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## The interventions of the European Central Bank: Effects, effectiveness, and policy implications

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# Research Notes in Economics & Statistics

## The Interventions of the European Central Bank: Effects, Effectiveness, and Policy Implications

We analyze the effectiveness of the foreign exchange market interventions conducted by the European Central Bank (ECB) in the fall of 2000 to support the external stability of the euro. To this end, in a first step different channels through which interventions may influence exchange rate dynamics are discussed. In a second step, a review of the existing empirical literature on the effectiveness of central bank interventions is used as the basis for evaluating the effectiveness of the ECB's intervention policy. Against this background, high-frequency exchange-rate data are used to examine the effects of the interventions. We present evidence that the interventions only had a very short-term impact on the exchange rate path with no medium-term effects. All in all, our results suggest that the ECB's intervention policy was not effective.

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## **The Interventions of the European Central Bank: Effects, Effectiveness, and Policy Implications**

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June 2001

### **Abstract**

We analyze the effectiveness of the foreign exchange market interventions conducted by the European Central Bank (ECB) in the fall of 2000 to support the external stability of the euro. To this end, in a first step different channels through which interventions may influence exchange rate dynamics are discussed. In a second step, a review of the existing empirical literature on the effectiveness of central bank interventions is used as the basis for evaluating the effectiveness of the ECB's intervention policy. Against this background, high-frequency exchange-rate data are used to examine the effects of the interventions. We present evidence that the interventions only had a very short-term impact on the exchange rate path with no medium-term effects. All in all, our results suggest that the ECB's intervention policy was not effective.

**Key Words:** European Central Bank, Foreign exchange market interventions

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## 1. The Setting

Central banks often have tried to manage exchange rates in an attempt to cope with the "open-economy trilemma" which reflects the impossibility to achieve free cross-border capital flows, exchange rate flexibility, and monetary autonomy simultaneously.<sup>1</sup> Exchange rates were not determined by market forces alone but also by actual or anticipated intervention activities of monetary authorities even after the Bretton-Woods System had broken down in 1973 and a system of floating foreign exchange (FX) rates had been established. Active exchange-rate policy was usually implemented by conducting occasional foreign-exchange-market interventions or by constraining spot rates to evolve within explicit bands of fluctuation. Examples of political events marking attempts to implement exchange-rate systems characterized by occasional interventions are the so-called Plaza Communiqué agreed upon by the G-5 central bank governors and finance ministers on September 22, 1985 and the Louvre Accord proclaimed at a G-7 summit held in Paris on February 22, 1987. An example of a policy regime aiming at invoking an explicit exchange-rate target zone is the former European Monetary System.

Confronted with significant and lasting devaluation pressure on the euro in the fall of 2000, the European Central Bank (ECB) also tried to influence the dynamics of the exchange rate through sterilized foreign exchange market interventions. On September 14, 2000, representatives of the central bank informed the public that the ECB would sell the equivalence of EUR 2.5 billion in interest revenues from foreign assets denominated in US dollars "in order to maintain the structure and risk profile of the ECB's balance as it was at the beginning of 1999" (ECB 2000a). Urged by a strong U.S. dollar reaching a new historical high against the euro, the ECB intervened again in the foreign exchange market on September 22, 2000. This intervention was coordinated between the Federal Reserve, the Bank of Canada, the Bank of Japan, and the Bank of England. Further interventions with the intention to support the external stability of the euro were initiated solely by the ECB on November 3 and 6 as well as on November 9, 2000.

In this paper, we analyze the effectiveness of the foreign exchange market interventions carried out by the ECB. To set the stage for the empirical analysis, we first discuss in section 2 different mechanisms through which interventions may influence exchange-rate dynamics. Section 3 reviews results reported in recent contributions to the empirical literature on the effectiveness of central bank interventions. In section 4, we analyze the effectiveness of the

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<sup>1</sup> See, for example, Obstfeld/Taylor (1998).

foreign-exchange-market interventions carried out by the ECB. High-frequency exchange-rate data are utilized to shed light on the short-run effects of actions taken by the ECB on the dynamics of the spot rate. We also estimate the effect of the interventions on the conditional volatility of exchange-rate returns. In addition, we use an event study methodology and daily exchange-rate data to compare the short-term impact of the interventions with their medium-term effectiveness. Section 5 summarizes the main findings of our empirical research and offers some concluding comments.

## **2. The Impact of Sterilized Foreign-Exchange-Market Interventions on Exchange-Rate Dynamics: The Theoretical Background**

Central bank interventions in foreign-exchange markets can be defined as sales or purchases of foreign currency by the monetary authorities of a country conducted with the intention to influence the future path of the exchange rate (see Baillie et al. 2000 and Schwartz 2000). It is common practice among central banks to sterilize the impact of foreign-exchange-market interventions on the monetary base. Sterilization is achieved by taking measures which help to neutralize the expansionary or contractionary effects of interventions.<sup>2</sup> Given that the impact of interventions on domestic money supply is typically neutralized, the question arises as to how sterilized interventions can affect exchange rates. In academic literature, three main channels have been suggested through which sterilized central bank interventions may influence the pricing of foreign exchange: the so-called *signaling channel*, the *portfolio balance channel*, and the *noise trader channel*.<sup>3</sup>

A core assumption of the *signaling approach* is that the exchange rate is an asset price and that foreign-exchange markets are competitive and informationally efficient in the sense that all information relevant for the pricing of foreign exchange is instantaneously embedded in the current realization of the spot rate. In such an environment, sterilized interventions can affect exchange rates if a central bank succeeds in influencing economic agents' expectations regarding the future evolution of these fundamentals (Mussa 1981).

Since a central assumption of the signaling approach is that market participants use all publicly available information when pricing foreign exchange, a sterilized intervention can affect the exchange rate only if the central bank has an informational advantage over the

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<sup>2</sup> For studies addressing the question whether central banks tended to sterilize the impact of interventions, see Obstfeld (1983), Neumann (1984), Mastropasqua/Micossi/Rinaldi (1988), Gaiotti/Giucua/Micossi (1989), von Hagen (1989) as well as Neumann/von Hagen (1992).

agents involved in the trading process. This asymmetric distribution of information implies that central banks have access to information which is not (or only with a certain time-lag) available to economic agents. Central banks can reveal this information at least partially by intervening in the foreign-exchange market.<sup>4</sup> Market participants can then collect the new information and adjust their expectations regarding the future evolution of fundamentals, which, in turn, implies that the intervention leads to a change in exchange rate.<sup>5</sup>

The *portfolio balance model* sheds light on another channel through which interventions may influence exchange-rate dynamics.<sup>6</sup> The central presumption underlying this theoretical framework is that economic agents regard assets denominated in domestic currency and assets denominated in foreign currency as imperfect substitutes. This assumption implies that sterilized interventions can affect the exchange rate because such policy action alters the relative supply of domestic and foreign bonds and, thus, requires an adjustment of the risk premium to balance demand and supply in international asset markets. For example, through buying European bonds for foreign assets (e.g., U.S. bonds) the European Central Bank can alter the relative supply of domestic and foreign currency denominated assets. Assuming that economic agents are risk averse which implies that domestic and foreign assets are imperfect substitutes, this policy action carried out by the ECB requires that private traders adjust the structure of their portfolios to account for the shift in the relative supply of bonds. This implies that in the aftermath of the intervention, wealth and substitution effects force international bond markets to seek a new equilibrium.

