CEPII

CENTRE
D'ÉTUDES PROSPECTIVES
ET D'INFORMATIONS
INTERNATIONALES

No 1999 – 14
September

The Impact of Foreign Exchange Interventions: New Evidence from FIGARCH Estimations

Michel Beine
Agnès Bénassy-Quéré
Christelle Lecourt

TABLE OF CONTENTS

SUMMARY

We investigate the impact of official intervention on the short run dynamics of the Deutschemark and the yen against the US dollar. To this goal, we rely on a FIGARCH model of the exchange rate dynamics, which yields a more appropriate measure of the ex post volatility of the exchange rates than the GARCH model. Indeed, the FIGARCH model implies a finite persistence of volatility shocks (while there is no persistence in the GARCH framework), and is strongly supported by the data.

We use daily data on nominal exchange rates and on foreign exchange interventions as released by the Federal Reserve and the Bundesbank over 1985-1995. Following Bonser-Neal and Tanner (1996) and Dominguez (1998), we compare these data with press reports, in order to distinguish "secrete" from "reported" interventions, and to perform estimations for the yen/dollar exchange rate despite the lack of official data. We also test for the impact of coordinated interventions, i.e. interventions carried out by several central banks simultaneously.

As a whole, the results show that official interventions manage to move the market (especially when they are reported in the press), but often in the wrong direction: official purchases of dollars increase exchange rate volatility and generally induce a dollar depreciation. These findings are mostly in line with the existing literature. Further investigations show that they do not stem from reverse causality, although central banks clearly lean against the wind. Conversely, the results concerning volatility and delayed effects tend to support the market structure interpretation according to which markets firstly test the determination of central banks to move the exchange rate in the direction given by the intervention.

Contrasting to previous empirical studies, we do not find that coordinated interventions are more powerful than isolated interventions once the amounts of sales or purchases are taken into account.

Finally, we show that the traditional GARCH estimations used in the literature tend to underestimate the effects of central bank interventions on the ex-post volatility of exchange rates. This illustrates that measuring volatility through the FIGARCH approach instead of the GARCH one matters in empirical work.

JEL Classification : F31, E58.

Keys words : Exchange rates, official interventions, FIGARCH models.

RÉSUMÉ

Nous examinons l'impact des interventions officielles sur la dynamique de court terme du Deutschemark et du yen par rapport au dollar US. Pour cela, nous utilisons un modèle FIGARCH, qui mesure mieux que le GARCH la volatilité *ex post* des taux de changes. En effet, le modèle FIGARCH conduit à une persistance finie des chocs de volatilité (alors qu'il n'y a pas de persistance dans le GARCH), et cette spécification est corroborée par les données.

Nous utilisons des données quotidiennes de taux de change nominaux et d'interventions officielles pour la période 1985-1995. Ces dernières sont fournies par la Réserve Fédérale et la Bundesbank. Comme Bonser-Neal et Tanner (1996) et Dominguez (1998), nous comparons ces données officielles avec les informations publiées dans la presse, de manière à séparer les interventions «secrètes » des interventions «reportées ». Cela nous permet aussi d'effectuer des estimations pour le taux de change yen/dollar en dépit de l'absence de données officielles. Nous testons aussi l'impact spécifique des interventions coordonnées, c'est-à-dire des interventions menées par plusieurs banques centrales simultanément.

Dans l'ensemble, les résultats montrent que les interventions officielles parviennent à faire bouger le marché (surtout lorsqu'elles sont reportées dans la presse), mais souvent dans la mauvaise direction : des achats officiels de dollars accroissent la volatilité du taux de change et entraînent généralement une dépréciation du dollar. Ces résultats sont cohérents avec la littérature existante. Des estimations complémentaires montrent qu'ils ne proviennent pas de la causalité inverse, même si les banques centrales agissent à contre-courant du marché. En fait, les résultats relatifs à la volatilité et aux effets retardés tendent à conforter l'interprétation en termes de microstructure du marché des changes, selon laquelle, lorsqu'une intervention survient, le marché commence par tester la détermination de la banque centrale à faire varier la monnaie dans le sens de l'intervention.

Contrairement à certaines études antérieures, nous n'obtenons pas un effet plus important des interventions lorsqu'elles sont coordonnées une fois pris en compte le montant des achats et des ventes.

Enfin, nous montrons que la modélisation GARCH traditionnellement utilisée dans la littérature tend à sous-estimer l'effet des interventions sur la volatilité *ex post* des taux de change. Ceci illustre l'importance de correctement mesurer la volatilité dans le travail empirique.

JEL Classification : F31, E58.

Mots clés : Taux de change, interventions officielles, modèles FIGARCH.

The Impact of Foreign Exchange Interventions: New Evidence from FIGARCH Estimations[§]

Michel BEINE[*], *Agnès BENASSY-QUERE*[**] *and Christelle LECOURT*[#]

1. INTRODUCTION

There is extensive evidence showing that real exchange rates became more volatile when the nominal rates were allowed to float, and that such exchange rate volatility hardly stabilized the domestic economies (see Flood and Rose, 1995). Such evidence is part of the rationale for the historical attempts to reduce exchange rate volatility through European exchange rate arrangements and monetary union. It also justifies the proposals for stabilizing exchange rates within fundamentals-determined target zones (Williamson, 1985, Williamson and Miller, 1987 and more recently, Bergsten and Miller, 1999). However, in the latter case, the reorganization of the International Monetary System can be successful only if central banks have powerful instruments to stabilize the exchange rates around what they think to be their fundamental values. The two available instruments are monetary policy and direct intervention on the foreign exchange market. These instruments are inter-related as far as official interventions are not sterilized. However, interventions can also have a signaling effect, i.e. they can provide information about future monetary policy (Dominguez and Frankel, 1993). In this case, the impact of interventions is independent from contemporaneous monetary policy.

Existing evidence on the impact of official interventions on exchange rates is rather mixed. A first generation of studies provided estimations based on quarterly variations of official

[*] CADRE, University of Lille 2, France and SES, MRW, Belgium.

[**] CADRE, University of Lille 2, and CEPII, France.

[#] CADRE, University of Lille 2, France.

[♣] We are grateful to C. Bonser-Neal and K. Dominguez for kindly providing data and advice, and to S. Laurent for his help on econometric issues. We also thank F. Abiven and B. Popek for assistance on updating the data base. This paper has benefitted from helpful comments from A. Boubel, H. Bourguinat as well as from the participants to the XVIièmes journées internationales d'Economie Monétaire et Bancaire, Poitiers, June 1999. All errors and deficiencies remain ours.

[1] See Dominguez and Frankel (1993) and Edison (1993) for surveys. Frankel (1982) and Obstfeld (1990) use such data.

reserves[1]. They showed little impact of these variations on exchange rates, especially when interventions were sterilized. However, the proxies used for interventions were subject to valuation effects which have nothing to do with interventions. In addition, such studies based on quarterly data could not assess the short-run impact of interventions.

Since the early 1990's, the question of the effectiveness of central bank interventions on the foreign exchange market has received a renewed interest due to the public release of daily data of interventions by several major central banks over past periods, and to the development of econometric techniques for daily data displaying non-normal distributions as well as time-dependent conditional variance. A second generation of empirical work devoted increasing attention to the effects on volatility (Bonser-Neal and Tanner 1996, Baillie and Osterberg 1997 a and b, Dominguez 1998) which was the cornerstone of the 1987 Louvre Agreement. Quite surprisingly, as a whole, the literature concludes that interventions either have no impact, or have a positive effect on exchange-rate volatility. In addition, there is some moderate evidence that the purchase of dollars by central banks was associated with subsequent dollar depreciation, which is often interpreted as a "leaning-against-the-wind" behavior from the central banks (Baillie and Osterberg 1997b).

Among this strand of literature, two approaches have been adopted to analyze the effects of central bank interventions on exchange rate volatility. The first one relies on an ex-ante measure of volatility, in particular on the variance observed on the options market (see for instance Bonser-Neal and Tanner 1996). The second one uses an ex-post measure drawn from econometric models that allow the variance to change over time. These models belong to the well-known ARCH and GARCH approaches initiated by Engle (1982) and Engle and Bollerslev (1986). The latter approach allows to study the effect of interventions on both the levels and the volatility. In addition, it deals with observed rather than expected volatility, which makes the interpretation of the results in terms of the efficiency of interventions more straightforward.

Up to now, the above-mentioned analysis based on ex-post measures have exclusively relied on a GARCH specification. Indeed, the GARCH framework seemed to be a well-established model and thus a reliable starting point in analyzing volatility. Nevertheless, the relevance of the GARCH framework -and its special cases, the Integrated GARCH one- has recently been questioned. Indeed, the stable GARCH model implies that the effect of a volatility shock vanishes over time at an exponential rate. By contrast, the IGARCH model implies a complete persistence of such a shock. These features stand in sharp opposition to stylized facts drawn from the study of financial markets. To cope with this issue, Baillie, Bollerslev and Mikkelsen (1996) introduce the Fractionally Integrated GARCH (FIGARCH) model that allows for some persistence of volatility shocks more in line with these facts. Empirical applications of this model to the major daily exchange rates confirm the relevance of this new framework (Baillie, Bollerslev and Mikkelsen 1996, Tse 1998, Beine, Laurent and Lecourt 1999).

The purpose of this paper is to assess the effects of central bank interventions on the variations and volatility of the Deutsche Mark/US Dollar (DEM and USD hereafter) and the Japanese YEN (YEN hereafter)/USD exchange rates using the FIGARCH framework. We compare the results with those of the literature and henceforth assess the importance of relying on a more appropriate measure of volatility. Furthermore, we follow Dominguez (1998) as well as Bonser-Neal and Tanner (1996) in distinguishing the nature of central bank interventions (coordinated or not, reported or secrete), but over a longer period (1985-1995). This fairly new approach turns out to yield quite interesting results that only partly support the previous findings. In particular, it is shown that ignoring the finite persistence of volatility shocks can result in a spurious rejection of the effects of interventions on the volatility of exchange rates. Moreover, our results exhibit some homogeneity across all the major sub-periods of interventions, including the most recent one (1992-1995) that was not investigated in the previous literature.

The paper is organized as follows. Section 2 recalls the technical background of the FIGARCH model. Section 3 presents the data. Section 4 tests for the effects of central bank interventions for the DEM/USD and YEN/USD. Section 5 proposes additional estimations aiming at assessing the robustness of the results and refining their economic interpretation. Section 6 concludes.

