391 *	*0.197*	-1.110	*1.810*	0.391	*0.329*
Ja oral intervention IO^{JA}	-0.101 *	*0.054*	-0.279	*0.239*	-0.394	*0.623*	0.088	*0.236*
US actual intervention IA^{US}	0.906 **	*0.495*	0.132	*0.095*	-0.912	*0.691*	0.201	*0.611*
Ja actual intervention IA^{JA}	-0.081 **	*0.039*	0.194 **	*0.092*	-0.323 *	*0.161*	0.096	*0.364*

Notes: ***,**,* indicate significance at the 99%, 95%, 90% levels, respectively. The estimation of the model is done analogously to model (2)-(3) for spot rates. As implied volatility takes only positive values, the absolute values of the communication and actual intervention variables are used.

Table 5: Impact effect of interventions on other asset prices

	equity market		short interest rates		long interest rates	
	coef.	*std.error*	coef.	*std.error*	coef.	*std.error*
US oral intervention IO^{US}	0.219 **	*0.109*	0.008	*0.041*	0.005	*0.005*
Ge/EA oral intervention $IO^{GE/EA}$	0.119 *	*0.056*	0.013	*0.023*	-0.001	*0.006*
Ja oral intervention IO^{JA}	-0.050	*0.168*	-0.004	*0.004*	-0.002	*0.007*
US actual intervention IA^{US}	0.198 *	*0.091*	0.003	*0.002*	0.004	*0.004*
Ge/EA actual intervention $IA^{GE/EA}$	-0.094	*0.154*	0.004	*0.005*	-0.015	*0.065*
Ja actual intervention IA^{JA}	0.154	*0.091*	0.001	*0.001*	0.001	*0.001*

Notes: ***,**,* indicate significance at the 99%, 95%, 90% levels, respectively.

Table 6: Events of combined US and euro area oral interventions

end date of event	# of days in event	# of inter-ventions	event type[1]	% exchange rate change: before	during	after
18 April 1990	1	1	-1	-0.316	0.377	-0.030
02 July 1990	1	1	-1	0.680	0.527	0.679
17 October 1990	6	3	-1	1.244	0.984	0.867
09 November 1990	1	1	-1	-0.067	0.202	0.202
03 December 1990	1	1	1	0.568	-1.057	-0.366
31 December 1990	2	2	-1	0.425	2.274	0.034
14 February 1991	7	3	1	0.446	-0.707	-0.914
02 April 1991	1	1	-1	1.905	0.871	0.329
04 June 1991	2	2	1	-1.263	-0.143	-0.114
20 June 1991	2	2	-1	-1.102	1.341	-0.584
12 July 1991	1	1	-1	-1.172	2.572	2.686
18 December 1991	1	1	-1	0.241	0.255	1.125
16 January 1992	5	2	1	-3.397	-3.720	2.323
24 April 1992	1	1	-1	0.060	0.727	0.575
22 July 1992	11	3	-1	1.409	0.331	0.303
10 August 1992	1	1	-1	0.695	0.205	-0.034
30 October 1992	1	1	1	0.467	-0.130	-1.943
28 April 1993	1	1	1	-0.867	-0.032	0.095
09 June 1993	4	2	1	-0.094	-2.117	-0.288
01 July 1993	1	1	-1	-1.160	0.767	0.678
04 October 1993	8	3	-1	0.890	0.325	0.400
14 January 1994	1	1	-1	-0.965	0.074	0.074
16 May 1994	12	3	1	0.484	-0.702	-0.089
22 July 1994	23	5	1	1.131	-0.263	0.044
05 October 1994	3	3	1	-0.264	0.493	0.292
21 October 1994	2	2	1	0.066	0.169	-0.067
22 November 1994	1	1	-1	-0.584	0.071	0.199
09 March 1995	5	3	1	1.414	3.400	-1.286
17 April 1995	5	2	-1	-2.334	2.979	2.845
11 May 1995	1	1	1	-0.504	-3.073	-4.118
25 October 1995	32	6	1	0.340	5.800	0.230
07 December 1995	1	1	1	-0.713	-0.159	-0.290
22 January 1996	2	2	1	-0.190	-0.215	0.223
19 March 1996	2	2	1	-0.068	-0.047	0.136
15 April 1996	1	1	1	-0.120	-0.575	-0.345
28 June 1996	2	2	1	0.131	0.166	-0.374
23 July 1996	1	1	1	0.141	-0.342	-0.248
29 October 1996	10	2	-1	-0.714	1.986	0.517
14 November 1996	1	1	1	0.066	-0.199	-0.238
02 December 1996	2	2	1	0.000	-1.822	-1.124
27 February 1997	19	4	1	-0.165	-2.929	0.017
07 April 1997	8	3	1	0.077	-1.418	-1.726
25 April 1997	2	2	1	0.157	-0.805	-1.016
21 May 1997	5	2	1	-0.029	0.119	-1.139
24 September 1997	9	3	1	1.011	0.467	1.960
02 December 1997	1	1	-1	-0.708	0.090	0.400
21 January 1998	1	1	-1	-0.163	1.072	1.923

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23 February 1998	1	1	-1	-0.258	1.364	1.341
19 March 1998	1	1	-1	-0.438	-0.327	-0.301
14 April 1998	1	1	-1	0.000	1.238	1.289
25 May 1998	6	2	1	-0.337	1.467	-0.656
07 September 1998	1	1	1	-0.231	0.000	0.115
08 October 1998	9	2	1	-0.292	2.671	-1.241
10 November 1998	1	1	-1	-0.913	0.297	0.638
12 January 1999	7	3	1	0.000	-1.322	1.444
04 February 1999	3	3	-1	-0.493	0.284	-0.389
19 March 1999	12	4	1	-0.430	0.091	-0.583
08 April 1999	4	2	1	-0.063	-0.312	0.186
09 August 1999	68	20	1	1.261	-0.263	-0.446
29 September 1999	16	7	1	-0.245	0.621	1.510
29 October 1999	10	4	1	1.058	-3.199	0.019
07 February 2000	51	15	1	-0.343	-3.395	0.366
23 February 2000	1	1	1	1.807	0.010	-1.017
20 March 2000	1	1	1	0.051	0.093	-0.802
07 June 2000	43	9	1	-0.376	0.974	0.273
07 July 2000	1	1	1	-0.178	-0.588	-0.073
20 September 2000	13	3	1	1.442	-6.195	0.906
07 December 2000	1	1	1	1.324	-0.179	-1.189
19 February 2001	2	2	-1	-1.340	1.038	-0.443
14 June 2001	46	9	1	-0.101	-2.781	0.737
25 July 2001	1	1	1	0.506	0.790	0.510
17 August 2001	3	2	1	1.091	1.639	0.219
10 September 2001	1	1	1	1.363	-1.019	0.408
22 October 2001	8	2	-1	-0.301	-2.133	-0.984
17 December 2001	28	7	-1	-0.256	0.750	-0.061
18 February 2002	32	6	-1	-0.465	-2.908	0.378
12 March 2002	1	1	-1	0.246	0.017	0.000
11 April 2002	12	4	-1	-0.017	0.630	0.068
02 May 2002	1	1	1	0.644	-0.359	1.208
21 May 2002	1	1	-1	0.043	-0.174	0.521
29 July 2002	37	8	-1	0.841	3.631	-0.233
17 September 2002	2	2	-1	-1.009	0.243	0.852
17 January 2003	36	7	-1	0.323	7.177	0.415
05 March 2003	22	8	-1	0.162	1.670	0.091
14 April 2003	18	5	-1	-0.658	1.872	0.432
26 June 2003	42	18	1	0.856	4.182	-0.984

Notes: [1] Type of event is equal to 1 if interventions go towards strengthening the US dollar, and -1 otherwise. As discussed in detail in the text, the pre- and post-event window for exchange rate changes is 5 days.