Another channel through which sterilized central bank interventions may affect exchange rates has been discussed in the strand of literature concerned with the *noise trading theory of*

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<sup>3</sup> In addition, recent studies including inter alio. Bhattacharya/Weller (1997) and Vitale (1999) have stressed that the *market microstructure* of foreign-exchange markets may be an important determinant of the effectiveness of central banks' foreign-exchange-market operations.

<sup>4</sup> In this context, the question arises why a central bank should resort to interventions in the FX market rather than to a transparent communication and information policy to disseminate its superior information. To resolve this problem, Mussa (1981) argues that central banks might be beleaguered by credibility problems which can only be resolved by resorting to monetary policy actions like interventions to underscore that monetary authorities follow a policy of "putting their money where their mouth is" and stand ready to act by an intervention.

<sup>5</sup> An important drawback of the signaling hypothesis is that it can only be employed to discuss exchange-rate movements in the aftermath of a publicly known sterilized intervention (Edison 1993). The signaling model thus predicts that central banks aiming at increasing the effectiveness of sterilized interventions should always inform market participants about their sales and purchases of foreign currency. However, as pointed out by Dominguez and Frankel (1993) central banks often carried out secret interventions. Neither does the signaling model provide an answer to the question why monetary authorities often use secret interventions to target spot rates, nor does the framework reveal how such secret interventions might affect the exchange rate.

<sup>6</sup> For early contributions to the strand of literature using portfolio models to analyze the effectiveness of central bank foreign exchange market interventions, see inter alia Tryon (1983), Boothe et al. (1985) and Loopesko (1984). See also Dominguez/Frankel (1993b). Branson/Henderson (1985) provide a comprehensive discussion of issues related to the modeling of asset markets with portfolio models.

*exchange rate determination*. Noise traders are financial market participants whose demand for financial security is not influenced by economic fundamentals alone (Black 1986). Instead, noise traders employ, for example, techniques provided by technical chart analysis to extract buy and sell signals from historical exchange rate trajectories. In noise trader models of exchange-rate determination it is assumed that, at least in the short and medium run, the group of technicians influences the dynamics of the spot rate so that the price of this asset can depart from its fundamental value.<sup>7</sup> In a market in which noise traders participate in the trading process, central banks can try to influence the position taking of these agents by utilizing interventions to establish or to break short-run price trends. If the central bank succeeds in affecting the exchange rate and noise traders respond to these changes, the price impact of the orders submitted by noise traders might then account for persistent exchange rate effects of sterilized foreign exchange market interventions (see e.g. Hung 1997 or Murray et al. 1990).<sup>8</sup>

### **3. The Empirical Evidence on the Effectiveness of Central Banks' Foreign-Exchange-Market Interventions**

The literature on the effectiveness of foreign-exchange-market interventions discusses the issue as to whether such operations tend to stabilize or destabilize exchange rates or even have no effect at all. No generally accepted conclusions have been generated so far. Most papers on this topic analyze the effectiveness of interventions in terms of either their effect on the level of the spot rate or their impact on the volatility of exchange rate returns.

#### **3.1 Evidence on the Impact of Central Bank Interventions on the Level of FX Rates**

A study by Dominguez and Frankel (1993a) was one of the first empirical investigations in which daily data on public interventions were used to assess the effectiveness of foreign-exchange-market interventions of central banks.<sup>9</sup> The authors apply a univariate regression approach to analyze the effectiveness of the foreign-exchange-market operations conducted by

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<sup>7</sup> The empirical relevance of the noise trader hypothesis has been confirmed in a number of studies of foreign exchange markets. See e.g. Allen/Taylor (1990, 1992) and Frankel/Froot (1990). For recent empirical evidence on this issue, cf. Menkhoff (1997, 1998), Lui/Mole (1998), Cheung/Chinn (1999a, 1999b), Cheung/Wong (2000), and Oberlechner (2001).

<sup>8</sup> Also note that a central bank which intends to exploit this noise trader channel to influence exchange rates by means of sterilized interventions needs to know the reaction function of noise traders (cf. Hung 1997 and Aguilar/Nydahl 2000).

<sup>9</sup> In the present section, results reported in recent studies are summarized. A description of earlier research on the effectiveness of foreign exchange market interventions of central banks is provided by Edison (1993). See also Almekinders (1995).

the U.S. Federal Open Market Committee and by the Deutsche Bundesbank.<sup>10</sup> The study is concerned with testing the portfolio balance channel through which sterilized interventions might affect exchange rates. This approach relies on the assumption that domestic and foreign assets are imperfect substitutes and that investors construct globally diversified portfolios on the basis of expected market returns. An interesting feature of this empirical study is that survey data are used to extract a series approximating market participants' exchange-rate expectations. The empirical results outlined in the study suggest that Federal Reserve and Bundesbank interventions which took place during the mid-1980's might have influenced exchange rates.<sup>11</sup>

Additional evidence on the effectiveness of interventions by the U.S. Fed and the Bundesbank is provided by Eijffinger and Gruijters (1992). Utilizing daily data covering the period from February 1985 to August 1988 to assess the impact of foreign-exchange-market interventions on the level of the exchange rate, it is demonstrated that central bank interventions were rather ineffective in this respect. Furthermore, the authors report some evidence that the coordination of interventions tended to influence positively the effectiveness of this policy instrument. As interventions frequently occur over a series of days, the authors also analyze whether the first intervention in such a series was more effective than subsequent foreign-exchange-market operations. While some evidence for this hypothesis is found for Bundesbank interventions, a similar result cannot be derived with respect to the interventions conducted by the U.S. central bank.

Recent evidence presented in Humpage (1999) suggests that interventions conducted by the U.S. central bank during the Louvre period effectively smoothed the U.S. dollar/deutsche mark (USD/DEM) and the U.S. dollar/Yen (USD/JPY) spot rates. Using a binary dependent variable model, Humpage reports that the probability of a successful U.S. intervention was higher whenever the Federal Open Market Committee coordinated foreign-exchange-market operations with other major central banks. According to the binary success criterion used in this study, foreign-exchange-market interventions are identified as effective if a sale (a purchase) of foreign currency is either followed by an appreciation (a depreciation) of the domestic currency or a in slowdown of the rate of appreciation (depreciation) of the home currency.

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<sup>10</sup> In addition, the interventions of the Swiss National Bank as an example for a central bank of a small open economy are analyzed in order to examine the sensitivity of the obtained results.

<sup>11</sup> Additional evidence on the effectiveness of interventions can be found in a related study by Dominguez/Frankel (1993b).