2. THE BASIC FIGARCH FRAMEWORK

We test whether US, German and Japanese central bank interventions affect the evolution and volatility of daily DEM/USD and YEN/USD exchange rates[2]. Our full investigation period ranges from 1985 to 1995 but, as explained below, we also decompose it into three sub-periods. We rely on a standard model with time-dependent conditional heteroskedasticity in the spirit of ARCH and GARCH models introduced respectively by Engle (1982) and Bollerslev (1986) . Following several authors, including for instance Palm and Vlaar (1997), the conditional mean is modeled as an MA(1) process[3] with daily effects and additional explanatory variables including central bank interventions on the foreign exchange markets. By contrast to the existing literature[4] the conditional variance is modeled as a FIGARCH (1, *d*, 1)[5]. Our two-equation model is thus written as:

$$r_t = m + e_t + qe_{t-1} + a'D_t + b'x_{t,} \quad e_t \mid \Omega_t \sim \Delta\left(0, s_t^2\right) \qquad (1)$$

$$s_t^2 = w + \left\{1 - [1 - b_1 L]^{-1}(1 - f_1 L)[1 - L]^{d}\right\} e_t^2 + c'D_t + f'|x_t|, \qquad (2)$$

where $r_t = \mathrm{Ln}(S_t / S_{t-1})$, μ is the mean of the process, Ω_t is the information set at time t and Δ is the conditional distribution. q, a', b', c', f', $w, b_1, f_{1,}$ and d are parameters to be

---

[2] These exchange rate data are mid rates quoted respectively in Frankfort at 2:00 pm and in Tokyo at 10:00 am each day. These data are provided by the International Bank for Settlements.

[3] This choice basically relies on the Schwarz Bayesian criterion (not reported here to save place) and is made without loss of generality. The introduction of a second order MA components dit not turn out to be supported by the data. Allowing for an AR(1) term leads to fairly similar results. The MA term in the conditional mean is dropped out when found non significant in order to keep a parsimonious framework.

[4] Although the purpose is quite different (the analysis deals with the forward risk premium and no effect on volatility is considered), Baillie and Osterberg (1998) also combine central bank interventions and FIGARCH innovations.

[5] The MA term capured by the f_1 parameter in the skedastic function is also dropped out when found insignificant. In this case, the basic model reduces to a FIGARCH (1, *d*, 0).

estimated with d being the fractional integration parameter and finally, L is the lag operator. D_t and x_t are explanatory variables capturing the daily effects and the impact the central bank interventions, and $|x_t|$ refers to the absolute value of x_t. These variables will be defined more precisely below. Of course, the conditional variance (2) may be generalized to higher AR and MA orders but necessary and sufficient conditions to ensure the variance to be positive are much more difficult to derive[6]. Interestingly, the FIGARCH(1, d, 1) model nests the GARCH(1,1) model (Bollerslev 1986) for $d = 0$ and the IGARCH model (Engle and Bollerslev, 1986) for $d = 1$. As advocated by Baillie et al. (1996), the IGARCH process may be seen as too restrictive as it implies infinite persistence of a volatility shock. Such a dynamics contradicts stylized facts (see Baillie et al., 1996; Bollerslev and Engle, 1993). By contrast, for $0 < d < 1$, the FIGARCH model implies a long-memory behavior and a slow rate of decay after a volatility shock.

Following Baillie and Bollerslev (1989) and Hsieh (1989) among others, we include a dummy variable Dt in both the mean and the variance equations in order to account for daily effects. Indeed, it has been shown that daily exchange rate variations and volatilities often depend on the day of the week (see Hsieh, 1989). However, since the estimation of the FIGARCH model requires a parsimonious structure, we follow Bollerslev and Mikkelsen (1998) and Beine, Laurent and Lecourt (1999) in using a simple specification that turns out to match relatively well the data. Hence, we have:

$$D'_t = (D_{1,t}\ ,\ D_{2,t}) \tag{3}$$

where $D_{1,t}$ and $D_{2,t}$ stand for the number of vacation days respectively before and after day t.[7] We dropped out $D_{1,t}$ and/or $D_{2,t}$ when non significant to keep the specification as parsimonious as possible.

Like for the GARCH model, the estimation of the FIGARCH model relies on the maximum likelihood or quasi-maximum likelihood (QML) procedure. In this respect, two important points need to be made. The first one concerns the choice of the underlying distribution. As shown by Baillie et al. (1996), the QML estimates obtained with a Gaussian assumption behave relatively well. Nevertheless, as explained by Baillie and De Cennaro (1990) or Pagan (1996), a Student-t distribution may be more appropriate to account for the leptokurticity characterizing the high frequency financial data. Therefore, the log-likelihood to be maximized becomes:

$$Ln\left(L_{ST-1}\right) = T\left[Ln\Gamma\{(v+1)/2\} - Ln\Gamma\{v/2\} - (1/2)Ln p\,(v-2)\right] \tag{4}$$

$$-1/2\sum_{t=1}^{T}\left\{1n\left(s_t^2\right) + (v+1)\left[1n\left(1+\frac{e_t^2}{s_t^2(v-2)}\right)\right]\right\}$$

where $\Gamma(.)$ is the gamma function and v is the degrees of freedom parameter.

[6] See Baillie et al. (1996) on this point.

[7] Daily effects can be interpreted as the expected or delayed impact of the news arriving during the vacation days.

The second point concerns the minimum number of observations required to estimate the FIGARCH model. This minimum number is related to the order of the expansion of the fractional filter $(1 - L)^d$ which is used in computing the coefficient of the infinite lag polynomial $\lambda(L)$ in the following representation of (2):

$$\sigma_t^2 = \left[\omega + c' D_t + f' \left|x_t\right|\right]\left[1 - \beta_1 L\right]^{-1} + \lambda(L)\varepsilon_t^2 \qquad (5)$$

Because of the positive value of d, it is advised to use a sufficiently high truncation lag order. For instance, Baillie et al. (1996) relies on a truncation order equal to 1000. Importantly, as shown by Teyssière (1997) through Monte Carlo simulations, using a too low order induces severe biases, especially in the skedastic function. On this basis, we do not study the effects of interventions on some sub-periods like the one between the Plaza (September 22nd 1985) and the Louvre (February 22nd 1987) agreements.

In order to assess the relevance of the FIGARCH specification, we also estimate a GARCH model. Representation (5) can also apply to the GARCH model but we will rely on the traditional representation to follow the previous literature. Hence, one has to be aware that some parameters including for instance f are not fully comparable between the two models.

Table 1 provides the initial estimation results for the (stable) GARCH and the FIGARCH models with daily effects (but without interventions). The estimation period ranges from 1/1/1985 to 12/31/91 and over the full period (l/1/1985 to 12/31/95). [8]

[8] For the relevance of the choice of these periods, see section 3 below. The data of nominal exchange rates were provided by the Bank of International Settlements. To save space, the estimates for the IGARCH model are not reported.

Table 1: GARCH(1,1) and FIGARCH(1,d,1) models of exchange rates

	DEM (1985-1991)		DEM (1985-1995)		YEN (1985-1991)		YEN (1985-1995)	
	GARCH	FIGARCH	GARCH	FIGARCH	GARCH	FIGARCH	GARCH	FIGARCH
m	-0.046	-0.043	-0.029	-0.029	-0.020	-0.023	-0.014	-0.016
	[-2.677] ***	[-2.530] **	[-2.198] **	[2.204] **	[-1.316]	[-1.529]	[-1.141]	[1.344]
q_1	-0.041	-0.043	-0.051	-0.052	-	-	-	-
	[-1.756) *	[-1.868] *	[-2.790] ***	[-2.907] ***				
a_2	0.037	0.035	0.015	0.014	0.027	0.028	0.011	0.012
	[2.032] **	[1.954] **	[1.024]	[1.000]	[1.709] *	[1.860] *	[0.893]	[0.946]
w	-0.021	0.023	-0.017	0.003	-0.004	0.006	-0.003	0.021
	[1.783] *	[0.756]	[-1.897] *	[0.155]	[-0.327]	[0.225]	[-0.038]	[1.277]
b_1	0.859	0.436	0.876	0.569	0.788	0.316	0.833	0.246
	[36.412] ***	[2.888] ***	[46.481] ***	[6.158] ***	[20.419] ***	[1.747] *	[25.207] ***	[2.605] ***
f_1	0.085	0.197	0.076	0.268	0.161	-	0.119	-
	[5.186] ***	[1.847] *	[6.089] ***	[4.847] ***	[4.988] ***		[4.985] ***	
d	0	0.295	0	0.353	0	0.434	0	0.336
		[3.119] ***		[3.646] ***		[2.497] **		[3.920] ***
c_1	0.132	0.178	0.112	0.180	0.091	0.157	0.068	0.143
	[4.621] ***	[4.505] ***	[5.190] ***	[5.872] ***	[3.189] ***	[4.163] ***	[3.393] ***	[5.179] ***
v	7.539	7.437	6.554	6.630	5.078	5.147	4.948	5.037
	[5.809] ***	[5.654] ***	[8.448] ***	[7.849] ***	[7.576] ***	[6.789] ***	[10.393] ***	[9.923] ***
b3	-0.115	-0.082	-0.117	-0.053	-0.796 **	-0.583 **	-0.492 **	-0.406 *
b4	4.929	4.675	5.046	4.729	11.366 *	9.185	9.541 *	7.921
Q(20)	27.260	27.924	28.407	29.599 *	20.141	19.322	24.970	24.468
Q (20)	23.799	16.587	28.106	16.846	6.308	6.648	12.496	11.223
LogLik	-1943.027	-1938.308	-3038.084	-3021.764	-1727.676	-1717.688	-2727.771	-2713.881

T-statistics of maximum likelihood estimates are in brackets.
*, **and *** indicate rejection respectively at the 10%, 5% and 1 % level.

As a whole, Table 1 suggests that the FIGARCH specification is supported by the data. Indeed, in all cases, the parameter d, i.e. the degree of fractional integration, is highly significantly different both from 0 and 1, rejecting the validity of both the GARCH and the IGARCH specifications. Note also that the for the DEM, the FIGARCH(1, d, 1) model is supported here since the f_1 parameter was found significant at least at the 10% level. In addition, daily effects enter both in the conditional mean and the conditional variance. In particular, it is found that vacation days are followed by higher volatility, which is line with the findings of the literature that concludes to higher volatility on Mondays (Hsieh 1989). Unsurprisingly, the Student-t distribution is also supported by the data: from analogous regressions (not reported here), v^{-1} is found significantly different from zero. Finally, a set of diagnostic statistics are provided: these are skewness (b_3) and kurtosis (b_4)[9] values as well as the Box-Pierce statistics of the residuals (Q(20)) and the squared residuals (Q^2(20)) at lag equal to 20. For both the GARCH and the FIGARCH model, the YEN exhibits excess

[9] In testing for excess skewness and kurtosis, one has to be very cautions because of the Student-*t* assumption. Indeed, the traditional inference procedures used in the normal case are misleading and hence, the confidence intervals have to be stimulated. Therefore, we rely on the simulated critical values proposed by De Ceuster and Trappers (1992), using the estimated v and a number of observations closed to ours.

skewness. As a whole, however, our MA(1)-FIGARCH(1,d,1) model with daily effects and Student-t distribution seems a satisfying starting point for the study of the effects of central bank interventions.