Table 7: Events of combined US and Japanese oral interventions

end date of event	# of days in event	# of inter-ventions	event type[1]	% exchange rate change: before	during	after
23 February 1990	1	1	1	-0.815	-0.279	-1.379
19 March 1990	5	2	1	-0.817	-0.276	-1.038
18 April 1990	2	2	1	0.000	-0.183	1.740
13 July 1990	1	1	1	0.519	-0.415	-0.590
24 September 1990	1	1	1	0.619	-0.371	0.000
17 October 1990	2	2	1	1.020	1.703	1.726
18 February 1991	9	3	-1	0.809	-0.761	-0.678
15 April 1991	30	8	1	-0.539	0.814	1.268
04 June 1991	1	1	-1	-0.650	0.222	-0.097
12 July 1991	1	1	-1	-0.125	1.717	1.304
08 October 1991	9	2	-1	0.080	2.319	-0.465
11 November 1991	1	1	-1	-0.299	0.000	0.378
29 November 1991	1	1	-1	0.000	0.156	-0.039
18 December 1991	1	1	1	-0.077	0.115	0.193
21 February 1992	31	10	-1	-1.268	-2.435	-0.386
15 May 1992	16	4	-1	-0.496	3.723	1.015
12 June 1992	6	2	-1	-0.026	0.667	-0.253
22 July 1992	11	3	1	0.162	-2.085	-1.166
10 August 1992	1	1	-1	-0.026	-0.192	-0.294
01 September 1992	1	1	-1	0.222	0.098	-0.074
30 September 1992	7	3	1	0.610	3.001	-0.406
30 October 1992	6	2	1	1.150	-2.022	-0.419
02 April 1993	1	1	-1	0.792	0.080	0.171
28 April 1993	8	2	1	0.939	-0.150	0.379
01 July 1993	26	4	1	0.688	0.890	-1.285
13 August 1993	2	2	-1	1.173	1.585	1.338
23 September 1993	1	1	-1	0.405	0.233	0.329
14 January 1994	7	2	-1	-0.180	1.693	0.670
28 February 1994	1	1	1	0.431	0.188	0.147
16 May 1994	12	3	1	0.972	-3.462	0.409
22 July 1994	23	6	1	1.692	1.368	0.357
05 October 1994	5	4	1	-0.707	-0.707	-0.149
25 October 1994	3	2	1	0.214	0.358	0.272
09 November 1994	1	1	1	0.224	-0.763	-0.709
09 March 1995	5	3	1	1.684	4.864	0.439
03 May 1995	23	5	1	3.512	3.334	-0.451
19 July 1995	1	1	1	0.622	1.048	0.088
03 October 1995	8	2	1	3.777	-2.488	-0.632
05 December 1995	1	1	1	-0.162	0.121	0.000
22 January 1996	2	2	1	-0.053	-0.159	-0.253
19 March 1996	2	2	1	-0.285	-0.308	-0.339
28 June 1996	2	2	1	-0.458	-0.232	-0.371
23 July 1996	1	1	1	0.443	-0.399	-0.946
29 October 1996	1	1	-1	-0.737	-0.103	0.103
14 November 1996	1	1	-1	-0.212	0.279	0.548
20 February 1997	14	3	1	0.280	-0.855	0.933
07 April 1997	8	3	1	-0.334	-1.238	-1.591
25 April 1997	1	1	1	-0.025	-0.190	-0.656
21 May 1997	5	2	1	1.151	2.466	-3.005
18 September 1997	5	2	1	-0.357	-1.986	-1.100

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22 December 1997	15	4	-1	-0.818	-1.030	0.039
21 January 1998	11	2	-1	-0.040	4.987	1.002
23 February 1998	1	1	-1	-1.399	-0.064	-0.128
30 April 1998	31	5	-1	-0.953	-2.198	-0.808
26 May 1998	7	3	1	-0.696	-2.339	-1.141
08 July 1998	1	1	1	1.122	-0.558	-1.705
07 September 1998	7	2	1	1.556	5.754	1.218
12 October 1998	11	4	1	-0.985	14.219	-1.902
10 November 1998	1	1	-1	-2.179	-0.538	0.000
12 January 1999	2	2	1	0.089	-1.452	-3.903
03 February 1999	2	2	-1	1.129	1.903	0.011
23 March 1999	7	3	1	0.489	0.511	0.177
18 August 1999	88	24	1	1.035	4.895	2.120
29 September 1999	16	7	1	-0.813	3.385	-0.074
29 October 1999	4	3	1	0.370	1.152	0.946
04 February 2000	50	15	1	2.878	-5.305	-0.958
18 April 2000	7	3	1	-0.702	0.686	-0.366
22 May 2000	1	1	1	1.575	-0.032	0.385
07 July 2000	1	1	1	-0.396	-0.540	0.215
20 September 2000	10	2	1	-0.212	-0.696	0.342
13 October 2000	1	1	1	0.140	-0.291	-0.699
01 December 2000	1	1	1	0.712	-0.745	-0.653
16 January 2001	5	4	-1	-0.638	-0.760	-0.063
19 February 2001	2	2	-1	0.597	-0.190	0.009
20 April 2001	7	2	1	-0.256	1.912	-0.099
22 May 2001	6	3	-1	-0.867	0.431	2.174
14 June 2001	6	2	1	0.062	-0.965	-0.691
25 July 2001	1	1	1	0.201	0.443	0.348
17 August 2001	3	2	1	0.402	1.240	-0.398
10 September 2001	1	1	1	0.654	-0.758	0.200
16 October 2001	1	1	1	0.219	-0.381	-0.322
12 November 2001	1	1	1	0.461	-0.021	-0.918
21 December 2001	5	2	1	-0.994	-1.756	-0.835
31 January 2002	10	3	-1	-0.513	-1.666	-0.169
11 March 2002	1	1	1	-0.680	0.288	-0.449
11 April 2002	12	4	1	0.173	1.228	-0.932
03 June 2002	27	9	1	0.695	3.940	-0.016
10 July 2002	17	10	1	-0.080	5.378	0.819
17 September 2002	2	2	-1	-1.282	-0.354	0.733
28 October 2002	1	1	-1	0.141	0.825	0.995
19 December 2002	9	2	1	1.056	2.414	0.415
27 January 2003	10	4	1	0.332	0.353	-0.683
20 March 2003	26	8	1	-0.284	0.973	-1.151
14 April 2003	3	2	-1	-0.329	-0.228	0.179
27 June 2003	43	17	1	0.559	0.126	-1.369

Notes: [1] Type of event is equal to 1 if interventions go towards strengthening the US dollar, and -1 otherwise. As discussed in detail in the text, the pre- and post-event window for exchange rate changes is 5 days.

Table 8: Events of combined US and euro area actual interventions

end date of event	# of days in event	# of inter-ventions	event type[1]	% exchange rate change: before	during	after
04 January 1990	4	1	-1	-0.001	0.728	2.196
07 March 1990	4	4	-1	-0.988	1.089	0.177
30 May 1990	2	2	1	0.000	-0.028	-1.308
17 July 1990	21	15	1	0.787	1.972	0.504
12 February 1991	7	7	1	0.409	1.070	-1.284
27 March 1991	13	7	-1	-1.497	-8.645	-1.315
25 April 1991	3	3	-1	-1.504	0.777	-0.086
21 May 1991	3	2	-1	-0.502	-1.048	0.639
10 June 1991	1	1	-1	-1.005	0.226	-0.112
16 July 1991	13	4	-1	-0.445	-0.135	-0.251
19 August 1991	1	1	-1	-0.822	-3.262	-1.972
20 July 1992	1	1	1	1.132	-2.240	-2.082
24 August 1992	12	4	1	0.291	5.223	2.085
04 May 1994	4	2	1	0.484	0.493	-1.770
24 June 1994	1	1	1	0.137	1.199	1.358
03 November 1994	2	2	1	0.535	-1.497	-0.040
03 March 1995	2	2	1	-0.150	2.486	2.851
05 April 1995	3	2	1	2.493	0.140	0.291
31 May 1995	1	1	1	-0.864	-1.977	-1.406
15 August 1995	1	1	1	0.265	-2.778	-2.910
22 September 2000	1	1	-1	1.431	2.390	1.853
09 November 2000	5	3	-1	-0.267	0.897	0.503

Notes: [1] Type of event is equal to 1 if interventions go towards strengthening the US dollar, and -1 otherwise. As discussed in detail in the text, the pre- and post-event window for exchange rate changes is 5 days.