An event study technique is used in a recent study by Fatum (2000) who analyzes the effectiveness of foreign-exchange-market interventions by the U.S. central bank and by the Bundesbank. He uses intervention data for the period September 1985 to December 1995. An intervention is rated as effective if a central bank succeeds either in moving the exchange rate in the direction intended by the foreign-exchange-market operation or in weakening an exchange rate trend prevailing before the intervention.<sup>12</sup> The results reported in the study suggest that the interventions conducted by the U.S. Fed and by the Bundesbank in the DEM/USD market during the sample period analyzed in the study were indeed effective. In particular, it is found that a coordination of the central banks FX market operations tended to influence the effectiveness of interventions positively.<sup>13</sup>

Kaminsky and Lewis (1996) also report that interventions affected exchange rates. They study the effectiveness of the interventions conducted by the U.S. central bank in the USD/DEM and the USD/JPY market during a period beginning in 1985 and ending in 1990. The empirical approach adopted by these authors is particularly suited to test the hypothesis that sterilized interventions mainly affect the exchange rate through the signaling channel. The signaling model implies that interventions allow economic agents to gain information regarding the future stance of monetary policy. In contrast to the predictions of the theoretical framework, the authors emphasize that U.S. interventions convey information that future monetary policy moves in the opposite direction suggested by the sign of the intervention. Consequently, interventions are also found to induce an exchange rate movement inconsistent with the interventions.<sup>14</sup>

### **3.2 Do Interventions Affect Exchange Rate Volatility?**

Bonser–Neal and Tanner (1996) use volatility data implicit in foreign currency options to analyze whether interventions reduced future variability of the spot market as expected by market participants. Monitoring the influence of macroeconomic announcements, they find that both U.S. Fed and Bundesbank interventions conducted during the period 1985 – 1991 in the USD/DEM and USD/JPY market either did not affect implied volatility significantly or

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<sup>12</sup> Using an exchange rate trend to trace the effectiveness of central bank interventions, it is also necessary to discriminate further between “blowing-with-the-wind “ and “leaning-against-the-wind “ interventions in order to avoid biased results (Fatum 2000, p. 9 – 10).

<sup>13</sup> As regards this latter finding, it should be taken into account that “about one half of the studies find that coordinated intervention is more effective than non-coordinated intervention, the other half find no special significance to the difference between regimes.“ (Edison 1993, p. 35).

<sup>14</sup> For additional evidence on the signaling theory of central bank interventions, see inter alia. Ghosh (1992) and Fatum/Hutchison (1999) and the references cited therein.

even contributed to inflate the expected variability of the spot rate. Madura and Tucker (1991) also find that interventions conducted during the years following the Louvre Agreement were unsuccessful in dampening exchange rate volatility. Their results thus corroborate the findings documented in Bonser-Neal and Tanner (1996). Similar results are documented in Baillie and Osterberg (1997) whose empirical evidence tends to support the notion that interventions tended to increase rather than decrease the variability of exchange rates.

Taking a noise trader approach, Hung (1997) points out that the impact of interventions on exchange rate volatility might change over time. Hung (1997) argues that central banks should employ interventions to raise exchange rate volatility if they intend to break exchange rate trends used by noise traders to extract buy or sell signals. Using data on U.S. interventions in the USD/DEM and in the USD/JPY market covering the period April 1985 to December 1986 as well as the Louvre period (March 1987 to December 1989), the author finds that the interventions carried out during the mid-1980's tended to decrease volatility. The interventions undertaken in the aftermath of the Louvre summit were intended to weaken the strong dollar. In contrast, interventions mainly motivated by the goal of stabilizing rates around prevailing levels in the aftermath of the Louvre Accord are found to have raised exchange rate volatility.

Aguilar and Nydahl (2000) study the impact of interventions by the Swedish central bank on the level and the volatility of the krona/U.S. dollar (SEK/USD) and the krona/deutsche mark (SEK/DEM) exchange rates. The authors set up a multivariate GARCH framework that allows to model the impact of interventions on the level and the conditional volatility of the SEK/USD and the SEK/DEM exchange rate within a unified framework. The results obtained from estimating this model as well as the findings of supplementary exercises relying on options implied volatilities to trace the effect of central bank interventions on anticipated exchange rate volatility indicate that interventions exerted only a rather weak influence on exchange rate volatility. When the model is reestimated for certain subperiods, it is found that interventions tended to dampen (increase) the volatility of the SEK/USD in 1995 (in 1993). In addition, weak empirical evidence for a destabilizing impact of interventions on SEK/DEM spot rate volatility is found for the year 1994.

#### **4. The Effectiveness of the ECB Intervention**

In this part of the paper, we analyze the effects of the interventions conducted by the ECB on the level and the volatility of the U.S. dollar/euro (USD/EUR) exchange rate. To determine

the immediate effects of the intervention, we utilize intra-daily USD/EUR exchange rate data and quantify the effect on the exchange rate level and on the bid-ask spread in foreign-exchange-markets. In addition, we use daily spot market data to estimate the impact of the interventions on the conditional volatility of exchange rate returns and to shed light on the medium-term effectiveness of the interventions.

#### **4.1 The Effects of the ECB's Intervention Policy with High Frequency Data**

It is instructive to begin the empirical analysis with a graphical examination of the USD/EUR exchange rate path on the intervention days as well as on the day before and the day after an intervention. To this end, Figure 1 depicts the dynamic evolution of the exchange rate on a minute by minute basis. The exchange rate is shown in index form with a value of unity representing the exchange rate at 06:00 a.m. on the day before the intervention.

Figure 1a shows the impact of selling the interest income on foreign exchange reserves against euros by the ECB on September 14, 2000. The graph demonstrates that this policy action had only a very moderate (if any) impact on the evolution of the euro's exchange rate. Because the ECB did not label this sale of foreign currency explicitly as an intervention, it is possible to argue that the tranquil conditions prevailing on the foreign-exchange-market on September 14 were in line with the interest of the ECB. According to this argument, the ECB's action can be rated as effective. Nevertheless, one should also acknowledge that the ECB started its sales of interest income at a time when the euro was extremely weak compared with the US-Dollar. Hence, a critical observer might be tempted to object that the timing of the sale of interest income was influenced by the developments on the foreign-exchange-market. The theoretical underpinning of this line of argument could be seen in the portfolio balance channel which stipulates that selling interest income can have, in principle, the same effect on exchange rates as a regular central bank intervention. Thus, if the main objective of the policy measure taken by the ECB officials on September 14 was to support the external stability of the euro rather than to restructure the central bank's balance sheet, the empirical evidence presented in Figure 1a strongly suggests that this operation was not effective in breaking the lasting depreciation trend of the euro.