To fully understand the different dynamic properties implied by the FIGARCH model, it may be interesting to look at the cumulative impulse response functions associated to each estimated model, i.e. respectively the stable GARCH one, the FIGARCH one and the IGARCH one. These cumulative impulse response functions aim at analyzing the effect and propagation of volatility shocks. For a given lag *k*, the impulse response coefficient denoted g_k is given by:

$$g_k = \partial E_t\left(e_{t+k}^2\right) / \partial v_t - \partial E_t\left(e_{t+k-1}^2\right) / \partial v_t \qquad (6)$$

where E_t is the expectation operator and $v_t = e_t^2 - s_t^2$. Setting a', b', c', and f' to zero to keep things simple, the computation of these weights can be recovered from the following expression[10]:

$$(1-L)e_t^2 = (1-L)^{1-d} f_1^{-1} w + (1-L)^{1-d} f_1^{-1}[1-b_1 L]v_t \qquad (7)$$

$$= V + g(L)v_t$$

where $g(L) = \Sigma_{k=0,\infty} g_k L^k$. From (7), one sees that these g_k will depend on the estimated value for *d*. The cumulative impulse response coefficient for a given *k*, i.e. $\sum_{i=0,k} g_i$ will provide a measure of the persistence of the volatility shocks implied by a particular model. Nevertheless, the pattern of the g_k coefficients will significantly differ depending on whether the value of *d* is equal to zero or is positive. Figure 1 plots the cumulative response functions in the DEM case (1985-1995 period) for the above estimated GARCH, FIGARCH and IGARCH models.

Figure 1: Cumulative response functions, DEM/USD

[10] For more details, see Baillie et al. (1996).

It can be seen that the IGARCH model imposes infinite persistence in its impulse response weights, whereas the GARCH model implies a rapid exponential decay of the impulse response function. However, the FIGARCH model suggests a more realistic slow hyperbolic decay. This means that the effect of a volatility shock is mean reverting but is quite persistent (lasting for more than ten months). In turn, this implies quite different measures for the conditional volatility used in the subsequent analysis of the effect of interventions.

3. DATA ON OFFICIAL INTERVENTIONS

The Federal Reserve and the Bundesbank kindly provided daily interventions over the period 1985-1995, but like Bonser-Neal and Tanner (1996), Baillie and Osterberg (1997 a and b) and Dominguez (1998), we were unable to get intervention data from the Bank of Japan. The official data (noted *I0* for "official interventions") represent daily net dollar purchases in billions of dollars by the Federal Reserve against the DEM and the YEN, and daily net dollar purchases by the Bundesbank against the DEM.

Central banks could decide to intervene in a concerted or coordinated manner in support of (or against) the same currency. To study whether interventions are more powerful when coordinated, we construct a dummy variable, noted COORD**,** which is equal to 1 when both banks are intervening at the same time in the same direction and 0 otherwise[11]. In order to keep the information on the amounts, we multiply this dummy variable by the sum of (coordinated) interventions (when available). This variable then replaces the initial data IO. This amounts to exclude individual interventions and allows to compare the initial results obtained with the individual interventions.

As suggested by Dominguez (1998), we also include the spread (denoted SPR) between the German and US as well as between the Japanese and US money market rates in order to take into account relative contemporaneous monetary policies in the three countries. When central banks intervene, the evolution of the spread may also indicate whether interventions are sterilized or not. However, the spread mainly moves in response to unexpected domestic monetary interventions[12]. The explanatory variables vector x_t takes the basic following form:

$$x_t = \quad [IO_{BB}\ , IO_{Fed}\ , SPR_{Ger\text{-}US}\ , SPR_{Jap\text{-}US}\ ]'$$

In order to disentangle the portfolio effect and the signaling effect of interventions, we follow Dominguez (1998), in splitting the official amounts *I0* into reported (denoted *IR)* and secret (*IS*) interventions. Daily central bank interventions are frequently reported in newspapers or over the wire services. Here, we consider the interventions reported by the *Wall Street Journal* over the period 1985 to 1991[13] and by the *Financial Times* over the 1992-1995 period. The variable "reported interventions" is set equal to 1 (respectively -1) if

[11] The Bundesbank and the Fed in support (or against) the Deutschemark or the Bank of Japan and the Fed in support (or against) the YEN.
[12] The German and Japanese interest rates are the call money rates and the U.S interest rate is the Federal Funds rate. The latter rate is available on the Federal Reserve web site, whereas the two former rates were collected by WEFA from Financial Times releases.
[13] We are grateful to Catherine Bonser-Neal for providing these data.

the *Wall* Street *Journal* or the *Financial Times* report Federal Reserve, Bundesbank or Bank of Japan purchases (respectively sales) of USD against the DEM or the YEN, 0 otherwise. The comparison between official data and those reported in the press enables to infer which operations were kept secret. For that purpose, we create the variable "secret interventions" in the following way: in case of an official intervention which is not reported by the press, the variable equals 1 for a purchase and -1 for a sale. In the opposite situation, i.e. when the press reports an intervention which did not take place, the variable is set to 0. Lastly, if official and reported interventions exhibit opposite signs (for example the press reported a purchase of dollars but it was actually a sale), the variable is set equal to 1 if there has been an official purchase and -1 for an official sale. The construction of this variable is summarized in Table 2. Note that it is unavailable for the BOJ since official interventions are not known.

Table 2: Construction of the secret Interventions Variable

		Reported Interventions		
		-1	0	1
Official Interventions	>0	1	1	0
	=0	0	0	0
	<0	0	-1	-1

As for coordinated interventions, we multiply these variables by the amounts of official interventions. As shown by Dominguez (1998) but also confirmed by auxiliary regressions (not reported here), ignoring the information provided by the amounts may indeed lead to quite different results.

Table 3 and 4 provide summary statistics on official, reported and secret interventions operations undertaken by the Fed, the Bundesbank and the Bank of Japan over the full period 1985-1995 as well as over three subperiods: the January 1985 to 22 February 1987 sub-period which basically includes the Plaza Agreement, the 23 February 1987 to December 1991 sub-period which corresponds to the Post-Louvre Agreement period and the longer 1985-1991 period during which the main official interventions took place[14]. After the Plaza meeting, G5 central banks explicitly stated that their goal was to get the dollar to depreciate[15]. Their intention was therefore to affect the level rather than the variance of exchange rates. During the second sub-period, the G-5 members changed their commitment into exchange rate stabilization by stating that nominal exchange rates were "broadly consistent with underlying economic fundamentals" (G-6 Communiqué, February 22, 1987). The explicit objective then was to reduce volatility.

[14] Nevertheless, the highest dollar purchases by the Federal Reserve took place on June, 24th 1994 against the DEM and on November 2nd against the YEN. Notice also that this 1985-1991 period is the usual period considered in the previous literature and is thus considered for the sake of comparison.

[15] They stated that "in view of the present and prospective changes in fundamentals, some orderly appreciation of the main non-dollar currencies against the dollar is desirable. They [the ministers and Governors] stand ready cooperate more closely to encourage this when to do so would be helpful" (G5 Annoucement, September 22, 1985).

Table 3 shows that almost all interventions took place over the period 1985-1991 and interventions were particularly active during the sub-period 1987-1991. The average official Fed dollar purchase and sale over the full period is about USD 162 millions on both markets. The corresponding figure is USD 122.8 millions for the Bundesbank over the same period[16]. Coordinated interventions account for a substantial proportion of total interventions over the period 1985-1991: out of 199 and 250 official interventions of the Fed and the Bundesbank respectively, 95 were coordinated. Likewise, out of 170 and 169 interventions of the Fed and Bank of Japan, 113 were coordinated.[17]

Table 3: Official, reported and secret Interventions (number of days)

		FED			**BB**			**B 0 J**	**Coordinated interventions**	
subperiod	number of days	IO	IR	IS	IO	IR	IS	IR	BB and Fed	BOJ and Fed
USD / DEM										
85-87	558	22	21	13	62	32	31	-	16	-
87-91	1265	177	148	52	188	115	83	-	79	-
85-91	1823	199	169	65	250	147	114	-	95	-
85-95	2868	215	184	68	264	161	115	-	97	-
USD / YEN										
85-87	558	22	21	10	-	-	-	36	-	14
87-91	1265	148	132	43	-	-	-	133		99
85-91	1823	170	153	53	-	-	-	169	-	113
85-95	2868	191	163	70	-	-	-	193	-	116

Source : Central Banks

Conditional probabilities of reported and secret interventions were constructed in order to determine which proportion of official interventions is shared by the reported and secret operations. The results are reported in Table 4. For instance, between 1985 and 1991, the probability that Bundesbank and Fed interventions actually occurred given that they were reported is rather high for the DEM (respectively 0.79 and 0.92) as well as for the YEN (0.76). This suggests that there were few false reports of interventions[18]. The Table also reports the probability that Bundesbank and Fed interventions were reported given that they actually occurred. This probability equals respectively 0.54 and 0.67 for the DEM and 0.69 for the YEN, since secret interventions represent a large part of official interventions operations (respectively 32% and 31% of official Fed interventions against the DEM and the YEN and 45% of official Bundesbank interventions against the DEM over the period 1985-1991). This phenomenon is especially obvious during the Plaza Agreement period.

[16] These amounts, which appear considerable, are in fact extremelly small when compared to the total daily activity in the foreign exchange market, which amounted to $600bn in April 1989 and to $1500bn in April 1998 (see BIS,1999).

[17] G-7 reports show that coordinated interventions account for a large part of total interventions of the G-3 economies over the 1985-1991 period: these represent about 75% for Germany and Japan and more than 90% for the United-states (Catte, Galli and Rebecchini, 1992).

[18] Over 1985-1987 however, the probability that the Fed interventions actually occured given that they were reported was lower (about 0.43 for the DEM and 0.57 for the YEN). This may suggest a learning process after the Plaza Agreement.