Table 9: Events of combined US and Japanese actual interventions

end date of event	# of days in event	# of inter-ventions	event type[1]	% exchange rate change: before	during	after
18 January 1990	12	3	-1	-0.001	-1.368	-1.345
09 April 1990	32	13	-1	-0.149	-1.182	1.266
15 March 1991	1	1	-1	-0.644	-1.574	-2.844
13 May 1991	1	1	-1	0.406	0.701	1.591
13 June 1991	4	2	-1	-1.005	-1.229	-0.222
19 August 1991	1	1	-1	-0.822	-3.262	-1.972
17 January 1992	1	1	-1	0.629	1.682	1.683
11 March 1992	18	4	-1	0.061	-2.852	0.036
01 April 1992	1	1	-1	0.030	-0.515	-0.092
30 April 1992	4	3	-1	0.727	0.032	1.098
25 June 1992	25	10	-1	-0.866	4.870	0.977
11 August 1992	13	4	-1	0.135	1.133	0.055
07 May 1993	26	17	1	1.069	0.571	-2.083
28 June 1993	24	14	1	0.037	-3.756	0.942
07 September 1993	28	18	1	-1.264	7.878	0.434
04 March 1994	14	9	1	1.466	0.430	-0.598
04 May 1994	27	16	1	-0.454	1.241	-1.770
12 July 1994	17	11	1	1.273	5.311	-0.649
03 November 1994	56	19	1	0.373	2.227	-0.040
18 April 1995	43	34	1	1.302	9.868	-0.146
31 May 1995	1	1	1	-0.864	-1.977	-1.406
07 July 1995	8	2	1	0.303	-0.431	-1.190
15 August 1995	10	3	1	0.734	-6.944	-2.910
22 September 1995	13	3	1	0.000	2.808	-0.802
27 February 1996	6	5	1	0.000	0.188	-1.113
18 November 1997	12	5	-1	-0.464	-0.194	-0.046
19 December 1997	3	3	-1	-0.270	0.299	-0.354
10 April 1998	2	2	-1	1.240	-0.510	-0.017
17 June 1998	1	1	-1	0.640	0.672	0.250
12 February 1999	1	1	1	-0.874	0.543	0.543
05 July 1999	18	4	1	0.096	-2.251	0.010
21 July 1999	2	2	1	0.981	2.317	0.999
14 September 1999	3	2	1	-0.509	-1.800	-0.125
30 November 1999	2	2	1	-0.343	-0.631	-0.158
04 January 2000	8	2	1	0.624	1.557	0.477
15 March 2000	5	2	1	0.135	0.780	0.372
03 April 2000	1	1	1	-0.498	0.115	0.680
28 September 2001	10	7	1	0.000	0.094	-0.703
04 June 2002	10	4	1	-0.174	2.176	-0.165
28 June 2002	5	3	1	0.617	2.112	0.304
29 January 2003	11	8	1	0.147	2.516	-0.069
10 March 2003	11	9	1	-0.494	2.618	0.304
26 May 2003	35	18	1	-0.433	10.509	-0.236
16 July 2003	10	9	1	-0.307	-3.462	0.421
30 September 2003	23	12	1	0.110	6.925	0.955

Notes: [1] Type of event is equal to 1 if interventions go towards strengthening the US dollar, and -1 otherwise. As discussed in detail in the text, the pre- and post-event window for exchange rate changes is 5 days.

Table 10: Success criteria of event-study approach

	combined US and euro area			combined US and Japan		
success criteria:	% success	p-value	% exchange rate change	% success	p-value	% exchange rate change
event criterion						
oral interventions	75.6%	0.002	0.577%	56.5%	0.168	0.474%
actual interventions	44.4%	0.760	0.962%	40.0%	0.923	1.146%
direction criterion						
oral interventions	65.1%	0.004	0.466%	65.2%	0.010	0.409%
actual interventions	66.7%	0.119	0.752%	77.5%	0.003	0.993%
reversal criterion						
oral interventions	62.7%	0.046	2.109%	65.9%	0.030	2.249%
actual interventions	69.2%	0.133	2.897%	81.3%	0.003	2.780%
smoothing criterion						
oral interventions	88.2%	0.001	2.109%	90.9%	0.001	2.249%
actual interventions	82.4%	0.006	2.897%	88.6%	0.002	2.780%

Notes: The success criteria are defined as in the text and are based on 5-day windows before and after the events. The p-values are obtained from a sign test of whether the number of "successes" (n_+) is larger than the number of "failures" (n_-), with the null hypothesis as $n_+ \sim$ *binomial (n, p = 0.5)* for the first three criteria and $n_+ \sim$ *binomial (n, p = 0.75)* for the smoothing criterion, and with n as the total number of events.

Table 11: Success criteria of oral interventions *by policy mantra*

US dollar - euro	US oral interventions				Euro area oral interventions			
	with mantra		against mantra		with mantra		against mantra	
success criteria:	% success	p-value	% success	p-value	% success	p-value	% success	p-value
event criterion								
oral interventions	55.6%	0.326	85.2%	0.000	76.7%	0.003	74.1%	0.010
direction criterion								
oral interventions	51.1%	0.500	70.4%	0.026	50.0%	0.572	77.8%	0.003
reversal criterion								
oral interventions	34.6%	0.962	75.0%	0.038	47.4%	0.676	83.3%	0.019
smoothing criterion								
oral interventions	80.8%	0.001	88.2%	0.001	68.4%	0.083	80.0%	0.055

Yen - US dollar	US oral interventions				Japanese oral interventions			
	with mantra		against mantra		with mantra		against mantra	
success criteria:	% success	p-value	% success	p-value	% success	p-value	% success	p-value
event criterion								
oral interventions	57.7%	0.226	59.3%	0.221	60.4%	0.140	76.0%	0.011
direction criterion								
oral interventions	57.7%	0.186	63.0%	0.124	81.4%	0.000	72.0%	0.022
reversal criterion								
oral interventions	60.0%	0.212	64.7%	0.166	76.9%	0.005	75.0%	0.073
smoothing criterion								
oral interventions	92.0%	0.001	87.5%	0.002	92.3%	0.001	91.7%	0.003

Notes: The success criteria are defined as in the text and are based on 5-day windows before and after the events. The p-values are obtained from a sign test of whether the number of "successes" (n_+) is larger than the number of "failures" (n_-), with the null hypothesis as $n_+ \sim binomial\ (n,\ p = 0.5)$ for the first three criteria and $n_+ \sim binomial\ (n,\ p = 0.75)$ for the smoothing criterion, and with n as the total number of events.

Table 12: Success criteria of oral interventions *if supported by actual interventions*

	combined US and euro area			combined US and Japan		
success criteria:	**% success**	**p-value**	**% exchange rate change**	**% success**	**p-value**	**% exchange rate change**
event criterion						
oral interventions	83.3%	0.100	0.494%	66.7%	0.076	0.729%
direction criterion						
oral interventions	66.7%	0.154	0.826%	81.1%	0.002	0.096%
reversal criterion						
oral interventions	60.0%	0.500	2.440%	76.3%	0.009	2.214%
smoothing criterion						
oral interventions	80.0%	0.004	2.440%	88.2%	0.012	2.214%

Notes: The success criteria are defined as in the text and are based on 5-day windows before and after the events. The p-values are obtained from a sign test of whether the number of "successes" (n_+) is larger than the number of "failures" (n_-), with the null hypothesis as $n_+ \sim binomial\ (n,\ p = 0.5)$ for the first three criteria and $n_+ \sim binomial\ (n,\ p = 0.75)$ for the smoothing criterion, and with n as the total number of events.