As depicted in Figure 1b, a noticeable response of the exchange rate to the intervention conducted by the ECB occurred on September 22, 2000. This intervention was carried out by the European Central Bank jointly with the Federal Reserve, the Bank of Japan, the Bank of England and the Bank of Canada. It can, thus, be classified as a coordinated intervention. In

addition, the ECB left no doubt that the euro purchases were conducted this time with the objective to strengthen the common European currency. Figure 1b shows that this intervention by the ECB and its partner central banks had a major short-term impact on the foreign exchange market. News of an intervention buffeted the market at 11:00 a.m. The exchange rate firmed from 0.87025 USD/EUR at 11:00 a.m. to 0.8942 USD/EUR at 11:20 a.m., which corresponds to an appreciation by 2.74 %. However, during the following trading day, the exchange rate exhibited a pronounced tendency to return to its pre-intervention level. Thus, while the immediate response of the spot rate to the news of a joint central bank intervention was significant, the intervention did not exert a lasting effect on the exchange rate level. Extending the analysis to the following trading day highlights that the effects of the intervention on the dynamics of the spot rate were at most minor. In particular, it can be seen that the ECB did not succeed in reversing or even stopping the considerable depreciation trend of the euro which had prevailed before the intervention.<sup>15</sup>

A further interesting fact revealed by Figure 1b is that the euro exhibited a tendency to appreciate even before the news of the intervention reached the market. This empirical finding can best be explained by taking into consideration the results of a recent study by Peiers (1997). She analyzes the microstructure of the foreign-exchange-market and uses intra-day data to determine the impact of Bundesbank interventions on the price formation process. The objective of her study is to show how the information of a central bank intervention spreads within the banking sector and how it is processed by different market participants. Applying Granger causality tests, she shows that some market participants apparently had an informational advantage over their competitors in the sense that they were aware of the intervention even before the central bank informed the public about its activities. A central result of her study is that in Germany especially Deutsche Bank seemed to have been better informed about the actions taken by the Bundesbank.<sup>16</sup> Her finding suggests that Deutsche Bank was able to take the right position in the market roughly 60 minutes before the information regarding Bundesbank interventions was published.<sup>17</sup> Peiers argues that because

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<sup>15</sup> Thus, confronting the immediate exchange rate effect with the effect over the following days shows that there was an overshooting in the response of the spot rate following the arrival of intervention news. This kind of overshooting behavior of the exchange rate due a central bank intervention is also described by Dominguez (1999) who calls such a price reaction as “intra-daily mean reversion“.

<sup>16</sup> The central finding of Peiers (1997) – i.e., that some market participants enjoy informational advantages with respect to the policy actions of the central bank – has been confirmed in a recent study by Dominguez (1999).

<sup>17</sup> Chang/Taylor (1998) report that the volatility of the JPY/USD exchange rate increased significantly one hour before the news of a central bank intervention was broadcast via Reuters.

Deutsche Bank was a market maker in the USD/DEM market, the Bundesbank used Deutsche Bank to conduct interventions.<sup>18</sup>

With respect to the coordinated intervention which took place on September 22, some commentators suspected that some American banks had obtained the information that central banks stood ready to step into the market some hours before the central banks started purchasing euros.<sup>19</sup> It was stated that Citibank, a leading market maker in the USD/EUR market, heavily sold dollars in the morning of the intervention day. The link between Citibank and the Federal Reserve was seen in the fact that Robert Rubin, who was co-chairman of Citigroup at the time of the intervention, had formerly been the Treasury Secretary. He was assumed to be in close contact with the U.S. Treasury. Such an informational advantage could be one possible explanation for the fact that the euro exhibited a slight tendency to appreciate even before the news that a multilateral intervention had been conducted reached the market.

Figures 1c, 1d and 1e depict the dynamics of the euro around three further ECB intervention days. Neither on November 3 nor on November 6 or on November 9, 2000, an effect of the intervention on the exchange rate lasting longer than approximately one day was achieved. Also notice that the intervention that took place on November 6 is extraordinary insofar as the ECB had already stepped into the FX market on November 3, the previous trading day. However, even though the ECB intervened on successive trading days, the presented figures indicate that the depreciation trend exhibited by the euro continued on the trading day following the intervention. Hence, we conclude that these interventions had no remarkable effect on the path of the euro and can, thus, not be classified as effective.

In contrast to the intervention conducted on September 22, the Federal Reserve did not participate in the foreign-exchange-market operations carried out by the ECB in November 2000. Taking this fact into consideration, Figures 1a – 1e suggest that central banks can exert a stronger impact on the exchange rate if they coordinate their actions. Thus, as unilateral interventions had only a minor effect on the exchange rate path, one might be tempted to conclude that the ECB should back its actions by ensuring the support of other major central banks. The conclusion that coordinated intervention activities may have a larger impact on the exchange rate than an intervention conducted by a single central bank alone is in line with the empirical findings documented in Eijffinger/Grujters (1992), Humpage (1999, 2000), and

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<sup>18</sup> Neely (2000) finds for a panel of central banks that monetary authorities often use domestic commercial banks to conduct interventions. Thus, it is reasonable that some commercial banks are able to achieve an informational advantage over other market participants with respect to the timing of foreign-exchange-market interventions.

Fatum (2000). In contrast, neither Humpage (1989) nor Humpage/Osterberg (1992) are able to find a significant difference regarding the effectiveness of coordinated and non-coordinated interventions. Notwithstanding the ambiguous findings documented in the existing empirical literature, we can infer from Figures 1 that the interventions carried out by the ECB exerted a relatively stronger temporary impact on the USD/EUR spot rate when the operation was coordinated with other major central banks.

To gain an impression of the strength of the impact of the interventions conducted by the ECB on exchange rate dynamics, Table 1 provides a quantitative analysis of the relationship between ECB's interventions and the EUR/USD exchange rate. The table presents the percentage changes in the exchange rate on an intervention day as well as on the day before and on the day after an intervention.<sup>20</sup>

The fourth column of Table 1 shows that the ECB was indeed able to influence the exchange rate path of the euro temporarily. Confirming the evidence presented in Figure 1, the coordinated intervention on September 22, 2000 had the strongest impact on exchange rate dynamics: the euro appreciated by 2.17 % during the intervention day but, as discussed above, this effect did not persist. As can further be seen in the table, the day following the intervention was characterized in all five cases by a depreciation of the euro. Moreover, in three out of five cases the euro had depreciated on the day before an intervention took place. Only the day preceding the coordinated central bank intervention on September 22, 2000 had seen an appreciation of the euro. Thus, on September 22, 2000, the central banks intervened into a rising market. Though this foreign exchange market operation can be classified as a leaning-with-the-wind intervention, it can be seen in the last column of the table that the euro came under pressure again on the day following the intervention.

Further interesting insights can be obtained by analyzing the question of how news regarding the ECB's intervention activities affected the bid-ask spread. Because it exerted a relatively strong impact on the exchange rate path, we depict in Figure 2 the impact of the coordinated intervention conducted on September 22, 2000 on the bid-ask spread. The exchange rate is shown on the left vertical axis; the bid-ask spread is shown on the right vertical axis. We used the day before the intervention day to scale figures. It can be seen that the bid-ask spread increased right after the news that the central banks had stepped into the market was released. While the mean spread between 11:30 a.m. and 12:30 p.m. on the day before the intervention

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<sup>19</sup> See, for example, Frankfurter Allgemeine Zeitung (2000).

<sup>20</sup> A similar event study methodology has been used by Fatum (2000) who analyzes the effectiveness of the intervention policy of the Fed and the Bundesbank.

was launched was 0.00038 USD/EUR, it increased to 0.000459 USD/EUR on the intervention day.

Figure 2 contains another interesting feature which can be explained by exploiting the insights provided by market microstructure theory: on the day following the intervention the bid-ask spread increased approximately at the same time the intervention news buffeted the market on the previous day. This observation might reflect that market participants are aware that a prominent stylized fact reported in the intervention literature stipulates that interventions tended to cluster over time. For example, LeBaron (1999) estimates that the probability for a Fed intervention in the USD/DEM market conditional upon an intervention on the previous day amounts to 58.4 % compared with 11.8 % for the unconditional probability. The conditional (unconditional) probability for Fed interventions in the USD/JPY market is 53.2 % (5.6 %) for the same time horizon [01/01/1979 – 12/31/1992]. Thus, as interventions in the past mostly tended to occur over a string of days, the time-patterns of the bid-ask spread may reflect the expectation of at least some market participants that the ECB could conduct interventions over a string of days.