Table 4: Conditional Probabilities of reported and secret Intervention

	USD / DEM				USD / YEN			
	85-87	87-91	85-91	85-95	85-87	87-91	85-91	85-95
$Prob(IO_{fed}/IR_{fed})^a$	0.43	0.84	0.79	0.79	0.57	0.79	0.76	0.73
$Prob(IR_{fed}/IO_{fed})^b$	0.41	0.70	0.67	0.68	0.54	0.71	0.69	0.64
$Prob(IS_{fed}/IO_{fed})^c$	0.59	0.29	0.32	0.31	0.45	0.29	0.31	0.37
$Prob(IO_{BB}/IR_{BB})^a$	0.98	0.91	0.92	0.92	-	-	-	-
$Prob(IR_{BB}/IO_{BB})^b$	0.50	0.55	0.54	0.56	-	-	-	-
$Prob(IS_{BB}/IO_{BB})^c$	0.50	0.44	0.45	0.45	-	-	-	-

[a] Calculated as the number of days for which we have observations on both official and reported interventions divided by the total number of days of reported intervention.
[b] Calculated as the number of days for which we have observations on both official and reported interventions divided by the total number of days of official intervention.
[c] Calculated as the number of days for which we have observations on both official and secret interventions divided by the total number of days of official intervention.
Source : Authors' calculations.

4. TESTING FOR THE EFFECTS OF CENTRAL BANK INTERVENTIONS

In assessing the effects of interventions on both the levels and the volatility of exchange rates, we use three different specifications for the explanatory vector $x_{t,}$ and perform estimations over three different periods or sub-periods. Our first specification of $x_{t,}$ is the basic one in which intervention variables are the official net purchases of USD by the two involved central banks. Since this information is not available for the BOJ, this variable is proxied by the reported interventions captured by a trinomic variable (- 1, 0, 1). In a second model, only coordinated interventions are included in $x_{t,}$. Finally, in a third regression, we split official interventions into the reported ones and the secret ones. This last specification is of course not available for the interventions of the B0J.

In all the models considered, we take Fed and Bank of Japan intervention at time *t-1* but Bundesbank intervention at time *t* in order to account for time discrepancies between the markets.[19]

We firstly estimate the three models over the full period (1985-1995). We then consider the 1985-1991 sub-period during which most interventions took place. Finally, following Dominguez (1998) among others, we consider a post-Louvre estimation period (02/87-12/91) that aims at assessing how the main statement of the Louvre agreement, i.e. reducing volatility through interventions- was actually achieved. As explained above, the insufficient number of observations needed to estimate the FIGARCH framework prevents us to consider a post Plaza sub-period (09/85-02/87).

Tables 5 and 6 report the effects of official interventions, for both the USD/DEM and the USD/YEN markets, and the results obtained with a GARCH and a FIGARCH specification

[19] The German market is six hours ahead of the US market and eight hours lagging the Japanese Market.

are compared. Table 7 deals with the impact of coordinated interventions[20]. Finally, Table 8 emphasizes the distinction between reported and secret interventions.

Table 5: Official Central Bank Interventions: DEM/USD

	1985-1995		1985-1991		1987-1991	
	GARCH	FIGARCH	GARCH	FIGARCH	GARCH	FIGARCH
m	-0.034	-0.033	-0.045	-0.049	-0.033	-0.031
	[-2.571] **	[-2.573] **	[-3.070] ***	[-2.839] ***	[-1.717] *	[-1.677] *
q_1	-0.056	-0.056	-0.053	-0.049	-0.073	-0.070
	[-3.051] ***	[-3.1191] ***	[-2.106] **	[-2.105] **	[-2.552] **	[-2.497] **
a_2	0.015	0.014	0.037	0.031	0.029	0.022
	[0.845]	[0.964]	[1.856] *	[1.775] *	[1.347]	[1.049]
$b_{IO,BB}$	-1.181	-1.133	-1.116	-1.138	-1.448	1.495
	[-3.612] ***	[-3.123] ***	[-2.672] ***	[-2.856] ***	[-3.538] ***	[-3.555] ***
$b_{IO,fed}$	0.220	0.303	-0.269	-0.066	-0.290	-0.072
	[0.562]	[1.001]	[-0.435]	[0.165]	[-0.633]	[-0.166]
b_{spread}	0.111	0.125	0.069	0.070	0.127	0.097
	[1.269]	[1.484]	[0.564]	[0.615]	[0.795]	[0.573]
w	-0.019	-0.004	-0.020	0.032	-0.011	0.098
	[-2.011] **	[-0.184]	[-1.538]	[0.878]	[-0.668]	[2.423] **
b_1	0.879	0.579	0.863	0.411	0.857	0.064
	[45.576] ***	[7.360] ***	[33.103] ***	[2.560] **	[23.303] ***	[0.933]
f_1	0.069	0.314	0.077	0.260	0.063	-
	[5.572] ***	[5.552] ***	[4.476] **	[1.698] *	[3.651] ***	
d	-	0.308	-	0.234	-	0.129
		[4.322] ***		[3.574] ***		[3.647] ***
c_1	0.112	0.162	0.132	0.158	0.118	0.160
	[5.149] ***	[5.594] ***	[4.561] ***	[4.157] ***	[3.208] ***	[3.619] ***
$f_{IO,BB}$	0.309	1.136	0.350	1.251	0.457	1.092
	[1.691] *	[1.843] *	[1.553] *	[1.783] *	[1.313]	[1.457]
$f_{IO,fed}$	-0.049	1.366	0.140	0.663	-0.076	0.954
	[-0.479]	[2.253] **	[0.972]	[1.207]	[-0.329]	[1.461]
f_{spread}	0.027	-0.147	-0.053	-0.160	-0.102	-0.131
	[0.476]	[-2.109] **	[-0655] **	[-2.237] **	[-1.502]	[-1.223]
v	6.371	7.067	7.192	7.722	7.097	8.460
	[8.474]	[7.786] ***	[5.896] ***	[5.615] ***	[5.066] ***	[4.239] ***
b_3	-0.150	-0.013	-0.164	-0.050	0.026	0.126
b_4	5.184	4.511	5.063	4.552	3.849	3.849
Q(20)	27.164	27.279	27.085	27.095	22.741	22.741
Q^2 (20)	28.539	19.837	28.350	17.724	19.954	19.954
Log Lik.	-3026.3	3001.6	-1934.4	-1926.2	-1244.6	-1244.6

t-statistics of maximum likelihood estimates are in brackets.
*, ** and *** indicate rejection respectively at the 10%, 5% and 1 % level.

[20] Concerning Table 7, the coefficient should not be compared across currencies because coordinated interventions by the Fed and the BOJ on the YEN do not include the amounts related to the BOJ.

Table 6: Impact of Official Interventions: YEN/USD

	1985-1995		1985-1991		1987-1991	
	GARCH	FIGARCH	GARCH	FIGARCH	GARCH	FIGARCH
m	-0.015	-0.015	-0.014	-0.016	0.002	-0.007
	[-1. 208]	[1.232]	[-0.938]	[-1.068]	[0.099]	[-0 340]
a_2	0.012	0.012	0.027	0.029	0.020	0.023
	[0.960]	[0.957]	[1.793] *	[1.887 *	[1.027]	[1.200]
$b_{IO,BOJ}$	-0.004	-0.046	-0.158	-0.152	-0.178	-0.166
	[-0.050]	[-0.597]	[-2.216] **	[-2.227] **	[-2.288] **	[-2.220] ***
$b_{IO,fed}$	-1.152	-0.916	-1.984	-1.926	-1.917	-1.865
	[1.885] *	[-1.362]	[-2.958] ***	[2.945] ***	[-2.749] ***	[-2.776] ***
b_{spread}	-0.040	0.011	-0.076	-0.038	0.018	0.042
	[-0.474]	[0.122]	[-0.479]	[-0.350]	[0.154]	[0.421]
w	0.001	0.015	-0.001	-0.006	-0.007	0.012
	[0.162]	[876]	[-0.022]	[-0.299]	[0.444]	[0.472]
b_1	0.821	0.200	0.765	0.205	0.790	0.187
	[22.221] ***	[2.421] **	[16.056] ***	[1.920] *	[14.319] ***	[1.357]
f_1	0.119		0.166	-	0.132	-
	[4.818] ***		[4.907] ***		[4.414] ***	
d	-	0.299		0.350	-	0.287
		[4.117] ***		[3.471] ***		[2.660] ***
c_1	0.062	0.134	0.078	0.148	0.056	0.110
	[2.890] **	[5.144] ***	[2.514] **	[4.228] **	[1.459]	[3.366] ***
$f_{IO,BOJ}$	0.076	0.346	0.084	0.283	0.064	0.304
	[2.148] **	[3.119] ***	[2.073] **	[2.795] **	[1.540]	[2.528] **
$f_{IO,fed}$	0.175	0.811	0.020	0.347	0.006	0.332
	[1.117] ***	[2.924] ***	[0.111]	[0.931]	[0.045]	[1.004]
f_{spread}	-0.062	-0.097	0.100	-0.083	0.105	-0.203
	[-1.143]	[-1.557]	[1.058]	[-1.243]	[0.832]	[-2.996] ***
v	4.972	5.261	5.175	5.345	6.587	6.743
	[10.152] ***	[9.276] ***	[7.247] **	[6.797] ***	[5.602] ***	[5.224] ***
b_3	-0.495 *	-0.523 **	-0.944 **	-0.795 **	-0.446 **	-0.381 ***
b_4	10.515 *	8.863	12.631 **	10.295 *	4.606	4.472
Q(20)	18.409	18.481	15.847	15.146	14.334	13.364
$Q^2(20)$	12.033	9.933	5.763	5.913	17.780	20.130
Log Lik.	-2716.084	-2695.946	-1709.6	-1698.6	-1184.9	-1178.9

t-statistics of maximum likelihood estimates are in brackets.

*, ** and *** indicate rejection respectively at the 10%, 5% and 1 % level.