Table 13: Success criteria of oral interventions *if not supported by monetary policy*

	combined US and euro area			combined US and Japan		
success criteria:	% success	p-value	% exchange rate change	% success	p-value	% exchange rate change
event criterion						
oral interventions	74.7%	0.001	0.541%	58.1%	0.096	0.038%
direction criterion						
oral interventions	63.3%	0.015	0.441%	65.1%	0.004	0.384%
reversal criterion						
oral interventions	60.9%	0.092	2.138%	70.8%	0.003	2.174%
smoothing criterion						
oral interventions	93.3%	0.000	1.770%	88.2%	0.003	0.019%

Notes: The success criteria are defined as in the text and are based on 5-day windows before and after the events. The p-values are obtained from a sign test of whether the number of "successes" (n_+) is larger than the number of "failures" (n_-), with the null hypothesis as $n_+ \sim binomial\ (n,\ p = 0.5)$ for the first three criteria and $n_+ \sim binomial\ (n,\ p = 0.75)$ for the smoothing criterion, and with n as the total number of events.

Table 14: Determinants of success of communication and actual interventions

	exchange rate						monetary policy			
	(1) trend		(2) volatility		(3) PPP deviation		(4) direction		(5) next meeting	
odds ratios	X_1: leaning with X_0: leaning against		X_1: high X_0: low		X_1: large deviation X_0: small deviation		X_1: leaning against X_0: leaning with		X_1: change X_0: no change	
success criteria:	**coef.**	**p-value**	**coef.**	**p-value**	**coef.**	**p-value**	**coef.**	**p-value**	**coef.**	**p-value**
event criterion										
oral interventions	1.994 **	0.038	2.883 **	0.047	3.169 **	0.019	1.252	0.477	0.928	0.811
actual interventions	2.446 *	0.059	1.299	0.605	1.897	0.197	0.966	0.946	2.057	0.186
direction criterion										
oral interventions	1.450	0.389	2.445 *	0.069	2.922 **	0.022	0.980	0.948	0.830	0.544
actual interventions	2.596 *	0.052	2.503 *	0.074	1.381	0.711	1.155	0.777	4.222 **	0.010
reversal criterion										
oral interventions	--		1.294	0.530	1.526	0.449	1.246	0.594	0.846	0.680
actual interventions	--		3.599 **	0.042	1.309	0.656	1.167	0.806	4.760 **	0.017
smoothing criterion										
oral interventions	--		1.468	0.509	1.493	0.472	0.762	0.640	1.307	0.631
actual interventions	--		1.429	0.597	0.905	0.883	1.494	0.561	2.250	0.248

Notes: ***,**,* indicate significance at the 99%, 95%, 90% levels, respectively.

(1) "Leaning against" the trend means that IO or IA intends to reverse the trend of the two-week pre-event period, whereas “leaning with” attempts to strengthen the trend. As the reversal and smoothing criteria are only defined for leaning-against-the-wind events, the respective success determinants cannot be obtained for these measures.

(2) "High" means that IO or IA event occurs in periods when exchange rate volatility is high, i.e. above its median value, in the past two weeks, and "low" when the intervention takes place during periods of low volatility.

(3) "Large deviation" means that IO or IA events takes place when level of exchange rate deviates more than its period median from the PPP exchange rate; "small deviation" implies the opposite.

(4) "Leaning against" and "leaning with" mean that IO or IA events go against the direction of monetary policy, e.g. attempt to strengthen the currency in a period of monetary easing, or support the direction, respectively.

(5) "Change" means that IO or IA event coincides or is followed in the coming two weeks by changes in monetary policy rates; and “no change” accordingly.

Table 14: Determinants of success of communication and actual interventions (cont.)

	coordination					
	(6) frequency		(7) IO - IA		(8) foreign IO or IA	
odds ratios	X_1: coordination X_0: no coordination		X_1: coordination X_0: no coordination		X_1: coordination X_0: no coordination	
success criteria:	**coef.**	**p-value**	**coef.**	**p-value**	**coef.**	**p-value**
event criterion						
oral interventions	3.219 ***	0.001	2.328 **	0.048	2.002	0.188
actual interventions	4.562 **	0.016	1.662	0.427	4.122 **	0.016
direction criterion						
oral interventions	1.322	0.507	1.920	0.146	3.400 **	0.037
actual interventions	1.125	0.819	2.572 *	0.074	2.561 **	0.039
reversal criterion						
oral interventions	1.573	0.422	1.384	0.589	2.011	0.405
actual interventions	1.371	0.607	1.719	0.371	1.600	0.744
smoothing criterion						
oral interventions	1.141	0.308	1.451	0.559	2.769	0.175
actual interventions	1.656	0.478	1.575	0.503	0.585	0.709

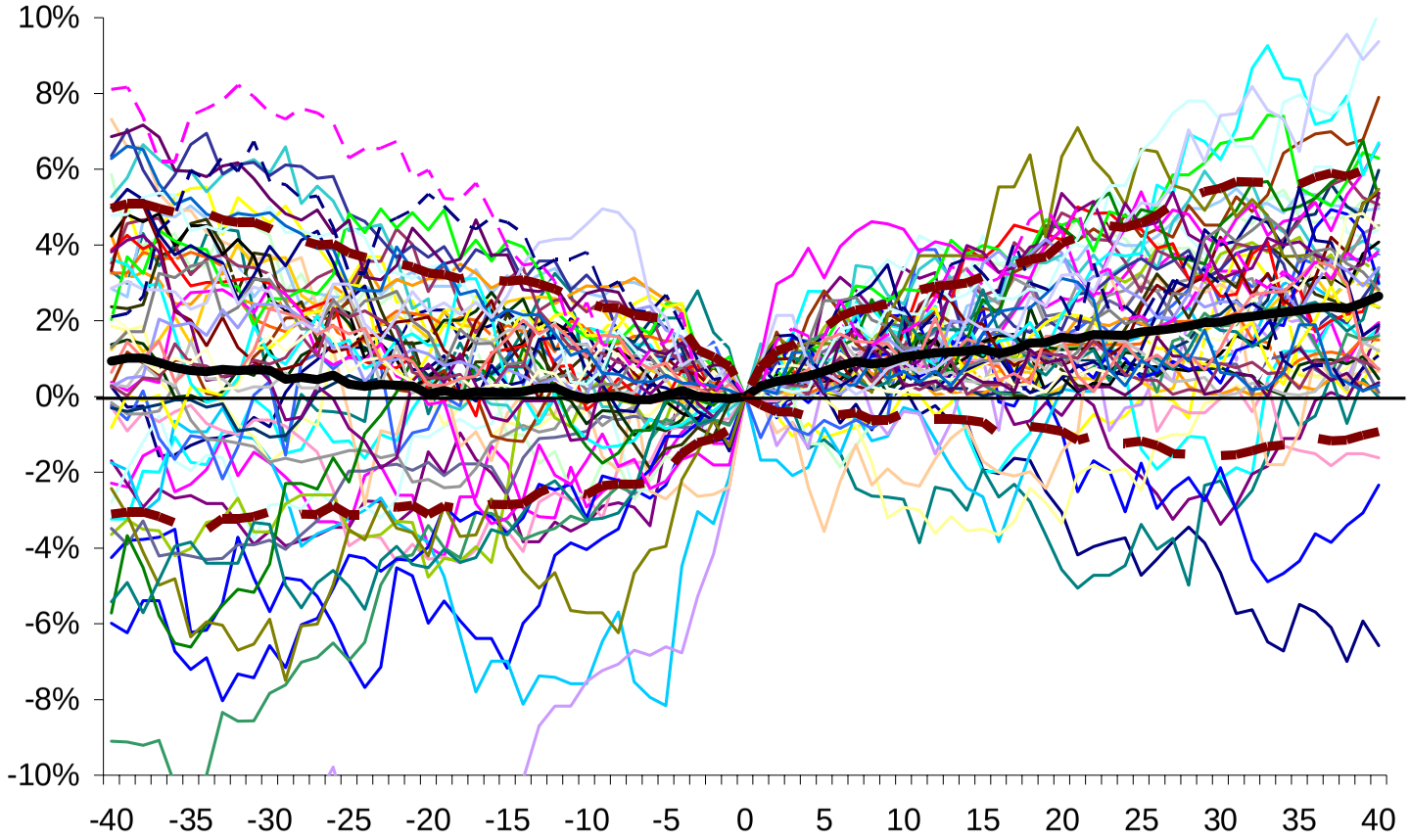
Notes: ***,**,* indicate significance at the 99%, 95%, 90% levels, respectively.