#### **4.2 The Effects of Central Bank Intervention on the Volatility of Exchange Rate Returns**

Another interesting question in the context of central bank intervention in the foreign exchange market is whether central banks are able to dampen exchange rate volatility. In order to analyze the link between the variability of exchange rate returns and central bank operations, an empirical measure of volatility is needed. In the intervention literature, this question has been analyzed frequently by estimating so-called Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models developed by Engel (1982) and extended by Bollerslev (1986).<sup>21</sup> To construct a GARCH model of conditional exchange rate volatility, the first step is to define the rate of return  $\Delta \tilde{e}_t$  of the spot rate  $E_t$  between time  $t-1$  and time  $t$  as  $\Delta \tilde{e}_t \equiv \ln(E_t) - \ln(E_{t-1})$  with  $\tilde{e}_t$  being the natural logarithm of  $E_t$  and  $\Delta$  denoting the first-difference operator. To rule out that possible systematic day-of-the-week effects distort the results of the volatility-based test for the effectiveness of ECB interventions, the following regression for the conditional mean of the raw data is estimated:

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<sup>21</sup> Surveys of the strand of the literature dealing with issues related to the construction and the estimation of GARCH models include Bollerslev et al. (1992), Bera/Higgins (1993) as well as Diebold/Lopez (1995).

$$(1) \quad \Delta \tilde{e}_t = \sum_{i=1}^5 \beta_i \tilde{d}_{i,t} + \varepsilon_t$$

where  $\tilde{d}_{i,t}$ , ( $i=1,\dots,5$ ) represent day-of-the-week dummies. We denote the residuals obtained from an OLS estimation of equation (1) as  $\hat{\varepsilon}_t \equiv \Delta e_t$ . Adopting a two-step methodology similar to the one employed by Pagan/Schwert (1990), Amin/Ng (1997), and Alexander (1998), the input data utilized in the estimation of the GARCH models, which are used to identify the time path of the conditional exchange rate volatility, is taken from the series  $\Delta e_t$ . The general specification of a GARCH process of order  $p \geq 0$  and  $q \geq 0$ , abbreviated as GARCH( $p,q$ ), can then be formulated as follows:

$$(2) \quad \Delta e_t = u_t \quad \text{with} \quad u_t | \Omega_{t-1} \sim D(0, h_t)$$

$$(3) \quad u_t = \eta_t \sqrt{h_t} \quad \text{with} \quad \eta_t \sim_{\text{i.i.d.}} D(0,1)$$

$$(4) \quad h_t = \omega + \sum_{i=1}^p \alpha_i u_{t-i}^2 + \sum_{i=1}^q \beta_i h_{t-i} + \delta \cdot \text{dummy}_t$$

where  $D(0, h_t)$  is a density function with mean zero and variance  $h_t$ . In addition,  $\Omega_{t-1}$  is the information set including the realizations of all relevant variables up to and including time  $t-1$ , and  $\eta_t$  is an i.i.d. white-noise process independent of  $u_{t-i}$  with zero mean and unit variance density  $D$ . Equation (2) implies that the conditional and the unconditional mean of the serially uncorrelated exchange rate returns are equal to zero. The unconditional variance of the exchange rate returns is constant and finite provided the roots of the characteristic polynomial of the difference equation (4) lie inside the unit circle (see e.g. Bera/Higgins 1993). In the subsequent analysis, we follow Engle (1982) and assume that the function  $D$  is given by the density of the normal distribution function. Furthermore, it turns out that setting  $p = q = 1$  suffices to capture the essential features of the dynamics of exchange rate returns volatility.

The important economic feature of the empirical model formalized in equations (1) – (4) is that the conditional variance  $h_t$  depends also on the foreign exchange market interventions of the ECB as measured by the variable  $\text{dummy}_t$ . This dummy variable is equal to unity whenever the central bank is present in the market and is zero if it is not. The significance of



the coefficient  $\delta$  allows to examine whether the interventions of the ECB dampened or increased exchange rate return volatility or whether interventions did not affect the variability of the spot rate at all.

To estimate the model, a series of daily US-dollar/euro exchange rate data beginning on January 5, 1999 and ending on December 29, 2000 was employed. The system of equations forming the GARCH model can be efficiently estimated simultaneously using a non-linear maximum likelihood routine. The results of implementing this procedure as well as several diagnostic tests performed to check the adequacy of the framework are summarized in Table 2. The figures reported in the table indicate that the coefficients of the GARCH model are all significantly different from zero. Moreover, the sum of the ARCH and the GARCH terms entering into the conditional volatility equation is significantly smaller than one, suggesting that the unconditional variance exists. The Q-statistic developed by Ljung/Box (1979) indicates that it is not possible to reject the null hypothesis of no remaining autocorrelation in the standardized residuals. The LM-test (ARCH) introduced by Engle (1982) witnesses that the null of no further GARCH effects in the squared standardized residuals of the GARCH (1,1) framework cannot be rejected. However, the significance of the test statistic suggested by Bera/Jarque (1982) indicates that it is not possible to retain the assumption that the standardized residuals of the GARCH model are standard normally distributed. To account for this departure from normality, the quasi-maximum likelihood method developed by Bollerslev/Woolridge (1992) to compute robust standard errors. As a final exercise, we tested for significant leverage effects in conditional volatility of exchange rate returns by estimating the asymmetric Threshold-ARCH model suggested by Glosten, Jagannathan and Runkle (1993) and by Rabenmananjara and Zakoian (1993). However, the corresponding TARCH coefficient turned out to be insignificant. Thus, taken together, the evidence summarized in Table 2 indicates that the baseline GARCH(1,1) model captures the dynamics of conditional exchange rate returns volatility fairly well.

From the economic point of view, the most interesting result reported in Table 2 is that we can reject the hypothesis that the ECB's interventions influenced the dynamics of the volatility of the USD/EUR spot rate returns. Hence, our findings confirm the results of several empirical studies on foreign exchange market interventions of the Fed, the Bundesbank, and the Bank of Japan in the 1980s and the 1990s. As emphasized by, for example, Aguilar/Nydahl (2000) and Dominguez (1998), and Bonser-Neal/Tanner (1996), the effect of intervention on exchange rate volatility is often found to be insignificant and in those cases in

which a significant effect is detected this outcome is almost always found to be not stable over time. It should also be noted that the result presented in Table 2 turned out to be robust against modifications of the estimated model. For example, in a sensitivity analysis we specified that the dummy variable is equal to unity on a day following the intervention day in order to correct for potential lags in market reactions. The estimates of this specification did not deviate significantly from the results of the benchmark specification and are not presented in Table 2.