Table 7: Impact of Coordinated Interventions

	DEM/USD			YEN/USD		
	1985-1995	1985-1991	1987-1991	1985-1995	1985-1991	1987-1991
m	-0.033	-0.046	-0.026	-0.016	-0.023	-0.010
	[-2.514] **	[-2.706] ***	[-1.378]	[-1.294]	[-1.532]	[-0.495]
f_1	-0.055	-0.045	-0.065	-	-	
	[3.047] ***	[-1.974] **	[-2.348] **			
a_2	0.016	0.036	0.026	0.011	0.026	0.019
	[1.119]	[1.977] **	[1.308]	[0.870]	[1.701] *	[0.976]
b_{coord}	-0.504	-0.468	-0.529	-0.156	-0.157	-0.180
	[-1.684] *	[-1.603] *	[-1.706] *	[-2.159] **	[-2.137] **	[-2.098] **
b_{spread}	0.124	0.073	0.108	0.001	-0.037	0.056
	[1.451]	[0.512]	[0.622]	[0.011]	[-0.345]	[0.507]
w	0.010	0.036	0.097	0.021	-0.004	0.013
	[0.441]	[1.044]	[2.396] **	[1.172]	[-0.182]	[0.515]
b_1	0.562	0.406	0.074	0.202	0.226	0.238
	[6.343] ***	[2.545] **	[1.016]	[2.659] ***	[2.180] **	[1.119]
$f1$	0.283	0.204	-	-	-	-
	[4.839] ***	[1.644] *				
d	0.329	0.259	0.143	0.295	0.355	0.310
	[3.913] ***	[3.313] ***	[3.647] ***	[4.450] ***	[3.590] ***	[2.566] **
c_1	0.172	0.168	0.176	0.139	0.150	0.115
	[5.609] ***	[4.248] ***	[3.740] ***	[5.165] ***	[4.225] ***	[3.435] ***
f_{coord}	0.765	0.734	0.944	0.329	0.264	0.265
	[1.754] *	[1.866] *	[2.015] **	[2.376] **	[2.166] **	[2.028] **
f_{spread}	-0.153	0.162	-0.131	-0.095	-0.083	-0.224
	[-2.450] **	[-2.210] **	[-1.223]	[-1.499]	[-1.204]	[1.457]
v	6.563	7.331	8.460	5.212	5.455	6.872
	[8.020] ***	[5.742] ***	[4.239] ***	[9.703] ***	[6.749] ***	[5.141] ***
b_3	-0.042	-0.086	-0.126	-0.419 *	-0.602 **	-0.153
b_4	4.808	4.780	3.936	7.854	9.344 *	4.788
Q(20)	29.918	27.840	23.552	21.055	16.556	14.915
$Q^2(20)$	16.955	18.878	16.478	8.898	6.130	19.286
Log Lik.	-3014.989	-1934.196	-1253.148	-2703.835	-1709.736	-1188.851

t-statistics of maximum likelihood estimates are in brackets.
*, ** and *** indicate rejection respectively at the 10%, 5% and 1% level.

Table 8: Impact of reported and secret Interventions

	DEM / USD			YEN / USD		
	1985-1995	1985-1991	1987-1991	1985-1995	1985-1991	1987-1991
m	-0.033	-0.048	-0.031	-0.016	-0.024	-0.013
	[-2.583] **	[-2.766] ***	[-1.562]	[-1.324]	[-1.593]	[-0.648]
f_1	-0.055	-0.046	-0.067		-	-
	[-3.007] ***	[-1.977] **	[-2.347] **			
a_2	0.015	0.032	0.022	0.012	0.028	0.023
	[1.002]	[1.743] *	[1.091]	[0.969]	[1.831] *	[1.199]
$b_{IR,BB\ or\ BOJ}$	-0.831	-0.818	-1.197	-0.039	0.065	0.056
	[-1.935] *	[-1.717] *	[-1.962] **	[-0.557]	[0.847]	[0.658]
$b_{IR,\ fed}$	0.519	0.099	0.020	-1.344	-1.841	-1.931
	[1.465]	[0.233]	[0.022]	[-2.316] **	[-2.898] ***	[-2.917] ***
$b_{IS,BB\ or\ BOJ}$	-2.312	-1.967	-2.147	-	-	-
	[-3.473] ***	[-2.670] ***	[-2.386] ***			
$b_{IS,\ frd}$	-0.179	-0.911	-0.641	0.643	-3.363	-2.935
	[-0.324]	[-1.134]	[-0.662]	[0.593]	[-3.327] ***	[-2.690] ***
B_{spread}	0.129	0.079	0.100	0.011	-0.033	0.045
	[1.526]	[0.534]	[0.594]	[0.127]	[-0.316]	[0.486]
w	-0.003	0.036	0.106	0.010	-0.013	0.013
	[-0.121]	[0.938]	[2.559] **	[0.522]	[-0.725]	[0.662]
b_1	0.587	0.434	0.060	0.159	0.166	0.153
	[7.689] ***	[2.716] ***	[0.877]	[2.613] **	[2.229] **	[1.371]
$f1$	0.321	0.252	-	-	-	-
	[4.268] ***	[1.912] *				
d	0.306	0.234	0.124	0.251	0.297	0.234
	[4.268] ***	[3.372] ***	[3.576] ***	[5.048] ***	[4.216] ***	[3.101] ***
c_1	0.161	0.158	0.163	0.127	0.143	0.107
	[5.464] ***	[4.048] ***	[3.517] ***	[5.202] ***	[4.335] ***	[3.412] ***
$f_{IR,\ BB\ or\ BOJ}$	1.461	1.601	1.433	0.148	0.160	0.138
	[2.036] **	[2.001] **	[1.803] *	[1.724] *	[1.787] *	[1.335]
$f_{IR,\ fed}$	1.860	0.800	1.103	3.115	2.700	2.519
	[2.232] **	[1.139]	[1.383]	[2.700] ***	[2.206] **	[2.366] **
$f_{IS,\ BB\ or\ BOJ}$	-0.162	-0.345	-0.151	-	-	-
	[-0.319]	[-0.638]	[-0.209]			
$f_{IS,\ fed}$	-0.099	-0.126	0.214	6.578	0.573	0.914
	[-0.274]	[0.188]	[0.304]	[2.281] **	[0.346]	[0.669]
f_{spread}	-0.153	-0.169	-0.137	-0.101	-0.099	-0.215
	[2.400] **	[-2.257] **	[-1.356]	[-1.723] *	[-1.690] *	[-3.585] ***
v	7.288	7.950	9.079	5.822	5.813	7.784
	[7.462] ***	[5.349] ***	[3.873] ***	[9.236] ***	[6.849]	[5.074] ***
b_3	0.001	-0.022	0.148	-0.357 **	-0.359 **	- 0.220 *
b_4	4.480	4.572	3.892	6.011	6.927	3.941
Q(20)	27.004	26.670	21.989	18.655	15.092	11.616
$Q^2(20)$	21.233	17.861	19.239	9.309	8.823	20.458
Log Lik.	-2994.046	-1921.987	-1242.331	-2679.654	-1693.944	-1175.132

t-statistics of maximum likelihood estimates are in brackets.

*, ** and *** indicate rejection respectively at the 10%, 5% and 1 % level.

The results suggest five main comments.

First, central bank interventions generally exert a significant impact on the conditional mean of exchange rate variations. This is obviously the case for the Bundesbank on the DEM for all the sub-periods. This is also the case with the Fed and the BOJ for the YEN. Interestingly however, the impact of these interventions displays an unexpected sign. In other terms, net purchases of dollars tend to be associated to subsequent depreciation of the dollar. This result is in line with previous findings of the literature (Almekinders and Eijffinger 1993, Dominguez and Frankel 1993, Baillie and Osterberg 1997b). It is also robust to the exclusion from the analysis of sterilized interventions, which are generally considered less powerful to move the exchange rate in the desired direction[21]. The traditional interpretation of this result (proposed for instance by Baillie and Osterberg 1997b) refers to leaning-against-the-wind effects, i.e. to the attempts by a central bank to oppose a depreciation of its currency. Hence, this would stem from reverse causality. In order to investigate this interpretation, we present causality tests in Section 5.1.

An alternative interpretation of this surprising sign is that daily frequencies obscure a sequence of effects that take place at a higher (intraday) frequency. After an initial successful intervention (within a couple of hours), the market can further attack the currency in order to test the commitment of the central bank to defend the currency. This may actually result in a depreciation at the end of the day[22]. Provided central banks keep on defending the currency and thus exhibit somme resolve to intervene, the adverse effect may be balanced later (for instance the day after). Official central bank intervention data on an intraday basis are unavailable and prevent us to specifically assess this hypothesis[23]. However, we can study whether interventions have a different impact in the very short run and one or two days after. The results are presented in Section 5.2.

Coming back to Tables 5 and 6, one notices that the interest rate spread has no significant impact on exchange rate variations. This may result from the fact that changes in short run interest rates were expected before they happened over the estimation period.

[21] We estimated another model where the intervention variable is I x SPR, where I is a dummy which is set to 1 when either the Federal Reserve or the Bundesbank (or the Bank of Japan) intervenes, zero otherwise, and SPR is the interest rate differential between the Bundesbank (or the BOJ) and the Fed. Hence, this intervention variable is positive (negative) in case of non-sterilized interventions consisting in selling (buying) dollars which leads to a change in the spread. Is is equal to zero either when no intervention occurs or when interventions are sterilized. Our results, which are not reported here in order to save space, show that a non-sterilized intervention consisting, for instance, in buying dollars, leads to a dollar depreciation, like in our baseling estimation. The impact of interventions on the volatility is no longer significant, which we found out ot be related to the fact that our non-sterilized interventions variable drops the informtion in terms of the amount of interventions.

[22] This interpretation was suggested by a discussion with some traders from Caisse des Dépôts et Consignations. It is consistent with our results concerning the impact of interventions on exchange-rate volatility (see below for comments).

[23] Notice however that Chang and Taylor (1998) use intraday data based on reported interventions of the BOJ retrieved from Reuter's headlines on a limited period (1992-1993).

[24] However, the effect is not significant for the DEM after the Louvre Agreement.

Second, our analysis yields quite interesting results concerning the effects on volatility of interventions. Indeed, we find strong evidence that central bank interventions tend to increase rather than to reduce the volatility of exchange rates[24]. In no case, ex-post volatility is found to decrease with some intervention. Such effects are found significant for each central bank at least over one sub-period. This result is also consistent with the major stream of the literature and particularly with Baillie and Osterberg (1997a and b), Dominguez (1998) and Bonser-Neal and Tanner (1996). It is consistent with the microstructure interpretation evoked above, according to which the market tests the determination of the central banks just after the interventions occur. Interestingly enough, the FIGARCH estimations (through the estimated degree of persistence in the variance *d*) suggest that these undesired effects can last for some time, which stresses further the importance of the results. It is also worth noting that increases in the interest spread seem to reduce exchange rate volatility in some cases.

Third, the distinction between reported and secret interventions appears to be of overwhelming importance in explaining the effects on both the mean and the variance of exchange rate variations. While secret interventions seem to exert a strong influence on exchange rate variations, their effect is generally not significant on their variance. By contrast, reported interventions clearly increase the volatility of exchange rates, regardless the sub-period considered. They are also found to influence the conditional mean, although the significance level is generally lower than for secret interventions. Some of these findings stand in clear opposition to the ones of Dominguez (1998) who found that secret interventions increase ex-post volatility. Several explanations for such a divergence in the results can be put forward. The first one lies in a somewhat different definition given to the reported and secret interventions compared to the methodology of Dominguez. The second one is that our secret and reported interventions exclusively refer to amounts and not to dummy variables that can neglect some important information. A third explanation would be that central banks keep their interventions secret when they do not want to move the market or when they prefer to avoid giving signals concerning future policies. Although partially informed, the market is less aware of interventions when the latter are not reported (see Dominguez and Frankel, 1993 p. 70 and 126). The fact that few agents are aware of secret interventions may explain why only reported interventions have a (positive) impact on volatility. Hence, the results are consistent with the idea that interventions increase exchange rate volatility through a signaling effect (which is absent from secrete interventions). The results also suggest that the signals provided by central bank intervention are not considered as fully credible or unambiguous.