(6) "Coordination" means that intervention events comprise multiple interventions, whereas "no coordination" implies that an event only has a single oral intervention or actual intervention.

(7) "Coordination" means that, in case of an IO event, the also supporting actual interventions occur during the event, whereas "no coordination" implies that no such support takes place.

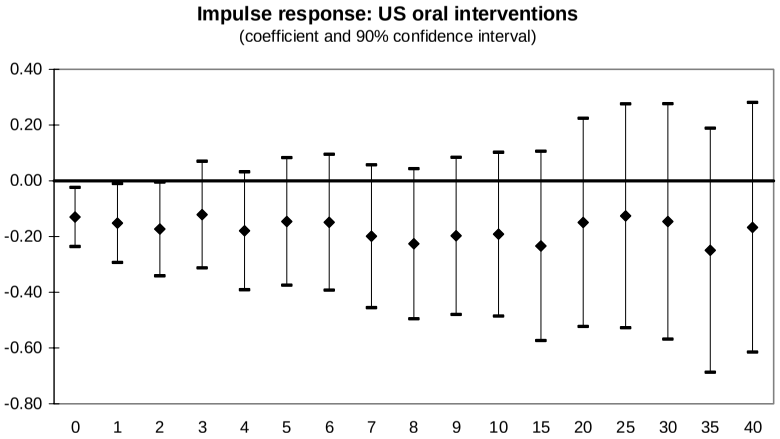
(8) "Coordination" implies that mutually supporting oral interventions take place in both countries, e.g. in Japan and in the United States, during the same event; "no coordination" means the no such coordination takes place.

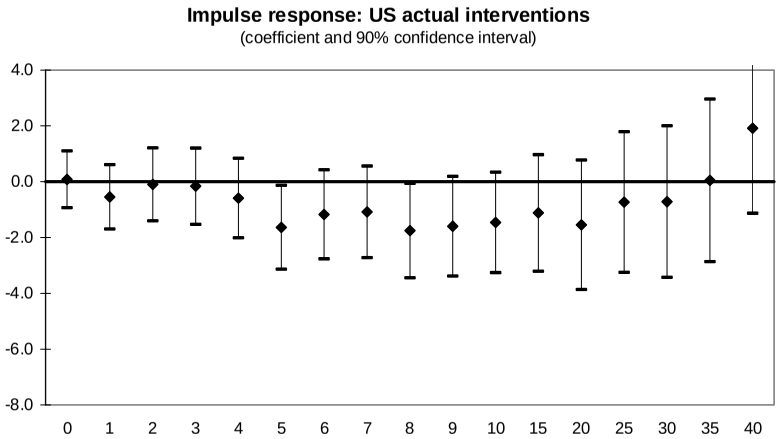
Figure 1: USD-EUR exchange rate movements around events (40 days before to 40 days after)

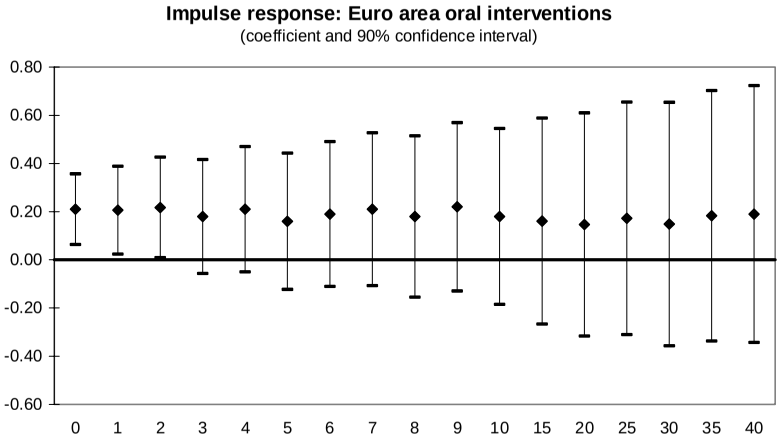


Notes: The fat, solid line shows the mean and the fat, dotted lines +/- one standard deviation of the USD-EUR exchange rate changes from 40 days before the start of the oral intervention event (combined US and euro area) till 40 days after the end of the event. Exchange rate movements have been normalised so that a "successful" intervention corresponds to an increase after the event.

Figure 2: Cumulated impulse responses of US and euro area interventions, USD-EUR exchange rate







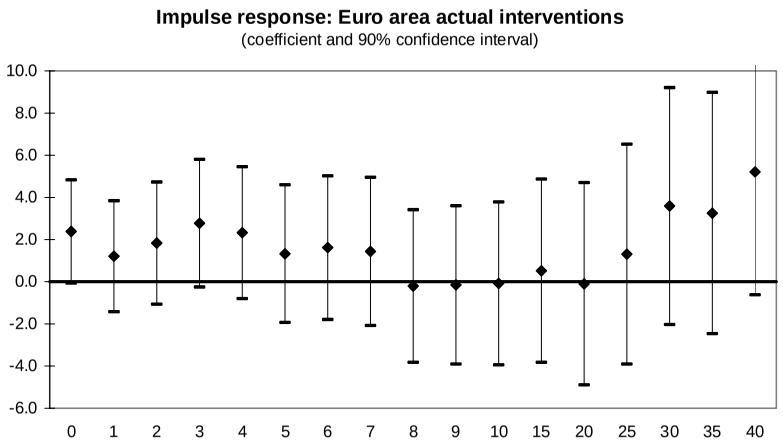


Figure 3: Cumulated impulse responses of US and Japanese interventions, YEN-USD exchange rate