### **4.3 Medium-Term Effects of Central Bank Intervention on the Level of the Exchange Rate**

So far, we have primarily been concerned with the short-term effects of central bank interventions in the foreign-exchange-market. However, it might be the case that the ECB interventions did not have short-term but medium-term effects on the exchange rate level which are not identified when high-frequency data are used to characterize the behavior of the market immediately after an intervention has taken place. Therefore, we now enlarge the width of the event window used to assess the effectiveness of the ECB's foreign-exchange-market operations and examine whether this alternative perspective offers additional insights into the effectiveness of the ECB's intervention policy.

In Figure 3a, we use a data sampled at a daily frequency to show the USD/EUR exchange rate for the period January 1999 to January 2001. Because there was no significant inflation differential between Euroland and the U.S. at the time, we focus on the nominal exchange rate. Figure 3a suggests that during the entire period examined here, the euro depreciated against the U.S. dollar. This overall trend was only interrupted during the period May – July 2000 when the euro appreciated slightly. However, in fall 2000, the overall depreciation trend against the euro gathered momentum again. As Figure 3a shows, the central bank interventions of September 2000 did not result in a break – not to mention a reversal – of this significant and enduring trend.

Yet, in November 2000, it seemed as if the euro had reached its absolute historical minimum and was able to gain some strength again thereafter. Despite the fact that the exchange rate of the euro vis-à-vis the dollar was significantly lower at that time compared with the spot rate level at the beginning of EMU in early 1999, the euro followed an upward trend in early 2001. This finding suggests that the interventions conducted by the ECB at the beginning of November 2000 had a major impact on the exchange rate path and were very

effective in the medium term. To test this hypothesis, we present in Figure 3b the exchange rate path of November 2000 in more detail. Figure 3b allows us to address the question that the turnaround in the euro observed in November 2000 can be attributed to the ECB's intervention policy. In contrast to the conclusion which can be drawn from scrutinizing the exchange rate dynamics shown in Figure 3a, we can see in Figure 3b that the euro's depreciation trend stopped at the end and not at the beginning of November 2000. Therefore, it is questionable whether the appreciation of the euro after November 2000 is related to the central bank interventions at the beginning of that month. Indeed, from Figure 3b we can see that the time period between November 9 and November 27 was also characterized by the overall depreciation trend which had already existed before the ECB decided to step into the market. For this reason, it can hardly be claimed that the appreciation trend of the euro which began at the end of November and continued during the whole month of December was caused by the ECB's intervention activity. Thus, the analysis of the medium-term effects confirms the results already derived in subsection 4.1: the foreign-exchange-market interventions conducted by the ECB in the fall of 2000 cannot be classified as an effective policy instrument.

## **5. Conclusion**

In this paper, we analyzed the short and medium-term effects of the interventions in the foreign-exchange-market conducted by the ECB in September and November of 2000. Our analysis suggests that these foreign-exchange-market operations conducted by the ECB did not exert a significant impact on exchange-rate dynamics. Although we were able to detect some effects of the interventions on the level of the exchange rate when using intra-day exchange-rate data, these effects were only minor and tended to be reversed on the days following the interventions. Thus, our analysis shows that the ECB was able to push the exchange rate in the direction intended by the intervention only on the actual intervention day. Analyses of the medium-term effects of the interventions confirmed this result.

Why did the interventions undertaken by the ECB exert only a temporary impact on the USD/EUR exchange rate?

For the signaling channel to work, one prerequisite is that the central bank sends unambiguous and clear signals through its information policy. Such signals should ideally be backed by an internationally coordinated intervention policy. One possible explanation for the lack of effectiveness of the intervention activities may thus be seen in the fact that the ECB

did not succeed to conduct coordinated interventions on a regular basis. While the intervention on September 22, 2000 was a coordinated one, which means that the ECB was supported by other major central banks, all other interventions were conducted unilaterally. This indicates that there seems to be a lack of international consensus regarding the euro's equilibrium exchange rate level or the effectiveness of the effectiveness of FX market interventions.

The effectiveness of an intervention also depends upon the ability of a central bank to convince the general public that such a foreign-exchange-market operation signals a coming change in monetary policy. In this case, interventions affect the exchange rate through the signaling channel if the central bank leaves no doubt that the intervention will be accompanied by a change in the stance of monetary policy. Taking this argument into consideration, the fact that the ECB emphasized that (i) the effects of the intervention on money supply were sterilized<sup>22</sup>, and, (ii) that there would be no change in monetary policy suggests that market participants expected that the ECB did not want to utilize intervention policy as a means to signal a change in its monetary policy.

Finally, it can be argued that the relative ineffectiveness of the FX market interventions carried out by the ECB can be attributed to the fact that the ECB's information policy was not only at odds with the signaling theory of exchange rate determination but was also inconsistent with the noise trading theory of foreign-exchange-market interventions. According to Hung (1997), central banks should conduct secret interventions when the intervention objective is to break or reverse a short or medium-term exchange rate trend. The ECB interventions analyzed in this paper were always made public via a press release confirming the intervention activity. Although one can argue that these statements were released some time after the interventions had been carried out, they nevertheless revealed the intervention activity shortly after it had taken place. In doing so, the ECB signaled to market participants relying on technical trading methods that a short-term strengthening of the euro realized immediately after an intervention was caused by an exogenous factor rather than by a turn around in the market's speculative activity.

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<sup>22</sup> See the announcement of the president of the ECB – Willem Duisenberg – during the discussion in the aftermath of the press conference on 05.10.2000. With respect to the question, whether the effect on the money supply was sterilized via the following open market operations the president answered that the size of the intervention was taken into account when the size of the next open market operations was determined. See ECB (2000b).

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**Table 1:** Percentage Change in the Exchange Rate During the Event Window