Fourth, the results with coordinated interventions are very similar to those obtained with separate variables for the various central bank interventions. In particular, there is some clear evidence that a coordinated purchase of dollars is significantly associated to subsequent dollar depreciation[25]. The same patterns apply to volatility, which is found in all cases to increase due to coordinated interventions. Our results contrast with the findings of Dominguez (1990) and Dominguez and Frankel (1993) showing that coordinated

[25] Interestingly, the coefficient on coordinated DEM/USD interventions is roughly half the coefficient (Table 7) obtained on Bundesbank interventions (Table 5).

interventions are more powerful than isolated interventions in moving the exchange rate level. It is however worth emphasizing that Dominguez and Frankel use a dummy variable for coordinated interventions. One advantage of our approach is that the magnitudes of the effects are fully comparable across both specifications.

Finally, it turns out that the FIGARCH measure of volatility yields interesting results. Even though the f coefficients are not fully comparable between the GARCH and the FIGARCH models (because of the specification of the constant term), it may be seen that the FIGARCH model captures more frequently the effects of interventions in terms of volatility. This is for instance obvious for BOJ interventions after the Louvre but also for the other cases concerning the significance levels of the f parameters. Henceforth, there is some tendency for the traditional GARCH models to spuriously reject the effects of interventions on the volatility of exchange rates. In turn, this further justifies the use of the FIGARCH model in dealing with ex-post measures of volatility.

5. ALTERNATIVE INTERPRETATIONS OF THE INTERVENTION PUZZLE

In this section, we further investigate the interpretations behind the unexpected signs obtained for the effects of interventions on the conditional mean of exchange rate variations. Section 5.1. deals with causality tests relative to the leaning-against-the-wind interpretation while section 5.2. allows for dynamic effects.

5.1. Reverse causality and leaning against the wind

In Section 4, it has been found that interventions exert a highly significant impact on the spot rate, but also that this effect is "incorrectly signed" with respect to the conventional rationale for interventions. In turn, this requires an additional analysis aiming at assessing the robustness of these results on the one hand, and refining the possible interpretation in terms of leaning-against the-wind effects on the other hand.

The first assessment requires to test for endogeneity biases that can be responsible for this result. This requires the use of our endogenous variables, i.e. r_t and s_t^2 as explanatory variables of interventions. Since an important part of the intervention data take zero values, this additional analysis is best performed in a probit model, in which we add the lagged interventions as control variables. The results of this analysis for the official interventions data are gathered in Table 9[26].

[26] Similar conclusions are obtained for the reported and the secret interventions but are not given here in order to save space.

Table 9: Probit Intervention model (official interventions)

	DEM				YEN			
	Federal Reserve		Bundesbank		Federal Reserve		BOJ	
	1985-1991	1985-1995	1985-1991	1985-1995	1985-1991	1985-1995	1985-1991	1985-1995
Constant	-1.599	-1.453	-1.337	-1.635	-1.815	-1.930	-1.795	-1.852
	[-30.824] ***	[-38.900] ***	[-29.964] ***	[-39.319] ***	[-29.968] ***	[-37.230] ***	[-29.934] ***	[-37.851] ***
r_t	-0.337	-1.340	1.274	-0.275	-0.341	-0.072	-0.015	-0.022
	[-0.176]	[-0.327]	[0.786]	[-0.160]	[-0.951]	[-1.986] **	[-0.570]	[-0.655]
s^2_{t-1}	0.028	-0.047	-0.022	-0.006	-0.059	0.094	-0.080	-0.007
	[0.642]	[0.802]	[-0.570]	[-0.161]	[-1.290]	[2.222] **	[-1.789] *	[-0.194]
$IO_{fed,\ t-1}$	6.704	0.674	4.520	4.324	6.365	2.979	0.996	2.293
	[8.020] ***	[9.865] ***	[6.669] ***	[10.576] ***	[6.053] ***	[5.297] ***	[6.294] ***	[4.109] ***
$IO_{BB,\ t-1}$	5.610	1.111	3.357	2.311	-	-	-	-
	[9.131] ***	[2.361] **	[5.661] ***	[5.592] **	-	-	-	-
$IO_{BOJ,t-1}$	-	-	-	-	0.643	0.957	0.440	1.181
					[4.242] ***	[7.517] ***	[2.702] ***	[9.679] ***
$IO_{fed,t-2}$	1.910	4.869	-0.335	1.183	2.721	2.064	0.700	0.311
	[2.842] ***	[9.865] ***	[-0.500]	[9.865] ***	[2.787] ***	[3.438] ***	[4.309] ***	[0.485]
$IO_{BB,t-2}$	-0.270	4.052	3.671	0.546	-	-	-	-
	[-0.421]	[8.857] ***	[6.562] ***	[0.954]				
$IO_{BOJ,t-2}$	-	-	-	-	0.721	0.824	0.148	0.761
					[4.726] ***	[6.232] ***	[0.857]	[5.848] ***
LR test	0.417	1.027	0.732	0.111	3.830	8.402 **	3.202	0.472
Correct cases	90.60%	91.03%	87.54%	93.32%	92.28%	93.21%	91.15%	93.94%

On the basis of Table 9, we can in general disregard the possibility of an endogenous bias in explaining the incorrectly signed effects of interventions on the condition mean of exchange rate variations. With few exceptions, neither the returns, nor the ex-post volatility seem to have induced the monetary authorities to intervene[27]. While we can discard the endogeneity bias on the basis of Table 9, we cannot however reject the possibility of a leaning-against-the-wind type of behavior. The reason is that the day-to-day changes r_t of the nominal exchange rate are too restrictive as an explanatory variable for interventions. As defined by Dominguez and Frankel (1993), leaning-against-the-wind interventions are "intervention operations that attempt to move an exchange rate in the opposite direction from its current trend". Indeed, Catte, Calli and Rebecchini (1992) show that most episodes of repeated interventions "acted to counter the trend of the dollar, leaning against the wind". To test for such phenomenon, one should use the deviation of the exchange rate S_t from a certain target level S*.

There are basically two possibilities. The first approach, adopted for instance by Baillie and Osterberg (1997b) relies on a proxy for the equilibrium exchange rate (for instance those reported by Funabashi 1989). The second one, used for instance by Dominguez (1998), specifies a trend variable, proxied for instance by a moving average of past values of S_t. To test for the robustness of the results, we follow both approaches. The equilibrium exchange rate S_t^* is proxied by the purchasing power parity (PPP) exchange rate which is implicitly at

[27] A noticeable exception is the effect on the YEN volatility of the interventions of the Fed and the BOJ. Nevertheless, for the BOJ, one should take this result with cautious. First, the obtained sign is counter-intuitive (more volatility reduces the probability of intervention). Second, one has to remember that the official interventions are proxied for the BOJ by the reported ones, with some possible errors occuring.

the center of international monetary negociations[28]. Alternatively, a trend is computed as a two-week moving average of past spot rates. Since both specifications yield the same conclusions, we report only the results based on the PPP target. Finally, in order to test for leaning-against-the-wind, we distinguish purchases from sales in the dependent probit variable. The estimations for the official interventions obtained from a probit model are reported in Table 10.

Table 10: Leaning against the Wind Effects

	DEM				YEN			
	Federal Reserve		Bundesbank		Federal Reserve		BOJ	
	1985-1991	1985-1995	1985-1991	1985-1995	1985-1991	1985-1995	1985-1991	1985-1995
Constant	-2.552	-2.681	-2.089	-2.073	-4.962	-3.429	-3.726	-2.787
	[-16.545] ***	[-15.965] ***	[-21.256] ***	[-25.970] ***	[-11.714] ***	[-11.404] ***	[-12.227] ***	[-12.170] ***
$(s_t\text{-}s_t^*)$	-5.314	-1.846	-2.572	-0.304	-0.066	-0.022	-0.044	-0.014
	[-7.234] ***	[-5-053] ***	[-4.850] ***	[-1.582]	[-8.312] ***	[-5.477] ***	[-7.312] ***	[-4.611] ***
Correct cases	89.04%	97.28%	96.56%	97.64%	94.29%	97.14%	95.79%	96.51%

Sales of USD

	DEM				YEN			
	Federal Reserve		Bundesbank		Federal Reserve		BOJ	
	1985-1991	1985-1995	1985-1991	1985-1995	1985-1991	1985-1995	1985-991	1985-1995
Constant	-1.466	-1.535	-1.279	-1.351	-1.527	-1.413	-1.463	-1.329
	[-31.725] ***	[-35.211] ***	[-30.555] ***	[-34.051] ***	[-33.246] ***	[-17.424] ***	[-27.285] ***	[-17.538] ***
$(s_t\text{-}s_t^*)$	0.318	0.712	0.468	0.697	0.002	0.006	0.005	0.009
	[4.864] ***	[7.212] ***	[4.864] ***	[7.907] ***	[1.152] ***	[5.078] ***	[3.635] ***	[7.294] ***
Correct cases	92.44%	95.20%	90.60%	93.16%	94.29%	96.25%	94.52%	96.51%

As a whole, these results strongly support an unsuccessful (at least in the very short run) leaning-against-the-wind behavior of central banks. All coefficients on S_t - S_t^* are consistent with this type of reaction: central banks tend to sell dollars when the latter appreciates away from its PPP level, and to buy it in the opposite case. Furthermore, almost all these coefficients are significant at the 1% level, for the three central banks and over all the periods under investigation. These findings confirm previous results in favor of the leaning-against-the wind interpretation (see among others Almekinders and Eijffinger 1993).

5.2 Lagged effects of interventions

An alternative explanation of the unexpected sign of central bank intervention provided by the study of financial markets microstructure refers to the behavior of the market testing the resolve of some central banks to intervene. In order to test for such an explanation despite the lack of intraday data, we allow for lagged effects of central interventions. If such a process holds, one should get the adverse sign in the short run, say the same day, as the market further attacks the currency under pressure to test the central bank commitment. By contrast, as the central bank keeps on defending the currency, one should obtain the expected effect on the exchange rate and thus a positive sign the day(s) after.