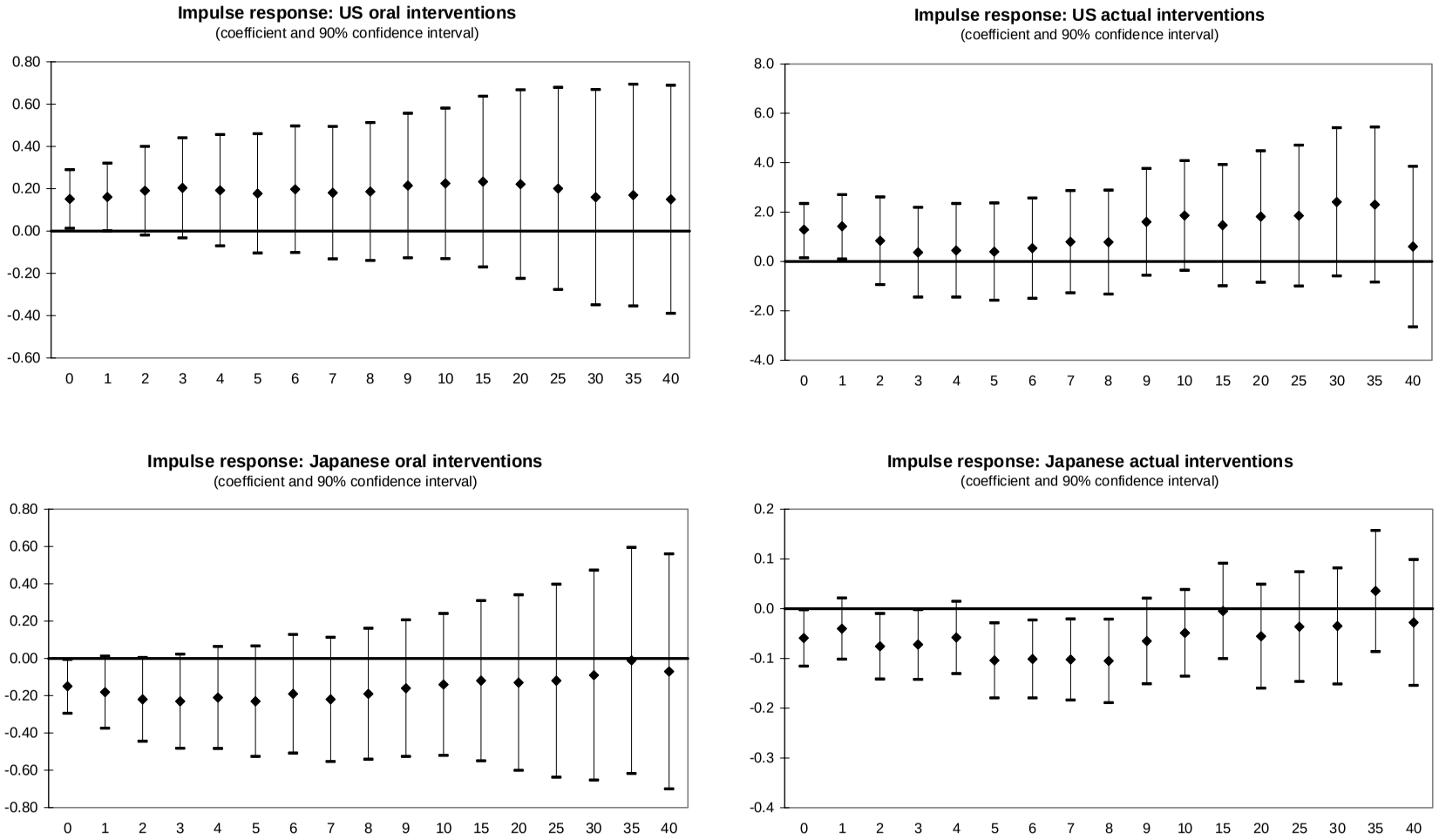
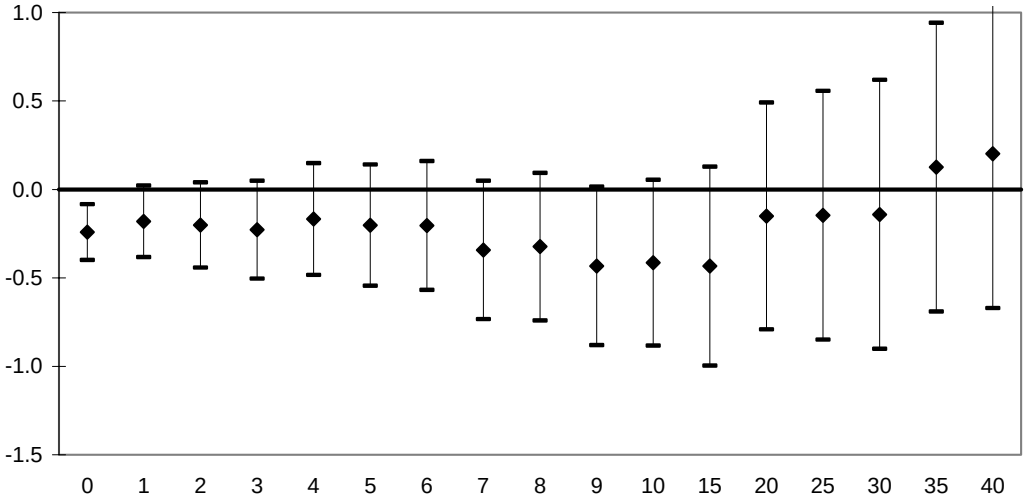


Figure 4: Cumulated impulse responses of selected macroeconomic news, USD-EUR exchange rate

Impulse response: US non-farm payroll employment
(coefficient and 90% confidence interval)



Impulse response: Euro area Ifo business confidence index
(coefficient and 90% confidence interval)