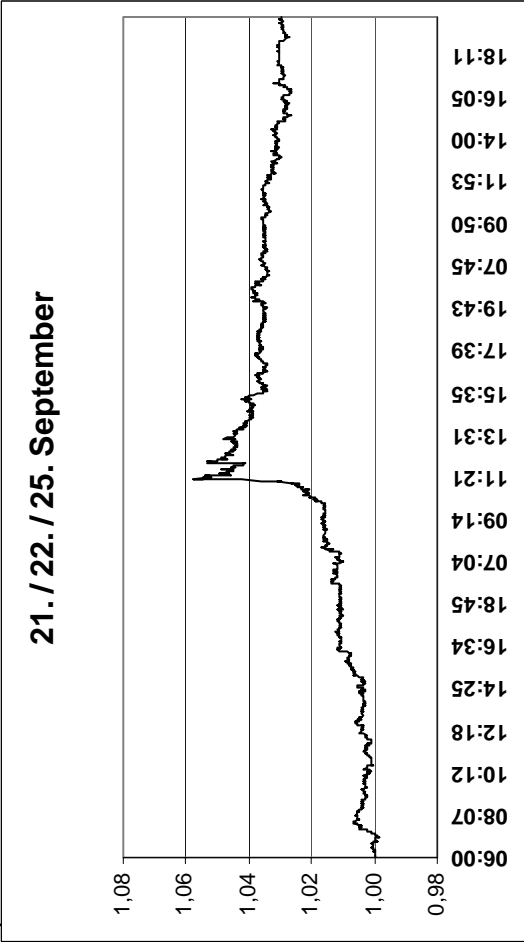
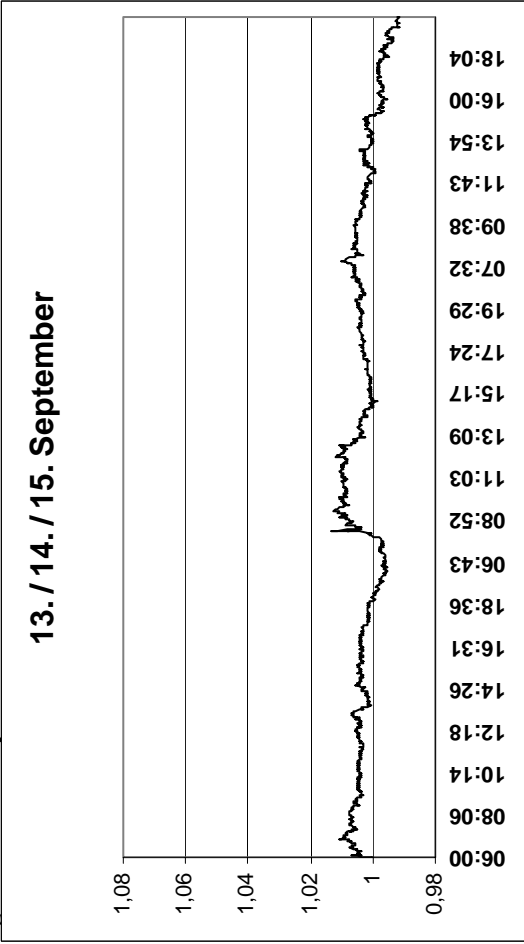
	<b>Day before Intervention 6:00 a.m.–8:00 p.m.</b>	<b>Night before Intervention 8:00 p.m.–6:00 a.m.</b>	<b>Intervention day 6:00 a.m.–8:00 p.m.</b>	<b>Night after Intervention 8:00 p.m.–6:00 a.m.</b>	<b>Day after Intervention 6:00 a.m.–8:00 p.m.</b>
1	09/13/2000	09/13/2000 – 09/14/2000	09/14/2000	09/14/2000 – 09/15/2000	09/15/2000
	- 0.28 %	- 0.07 %	0.89 %	- 0.14 %	- 1.20 %
2	09/21/2000	09/21/2000 – 09/22/2000	09/22/2000	09/22/2000 – 09/25/2000	09/25/2000
	1.10 %	0.23 %	2.17 %	0.32 %	- 0.85 %
3	11/02/2000	11/02/2000 – 11/03/2000	11/03/2000	11/03/2000 – 11/06/2000	11/06/2000
	- 0.01 %	0.15 %	0.70 %	0.02 %	- 0.58 %
4	11/03/2000	11/03/2000 – 11/06/2000	11/06/2000	11/06/2000 – 11/07/2000	11/07/2000
	0.70 %	0.02 %	- 0.58 %	0.31 %	- 0.21 %
5	11/08/2000	11/08/2000 – 11/09/2000	11/09/2000	11/09/2000 – 11/10/2000	11/10/2000
	- 0.67 %	- 0.05 %	1.24 %	0.02 %	- 0.48 %

**Table 2:** Modeling Conditional Exchange Rate Returns Volatility

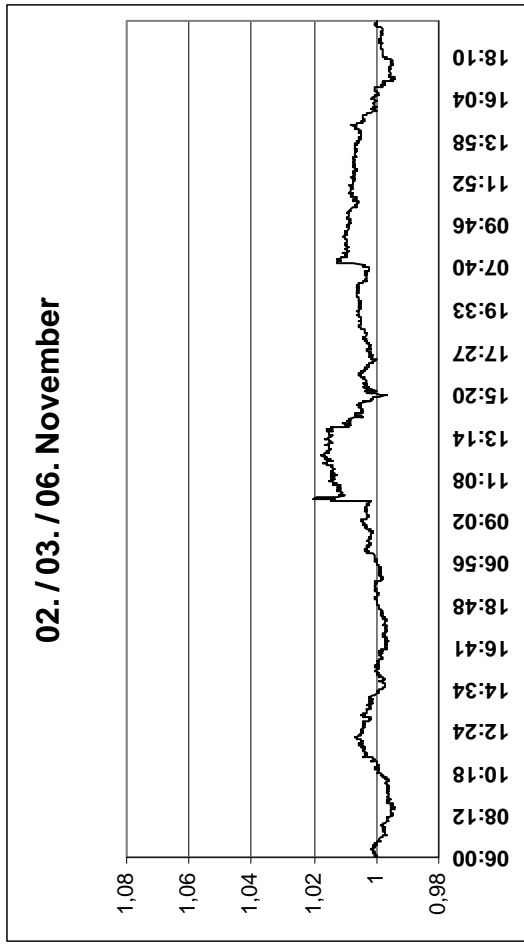
<i>Variance equation</i>				<i>TARCH</i>
Constant <sup>a</sup>	ARCH-coeff.	GARCH-coeff.	dummy	<i>coefficient</i>
0.00001*	0.15**	0.60***	0.000008	0.05
(2.66)	(2.30)	(3.32)	(0.17)	(0.51)
<i>Diagnostic</i>	Q(4)	ARCH(4)	JB	LL <sup>b</sup>
<i>Tests</i>	2.03	3.99	115.26***	1869.39

*Note:* <sup>a</sup> Figures in brackets are standard normally distributed  $z$ -statistics computed as the ratio of the respective coefficients and the corresponding standard deviations. Robust standard errors have been obtained by implementing the technique of Bollerslev and Woolridge (1992). \* (\*\*,\*\*\* ) denotes significance at the 10% (5%, 1%) significance level. <sup>b</sup> LL denotes the value of the maximized log likelihood function.