[28] The PPP exchange rate is defined here as the nominal exchange rate which would have kept the real exchange rate at its mean value over 1974-1991 (or 1974-1995). Monthly consumer price indexes are taken from the IMF International Financial Statistics, and interpolated in order to get daily data.

Table 11 reports the regressions carried out to test for these effects. To keep things simple, we allow for lagged effects up to two days and consider only the basic specification with special interventions of each central bank as explanatory variables. In order to save space, we only report the results for the 1985-1991 period for which the interventions tend to be clustered over time[29].

The results reported in Table 11 partly support the explanation in terms of testing the commitment of the central banks. The one-day lagged effect on exchange rate variations is definitely of the opposite sign compared to the contemporaneous one. This is obvious for instance for the interventions of the Fed on the YEN market for which a sequence of interventions manages to balance the adverse short run effect. Note however that the lagged effects in the other cases are not found significant and thus suggest that this explanation does not hold for every central bank on every market.

6. CONCLUSIONS

In this paper, we have investigated the empirical effects of the major central bank interventions on the short run dynamics of the major nominal exchange rates (DEM and YEN) against the USD. To this goal, we have relied on a quite new econometric framework, the FIGARCH model that yields a more appropriate measure of the ex-post volatility of the exchange rates than the traditional GARCH approach does. Indeed, the FIGARCH model implies a more realistic dynamics of the persistence of volatility shocks and is strongly supported by the data over all the periods under investigation.

As a whole, our FIGARCH estimations show that official interventions manage to move the market (especially when they are reported in the press), but often in the wrong direction: official purchases of dollars increase exchange rate volatility and generally induce a dollar depreciation. Further investigations show that our results do not stem from reverse causality, although central banks clearly lean against the wind. Conversely, our results on volatility and on delayed effects tend to support the market microstructure interpretation according to which markets firstly test the will of central banks to defend a currency after an intervention occurs. To sum up, these findings point out the limited efficiency of central bank interventions as a stabilization instrument, at least in the very short run.

Another important point lies in the different results associated to the GARCH and the FIGARCH frameworks. It is shown that the traditional GARCH estimations used in the literature tend to underestimate the effects of the central bank interventions on the ex-post volatility of exchange rates. In turn, this illustrates that measuring the volatility through the FIGARCH approach instead of the GARCH one matters in empirical work.

[29] Similar results are obtained for the other sub-period, i.e. the post Louvre period (1987-1991).

BIBLIOGRAPHY

ALMEKINDERS, G.J., EIJFFINGER, S.C.W, (1993), "Accounting for Daily Bundesbank and Federal Reserve Intervention", Tilburg University, Mimeo.

BAILLIE, R.T., BOLLERSLEV, T., (1989), "The Message in Daily Exchange Rates: a Conditional Variance Tale", *Journal of Business and Economic Statistics*, 7,3, 297-305.

BAILLIE, R.T., BOLLERSLEV, T., MIKKELSEN, H.O, (1996), "Fractionally Integrated Generalised Autoregressive Conditional Heteroskedasticity, *Journal of Econometrics*, 74, 3-30.

BAILLIE, R.T., DE GENNATO , R.P. (1990), "Stock Returns and Volatility", *Journal of Financial and Quantitative Analysis*, 5, 203-214.

BAILLIE, R.T., OSTERBERG, W.P. (1997a), "Why do Central Banks Intervene ?", *Journal of International Money and Finance*, 16 (6), 909-919.

BAILLIE, R.T., OSTERBERG, W.P. (1997,b), "Central Bank Intervention and Risk in the Forward market, *Journal of International Economics*, 43, 483-49.

BAILLIE, R.T., OSTERBERG, W.P. (1998), "Central Bank Intervention and Overnight Uncovered Interest Rate Parity, Federal Reserve Bank of Cleveland Working paper n°9823, December.

BANK OF INTERNATIONAL SETTLEMENTS (1999), "Central Bank Survey of Foreign Exchange and Derivatives Market Activity 1998", May.

BEINE M, LAURENT, S., LECOURT, C. (1999), "Accounting for Conditional Leptokurtosis and Closing Days Effects in FIGARCH Models of Daily Exchange Rates. Paper presented at the Sixth Workshop on Financial Modelling and Econometric Analysis, Lille III, January 1999.

BERGSTEN, F., MILLER, M. (1999), "Managing Exchange Rates with the Euro, paper presented at the Friedrich Ebert Fundation workshop on the International Monetary and Financial System after the Euro, Brussels, February.

BOLLERSLEV, T. (1986), "Generalized Autoregressive Conditional Heteroskedasticity, *Journal of Econometrics*, 31, 307-327.

BOLLERSLEV, T., MIKKELSEN, H.O. (1998), "Long-Term Equity Anticipation Securities and Stock Market Volatility Dynamics", Forthcoming in *Journal of Econometrics.*

BONSER-NEAL, C., TANNER, G. (1996), "Central Bank Intervention and the Volatility of Foreign Exchange Rate: Evidence from the Options market, *Journal of International Money and Finance*, 15 (6), 853-878.

CATTE P., GALLI, G., REBECCHINI, S. (1992), "Exchange Markets can be managed ! Report on the G-7", *International Economic Insights*.

CHANG, Y., TAYLOR, S. (1998), "Intraday Effects of Foreign Exchange Intervention by the Bank of Japan, *Journal of International Money and Finance*, 17, 191-210.

DE CEUSTER, M., TRAPPERS, D. (1992), "Diagnostic Checking of Estimation with a Student-t Error Density, paper presented at the ESEM, Brussels, August.

DOMINGUEZ, K.M. (1990), "Market Responses to Coordinated Central Bank Intervention, Carnegie-Rochester Conference on Public Policy, 32, 121-64.

DOMINGUEZ, K.M., FRANKEL, J.A. (1998), "Central Bank Intervention and Exchange Rate Volatility, *Journal of International Money and Finance*, 17, 161-190.

DOMINGUEZ, K.M., FRANKEL, J.A. (1993), "Does Foreign Exchange Intervention Work?, Institute for International Economics, Washington, DC.

EDISON ,H. (1993) "The Effectiveness of Central Bank Intervention: A survey of the Post-1982 Literature, Special Paper on International Economics, 18, Princeton University.

ENGLE, R.F. (1982), "Autoregressive Conditional Heteroskedasticity with Estimated of the Variance of UK Inflation, *Econometrica*, 50, 987-1008.

ENGLE, R.F., BOLLERSLEV, T. (1986), "Modeling the Persistence of Conditional Variances, *Econometric Reviews*, 5, 1-50.

FISCHER, A. AND M., ZURLINDEN (1998), "Are Interventions Self-Exciting?", CEPR Discussion Paper n° 1964.

FLOOD, R., ROSE, A.K. (1995), "Fixing Exchange-Rates: A Virtual Quest for Fondamentals, *Journal of Monetary Economics*, 36, 3-37.

FRANKEL, F. (1982), "A Test of Perfect Substituability in the Foreign Exchange Market, *Southern Economic Journal*, 46, 4.

FUNANASHI, Y. (1988), "Managing the dollar: from the Plaza to the Louvre", Institute for International Economics, Washington.

HSIEH, D.A. (1989,) "Modeling Heteroskedasticity in Daily Foreign Exchange Rates, *Journal of Business and Economic Statistics*, 7, 3, 307-17.

OBSTFELD, M. (1990), "The Effectiveness of Foreign Exchange Interventions: Recent Experience, 1985-1988, in Branson, Frankel and Goldstein Eds, International Policy Coordination and Exchange Rate Fluctuations", NBER, University of Chicago Press.

PAGAN, A. (1996), "The Econometrics of Financial Markets, *Journal of Empirical Finance*, 3, 15-102.

TEYSSIÈRE, G. (1997), "Double Long-Memory Financial Time Series", paper presented at the ESEM, Toulouse.

TEYSSIÈRE, G. (1998), "Multivariate Long-Memory ARCH Modelling for High Frequency Foreign Exchange Rates", Proceedings of the High-Frequency Data in Finance, Olsen & associates, Zurich, April.

TSE, Y.K. (1998), "The Conditional Heteroskedasticity of the YEN-Dollar Exchange Rates", *Journal of Applied Econometries*, 13, 1, 49-56.

WEBER, A. (1994), "Intervention, International Policy Coordination anf the Future of EMU: A German Perspective", presented at the conference on European Currency Crises and After.

WEBER, A. (1995), "Exchange Rates and the Effectivneness of Central Bank Intervention: New Evidence for the G3 and the EMS", in C. Bordes, E. Girardin and J. Melitz (eds), European Currency Crises and After, Manchester University Press.

WILLIAMSON, J. (1985), "The Exchange Rate System, Policy Analysis in International Economics", vol. 5, Institute for International Economics, Washington.

WILLIAMSON, J., MILLER, M. (1987), "Targeting and Indications : a Blueprint for the International Coordination of Economic Policy, Policy Analysis in International Economics", vol. 22, Institute for International Economics, Washington.

ZURLINDEN, M. (1996), "Devisenmaxktinterventionen der Schweizerischen NationalBank 1986-1994, Schweizerischen NationalBank", *Geld, Wdhrung und Konjonktur*, 14, 163-187.

LIST OF THE WORKING PAPERS RELEASED BY THE CEPII[30]

1999

Forum Economique Franco-Allemand, Deutsch-Französisches Wirtschaftspolitisches Forum , "Reduction of Working Time/Eastward Enlargement of the European Union, 5th meeting, Paris, July 6-7, 1999, *document de travail n°99-13,* septembre.

"A Lender of Last Resort for Europe", Michel Aglietta, *document de travail n°99-12,* septembre.

"La diversité des marchés du travail en Europe : Quelles conséquences pour l'Union Monétaire", deuxième partie : Les implications macro-économiques de la diversité des marchés du travail, Loï c Cadiou, Stéphanie Guichard, Mathilde Maurel,*document de travail n°99-11,* juin.

"La diversité des marchés du travail en Europe : Quelles conséquences pour l'Union Monétaire", première partie : La diversité des marchés du travail dans les pays de l'Union Européenne, Loï c Cadiou, Stéphanie Guichard,*document de travail n°99-10,* juin.

"The Role of External Variables in the Chinese Economy", Stéphane Dées, *document de travail n°99-09,* juin.

"Hautes technologies et échelles de qualité : de fortes asymétries en Europe", Lionel Fontagné, Michael Freudenberg, Deniz Unal-Kesenci, *document de travail n°99-08,* juin.

"The Role of Capital Accumultion, Adjustment and Strucural Change for Economic Take – Off: Empirical Evidence from Africa Growth Episodes", Jean-Claude Berthélemy et L. Söderling, *document de travail n°99-07,* avril.