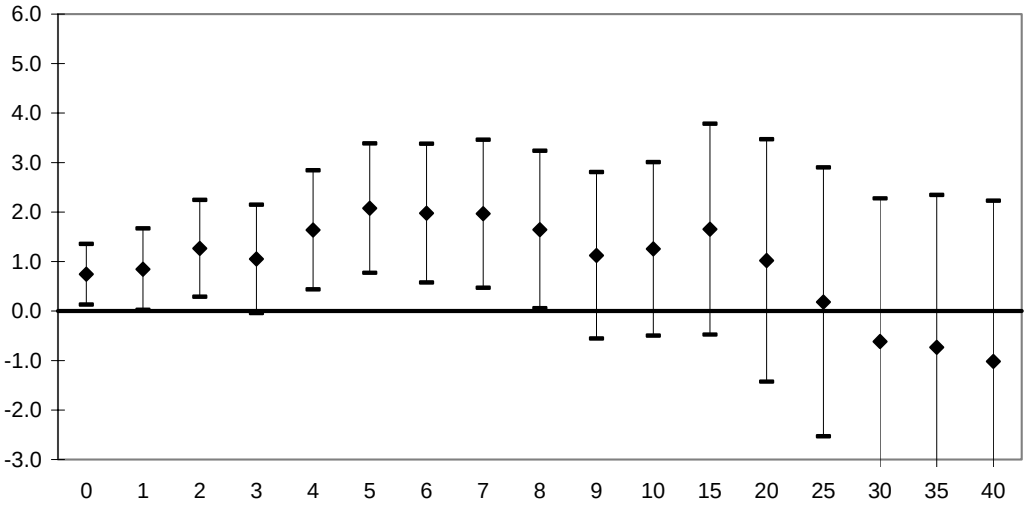


Figure 5: Effect of interventions on forward exchange rates, USD-EUR

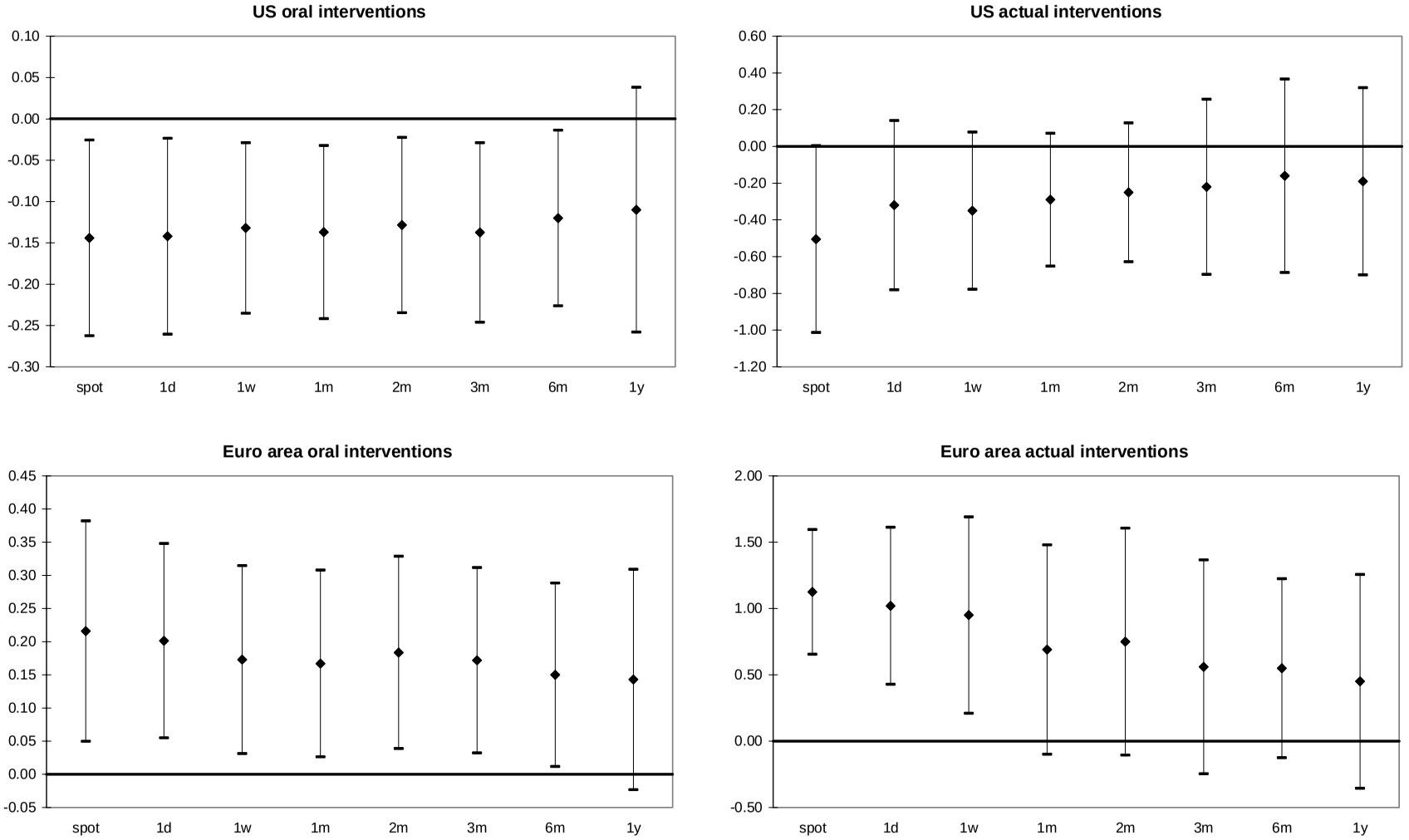
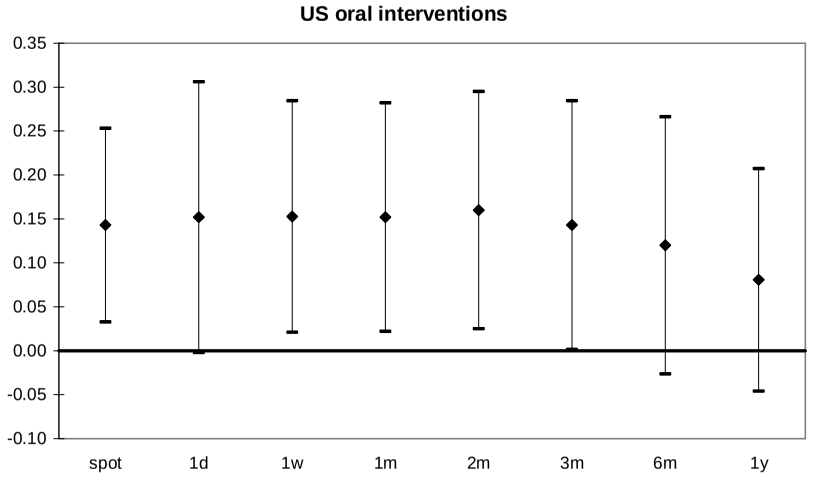
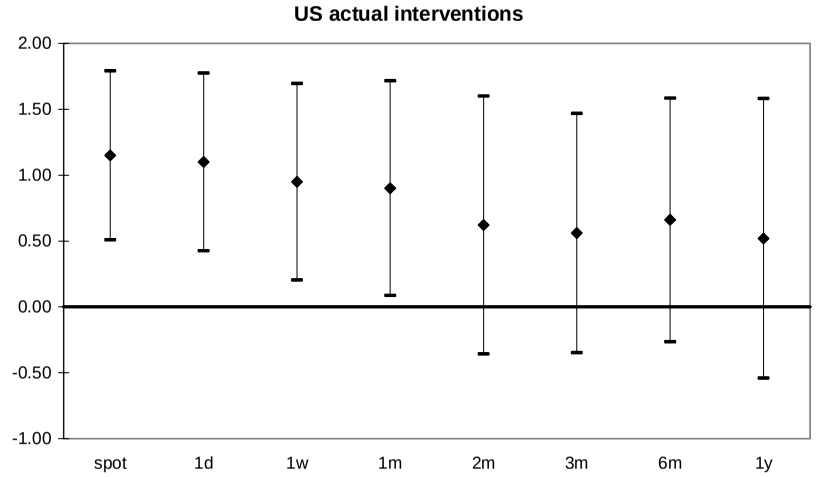
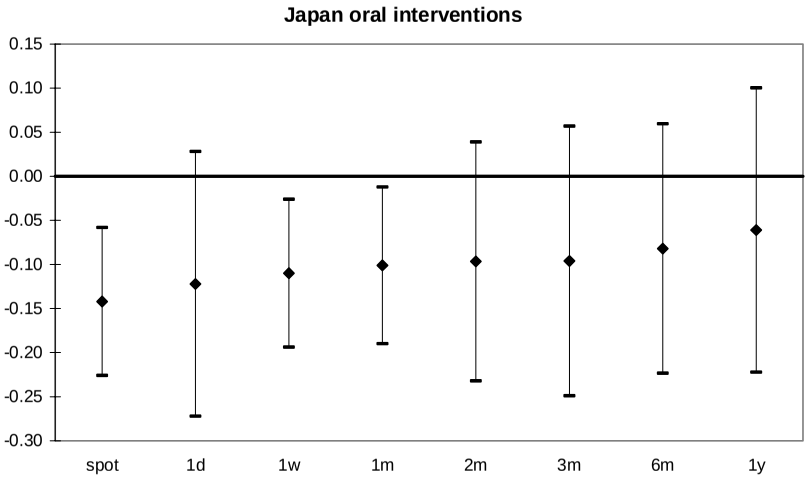