**Figures 1:** Intra-day Effects of the Interventions of the ECB on the Level of the USD/EUR spot rate

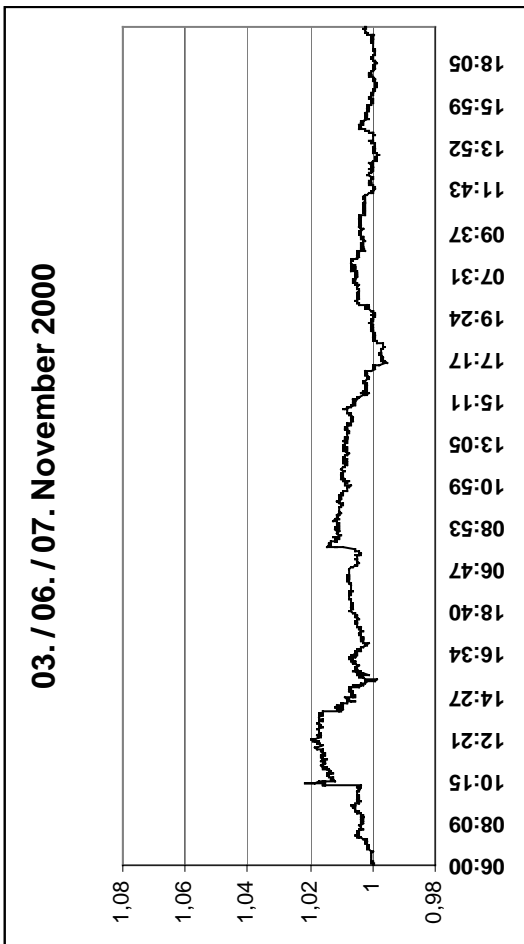


**Figure 1a:** Intervention on September 14, 2000

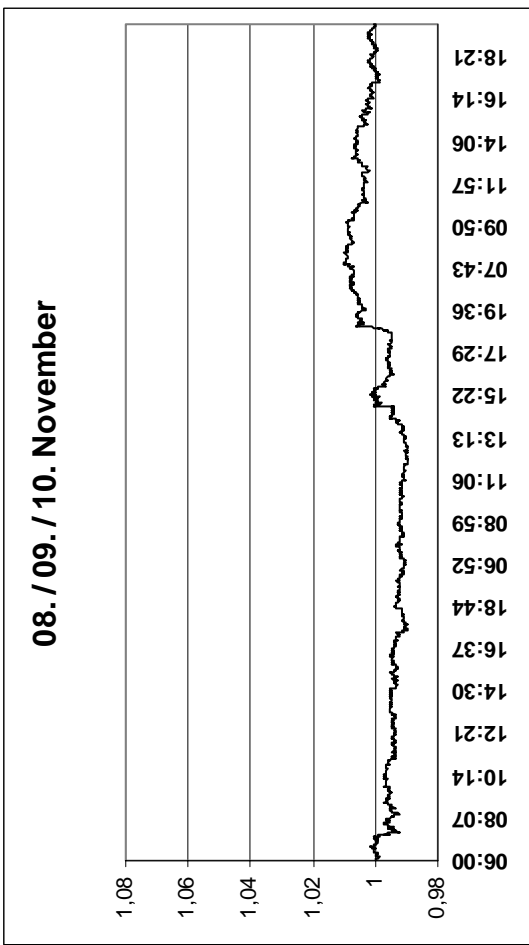


**Figure 1c:** Intervention on November 3, 2000

**Figure 1b:** Intervention on September 22, 2000



**Figure 1d:** Intervention on November 6, 2000



**Figure 1e:** Intervention on November 9, 2000

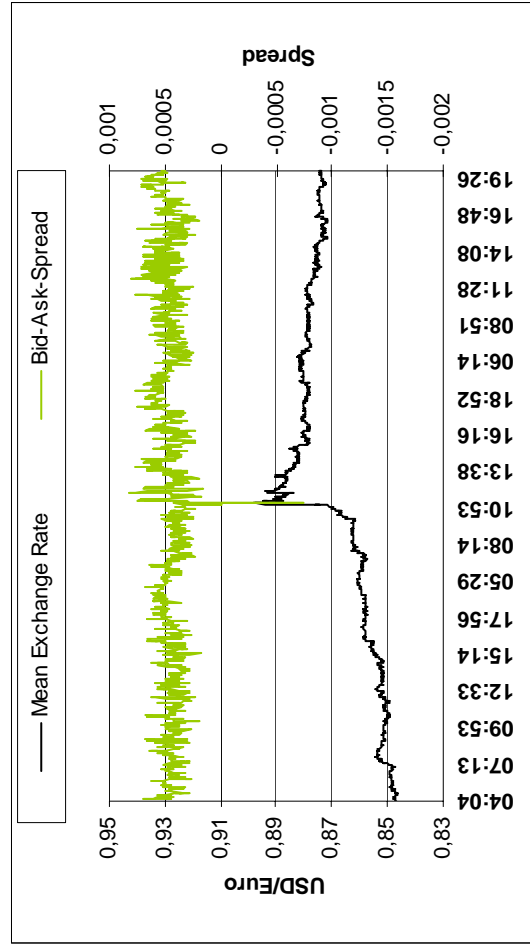
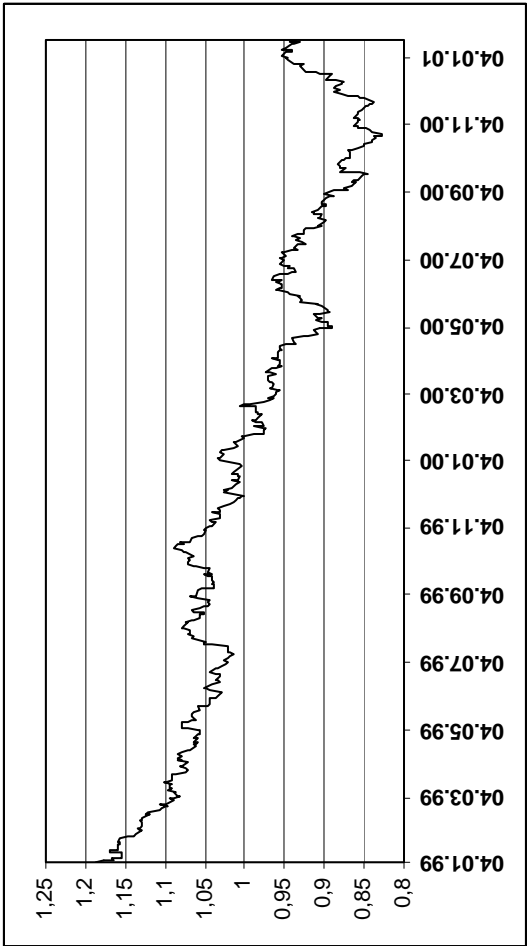
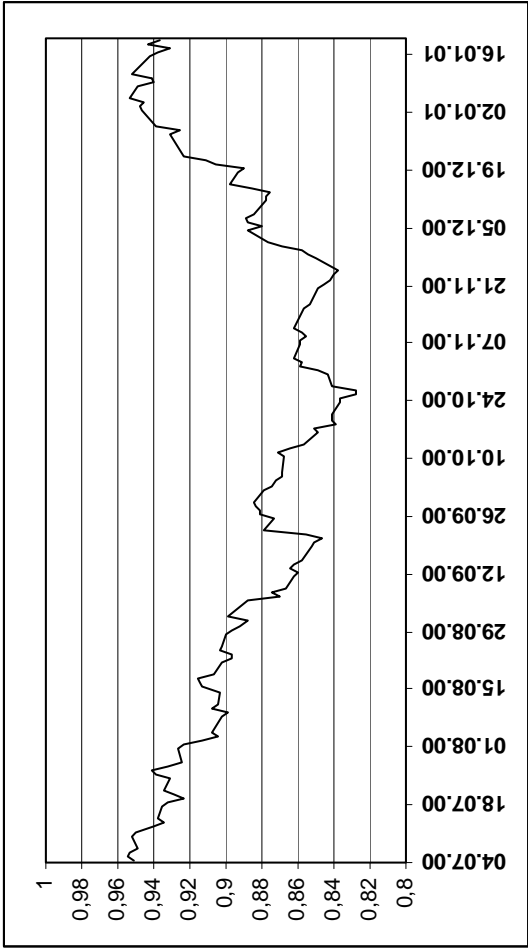


Figure 2: Bid-Ask-Spread (September 21 / 22 / 25, 2000)



**Figure 3a:** Medium-term exchange-rate path



**Figure 3b:** Medium-term exchange-rate path  
(Magnification of Figure 3a)

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