"Enterprise Adjustment and the Role of Bank Credit in Russia: Evidence from a 420 Firm's Quality Survey", Sophie Brana, Mathilde Maurel, Jérôme Sgard, *document de travail n° 99-06,* avril.

"Central and Eastern European Countries in the International Division of Labour in Europe", Mickaël Freudenberg et Françoise Lemoine, *document de travail n° 99-05,* avril.

Forum Economique Franco-Allemand/Deutsch-Französisches Wirtschaftspolitisches Forum, "Economy Policy Coordination and Financial Supervision in the EMU", 4th meeting, Bonn, January 11-12 1999, *document de travail n°99-04,* avril.

[30] Working papers are circulated free of charge as stocks are available ; thank you to send your request to CEPII, Sylvie Hurion, 9, rue Georges Pitard, 75015 Paris, or by fax 33 01 53 68 55 03 or by e-mail : HURION@CEPII.FR. CEPII *is also on the Web : http://www.cepii.fr.*

"Models of Exchange Rate Expectations: Heterogeneous Evidence from Panel Data", Agnès Bénassy-Quéré, Sophie Larribeau, Ronald McDonald, *document de travail n°99-03*, avril.

Forum Economique Franco-Allemand/Deutsch-Französisches Wirtschaftspolitisches Forum, "Labour Market & Tax Policy in the EMU", Paris, July 6-7 1998, *document de travail n°99-02,* mars.

"Programme de travail 1999", Jean-Claude Berthélemy, *document de travail n°99-01,* janvier.

1998

"Rapport d'activité 1998", Jean-Claude Berthélemy, *document de travail n°98-15,* décembre.

"Monetary Policy under a Fixed Exchange Rate Regime, The case of France" Benoît Mojon, *document de travail n° 98-14,*décembre.

"Wages and unemployment : trade-off under different labour market paradigms" Olivier Bontout et Sébastien Jean, *document de travail n°98-13,* décembre.

"Structures financières et transmission de politique monétaire. Applications à l'Allemagne, la France, l'Italie et le Royaume Uni" Benoît Mojon, *document de travail n°98-12,* octobre.

"Le marché du travail britannique vu par la France" Michel Fouquin, Sébastien Jean, Aude Sztulman, *document de travail n°98-11,* octobre.

"Compétitivité de régime de change en Europe Centrale", Michel Aglietta, Camille Baulant, Virginie Coudert, *document de travail n°98-10,* octobre.

"Sensibilité des salaires relatifs aux chocs exogènes de commerce international et de progrès technique : une élévation d'équilibre général", Sébastien Jean et Olivier Bontout, *document de travail n°98-09,* septembre.

"Evolution sur longue période de l'intensité énergétique", Pierre Villa, *document de travail n°98-08,* septembre.

"Sacrifice Ratios in Europe: a Comparison", Laurence Boone, Benoît Mojon, *document de travail n°98-07,* août.

"La politique japonaise et la crise monétaire", Stéphanie Guichard, *document de travail n°98-06,* juillet.

"La régionalisation du commerce international : une évaluation par les intensités relatives bilatérales", Michaël Freudenberg, Guillaume Gaulier, Deniz Ünal Kesenci, *document de travail n°98-05,* août.

"Pegging the ceec's currencies of the euro", Agnès Bénassy-Quéré et Amina Lahrèche-Révil, *document de travail n°98-04*, juillet.

"The international role of the euro", Agnès Bénassy-Quéré, Benoît Mojon, Armand-Denis Schor, *document de travail n°98-03*, mars.

"EMU and Transatlantic Exchange Rate Stability", A. Bénassy Quéré et B. Mojon, *document de travail n°98-02*, avril. (épuisé).

"Programme de travail 1998", Jean-Claude Berthélemy, *document de travail n°98-01*, avril.

1997

"Why the Euro Will Be Strong : an Approach Based on Equilibrium Exchange Rates", Michel Aglietta, Camille Baulant, Virginie Coudert, *document de travail n°97-18*, décembre.

"How foreing Direct Investment Affects International Trade and Competitiveness. An Emppirical Assessment", Lionel Fontagné, Mickaël Pajot, *document de travail n°97-17*, décembre.

"Cycles de production industrielle : une analyse historique dans le domaine des fréquences", Pierre Villa *document de travail n°97-16*, novembre.

"International and External Policy Coordination: a Dynamic Analysis", Fabrice Capoën, Pierre Villa, *document de travail n°97-15*, octobre.

"Optimal Pegs for Asian Currencies'", Agnès Bénassy-Quéré, *document de travail n°97-14*, octobre.

"Pour ou contre le système commun de TVA?", Stéphanie Guichard, Claire Lefèbvre, *document de travail n°97-13*, juin.

"The Euro and Exchange Rate Stability", Agnès Bénassy-Quéré, B. Mojon, Jean Pisani-Ferry, *document de travail n°97-12*, juin.

Estimation du cycle à l'aide d'un modèle à tendance stochastique et application au cas du Royaume-Uni", Laurence Boone, *document de travail n°97-11*, juin.

"Looking for French Monetary Policy", Benoît Mojon, *document de travail n° 97-10*, juin.

"Incertitude sur le choix du modèle et rationalité", Pierre Villa, *document de travail n° 97-09*, mai.

"Quel est l'impact du commerce extérieur sur la productivité et l'emploi ?", Olivier Cortes, Sébastien Jean, *document de travail n° 97-08*, avril

"Trade Patterns Inside the Single Market" Lionel Fontagné, Michael Frendenberg & Nicolas Péridy, *document de travail n° 97-07,* avril.

"The Exchange Rate Policy of the Euro: A Matter of Size", Philippe Martin, *document de travail n° 97-06,* avril. (épuisé)

"Ces taux de change réels qui bifurquent", Pierre Villa, *document de travail n° 97-05,* avril.

"Chômage non-qualifié et imitation : les raisons d'un accord international sur la propriété intellectuelle", Lionel Fontagné & Jean-Louis Guérin, *document de travail n° 97-04,* mars.

Symmetry and Asymmetry of Supply and Demand Shocks in the European Union a Dynamic Analysis", Laurence Boone, *document de travail n° 97-03,* février. (épuisé)

"Interest Rates in East Asian Countries: Internal Financial Structures and International Linkages", Isabelle Bensidoun, Virginie Coudert et Laurence Nayman, *document de travail n° 97-02,* janvier. (épuisé)

"Intra-Industry Trade: Methodological Issues Reconsidered", Lionel Fontagné, Michael Freudenberg, *document de travail n° 97-01,* janvier. (épuisé)

1996

"The Cost of Fiscal Retrenchment Revisited: How Strong is the Evidence?", Philippine Cour, Eric Dubois, Selma Mahfouz & Jean Pisani-Ferry, *document de travail n° 96-16,* décembre.

"Les dynamiques sectorielles de la croissance en Europe centrale", Françoise Lemoine, *document de travail 96-15,* décembre.

"Growth and Agglomeration", Philippe Martin & Gianmarco I.P. Ottaviano, *document de travail n° 96-14,* décembre.

"La coordination interne et externe des politiques économiques : une analysee dynamique", Fabrice Capoen et Pierre Villa, *document de travail n° 96-13,* décembre. (épuisé)

"L'intégration asymétrique au sein du continent américain : un essai de modélisation", Philippine Cour et Frédéric Rupprecht, *document de travail n° 96-12,* octobre.

"Croissance et contrainte financière dans les PED", Pierre Villa, *document de travail n° 96-11,* octobre.

"Bulgaria From Entreprise Indiscipline to Financial Crisis", Roumen Avramov et Jérôme Sgard, *document de travail n° 96-10,* juillet.

"Potentialities and Opportunities of the Euro as an International Currency", Agnès Bénassy-Quéré, *document de travail n° 96-09,* août. (épuisé)

"Credit Crisis and the Role of Banks During Transition: a Five-Country Comparison", Jérôme Sgard, *document de travail n° 96-08,* août.

"Exchange Rate Regimes and Policies in Asia", Agnès Bénassy-Quéré, *document de travail n° 96-07,* juillet.

"France in the Early Depression of the Thirties", Pierre Villa, *document de travail n° 96-06*, juillet.

"Pays émergents, emploi defficient ?", Olivier Cortès et Sébastien Jean, *document de travail n° 96-05*, mars.

"Trade with Emerging Countries and the Labor Market : the French Case", Olivier Cortès, Sébastien Jean et Jean Pisani-Ferry, *document de travail n° 96-04,* mars.

"The Transmission of Monetary policy in the European Countries", Fernando Barran, Virginie Coudert et Benoit Mojon, *document de travail n° 96-03* , février. (épuisé)

"Trade Policy and Trade Patterns During Transition : A Comparison Between China and CEECs", Françoise Lemoine, *document de travail n° 96-02*, février.

"Financial Markets Failures and Systemic Risk", Michel Aglietta, *document de travail n° 96-01*, janvier

1995

"Why NAFTA Might be Discriminatory", Lionel Fontagné, *document de travail n° 95-12*, décembre. (épuisé)

"Régionalisation et échanges de biens intermédiaires", Lionel Fontagné, Michael Freudenberg et Deniz Ünal-Kesenci, *document de travail n° 95-11*, décembre.

"The Geography of Multi-speed Europe", Philippe Martin et Gianmarco I.P Ottaviono, *document de travail n° 95-10,* novembre.

"The Political Economy of French Policy and the Transmission to EMU", Christian de Boissieu et Jean Pisani-Ferry, *document de travail n° 95-09,* octobre (épuisé).

"L'importance des exclus de l'intégration monétaire en Europe", Philippe Martin, *document de travail n° 95-08*, novembre.

"Asymétries financières en Europe et transmission de la politique monétaire", Virginie Coudert et Benoit Mojon, *document de travail n° 95-07,* septembre (épuisé).

"La mesure du capital éducatif", Pierre villa, *document de travail n° 95-06,* septembre.

"Capital humain, mobilité des capitaux et commerce international", Pierre Villa, *document de travail n° 95-05*, juin.

"L'Europe à géométrie variable : une analyse économique", Jean Pisani-Ferry, *document de travail n° 95-04*, avril. (épuisé)

"Comparaison de l'efficacité énergétique des pays d'Europe centrale et orientale avec celle des pays de l'OCDE", Nina Kounetzoff, *document de travail n° 95-03*, mars.

"L'organisation de la politique économique dans un cadre stratégique", Pierre Villa, *document de travail n °95-02*, mars.

"Interest Rates, Banking, Spreads and Credit Supply: The Real Effects", Fernando Barran, Virginie Coudert, Benoît Mojon, *document de travail n° 95-01*, mars. (épuisé)