Figure 6: Effect of interventions on forward exchange rates, YEN-USD







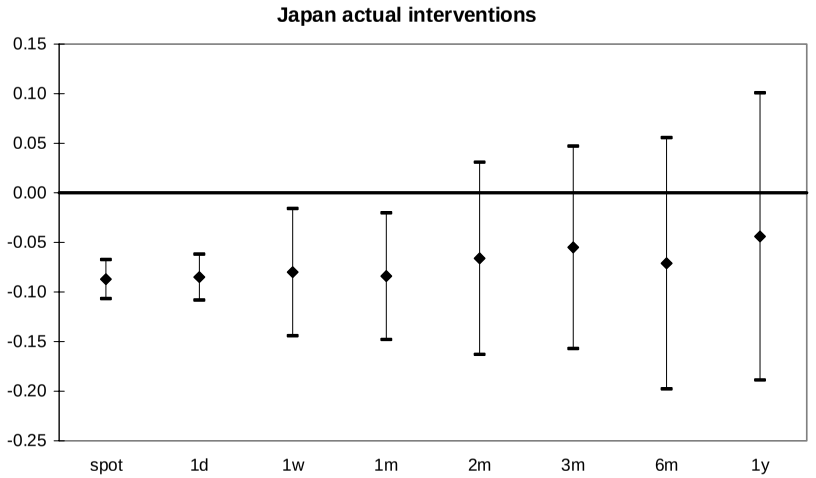
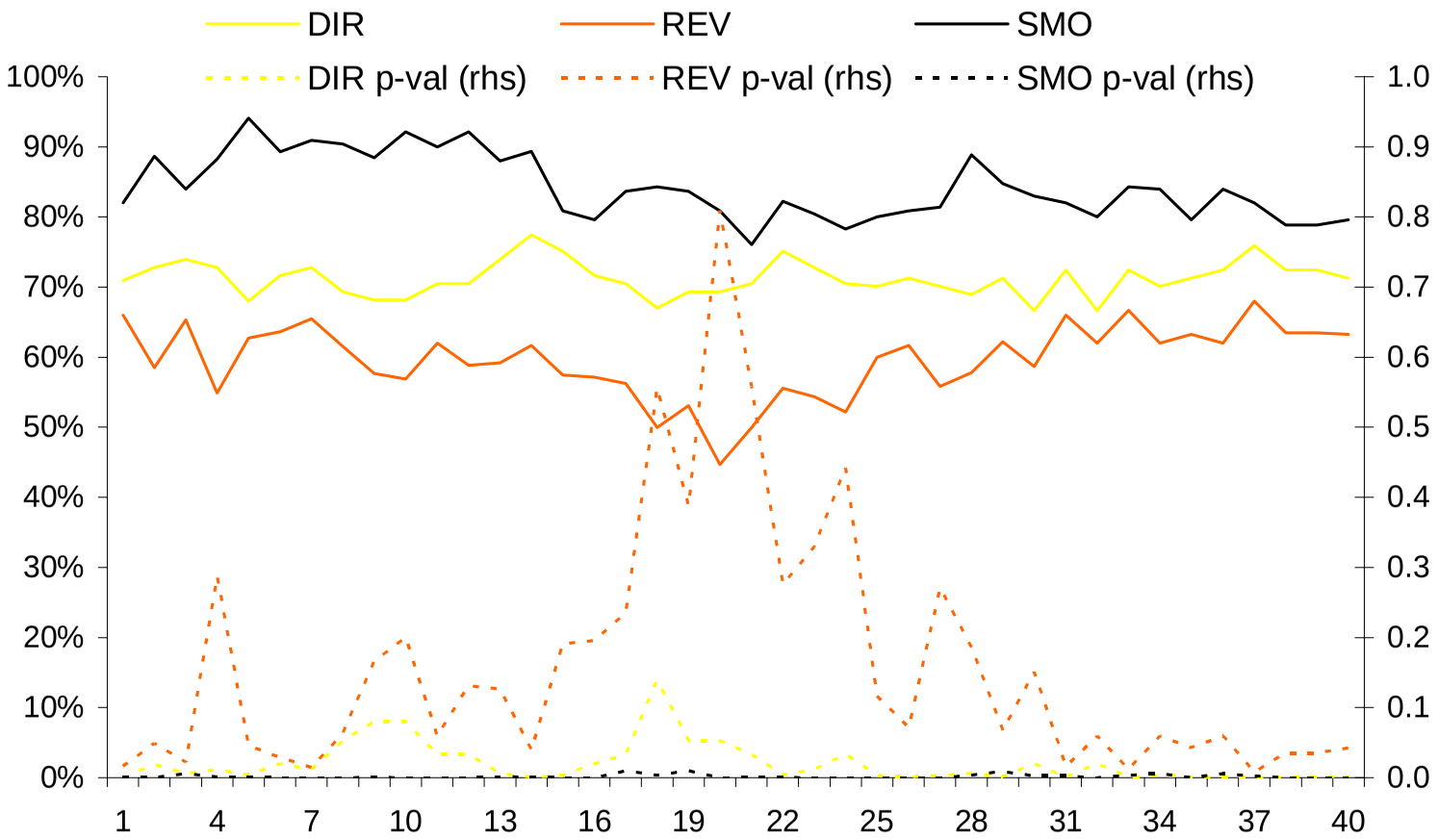
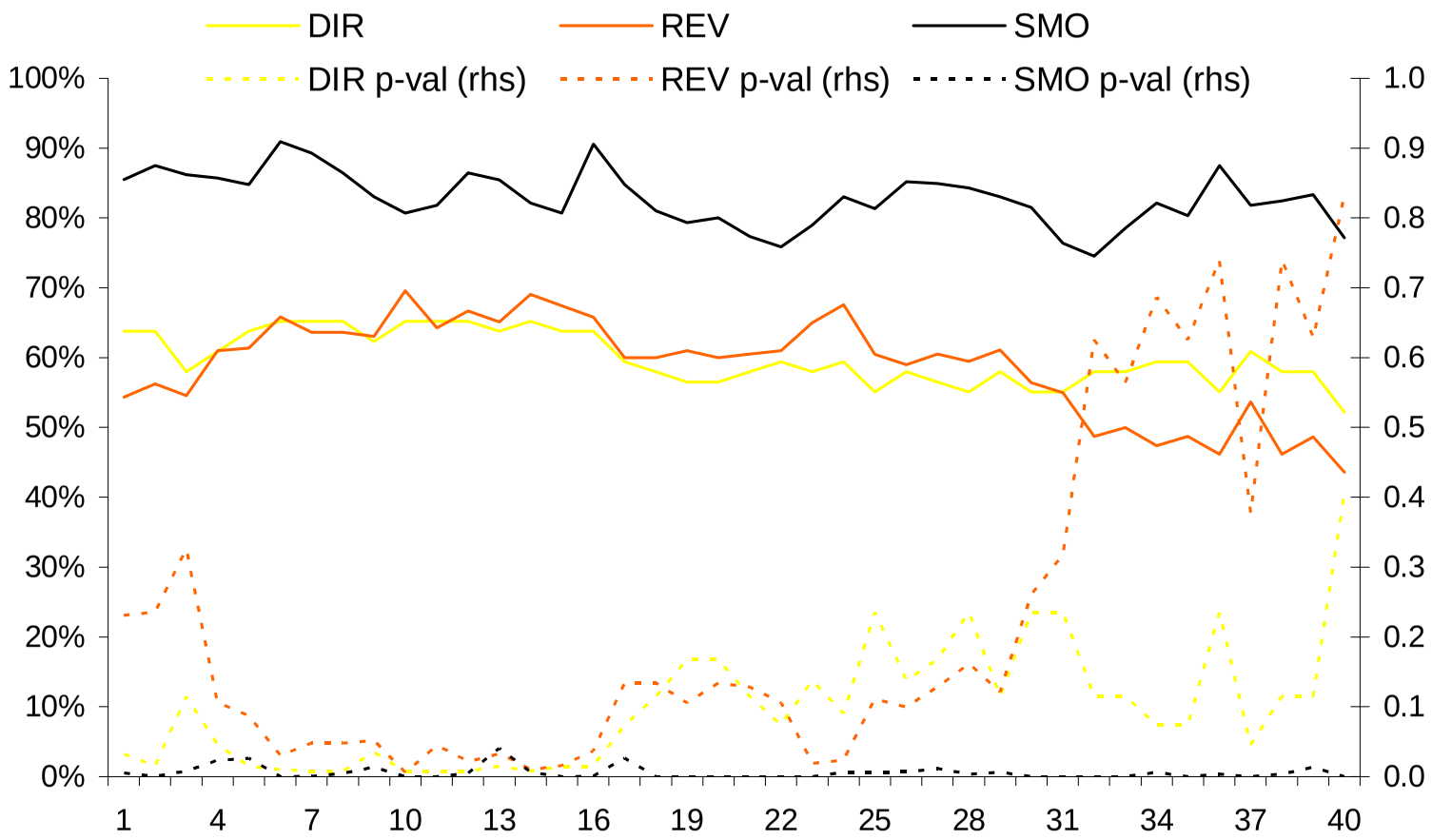


Figure 7: Evolution of the success criteria over post-event window, oral interventions



Notes: The solid lines show the percentage share of successes in total events for the direction criterion (DIR), the reversal criterion (REV) and the smoothing criterion (SMO) from 1 to 40 days after the end of the oral intervention events (combined US and euro area). The dotted lines show the corresponding p-values (right-hand-side y-axis).

Figure 8: Evolution of the success criteria over post-event window, actual interventions



Notes: The solid lines show the percentage share of successes in total events for the direction criterion (DIR), the reversal criterion (REV) and the smoothing criterion (SMO) from 1 to 40 days after the end of the actual intervention events (combined US and Japan). The dotted lines show the corresponding p-values (right-hand-side y-axis).

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