How public information of central bank interventions affect exchange rate volatility? The case of Peru

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November 19th, 2010

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Plan of the presentation

- Objectives
- Theoretical Model
- Empirical Model
- Estimation Strategy
- Results
- Conclusions

Objectives

1. To present a stochastic optimal control model for central bank interventions in the foreign exchange market in similar spirit to Mundaca and Oksendal (1998).
2. To test empirically the predictions of our theoretical optimal control model by *first,* estimating the BCRP *reaction function* for intervening in the foreign exchange market; and *second,* by analyzing empirically what is the *effect of the BCRP's intervention* policy on the *sol/USD*, and its *volatility*.

Institutional factors

- Peru follows a flexible exchange rate but the central bank determines on a *daily basis*, the implicit band within which the sol/USD is allowed to move. This implicit band is not made public information.

- The BCRP has made rather clear that it has as objective to minimize excessive volatility of the sol, but in recent years, interventions have concentrated in US dollar purchases. (See Humala and Rodriguez (2009).)

Institutional factors

- It is common knowledge both i) that interventions on any day t, take place between 11.00 and 13.30 only; and ii) the amount of intervention at the end of every day (Armas (2005)).

- How the sol/USD has developed up to 11.00 am with respect to previous days, are very important for the BCRP when deciding to intervene.

The theoretical model

- It is based on the work of Mundaca and Oksendal (1998).
- It is a theory of combined stochastic control.
- The monetary authorities minimizes the costs of changes in the exchange rate and those of intervening to stabilize the exchange rate.
- The central bank aims to keep the exchange rate stable. To achieve its objective, it implements two types of control:

i) Intervening frequently with small amounts to smooth exchange rate changes.

ii) Intervening forcefully using a large optimal amount in order avoid drastic changes in the exchange rate.

The theoretical model

- As in in Mundaca and Oksendal (1998), the range of variation of the exchange rate is determined endogenously from the solution of the optimal stochastic intervention control problem.

The theoretical model

- The exchange rate follows the following stochastic process:

$$Y_t = y + \int_{s=0}^{t} bm_s ds + \sigma B_t(\omega) + \sum_{j:\theta_j \le t} \gamma(\xi_j)$$

- y is the initial value of the exchange rate Y_t (i.e. sol/USD), bm_s measures the *continuous* interventions by the central bank; $\sigma > 0$ is a constant; $B_t(\omega)$ denotes Brownian motion, and $\gamma(\xi_j)$ measures *discrete* interventions.

The theoretical model

- Taking into consideration the above, the total and discounted expected cost of applying the *combined intervention control discrete* and *continuous* is:

$$J^{w}(s,y)=E^{s,y}\left[\int_{s}^{T}e^{-\rho t}(K(Y_t-\bar{Y})+R(m))dt+\sum_{j:\theta_j\leq T}L(\xi_j)e^{-\rho\theta_j}\right]$$

The empirical model

We test our theoretical model by:

1. *First* estimating the central bank's reaction function for intervening.

2. *Second,* by estimating the conditional mean and variance of the Sol/USD rate. The variance is assumed to follow an EGARCH (1,1) (Nelson (1991)) (EGARCH(1,1)).

The empirical model

- Expected central bank intervention decisions are assumed to be endogenously determined, and to affect both the conditional mean and variance. Past information on intervention is also analyzed. We follow closely, Mundaca's (2001) econometric methodology.

- Note that it is uncertain for the market exactly when interventions ***will*** take place. It is also unknown to the market how much appreciation/depreciation on one side, and volatility on the other side, the BCRP is ready to tolerate.

TIMING OF DECISIONS

Decision
Making: **BCRP**

Expectations
Formed: **Market**

t-5… t-1 11.00 13.30

The empirical model: The BCRP's reaction function

- Consider MB and MS the variables representing the central bank participation buying and selling foreign exchange, respectively. These decisions to intervene are defined as follows:

$$M_t^B = \delta_{11} apprec_{t-1} + \delta_{12}(X_t^{11am} - \bar{X}_{t-1}^{5days}) + \delta_{13} Spread_{t-1} - \mu_t^B \quad (4.1)$$

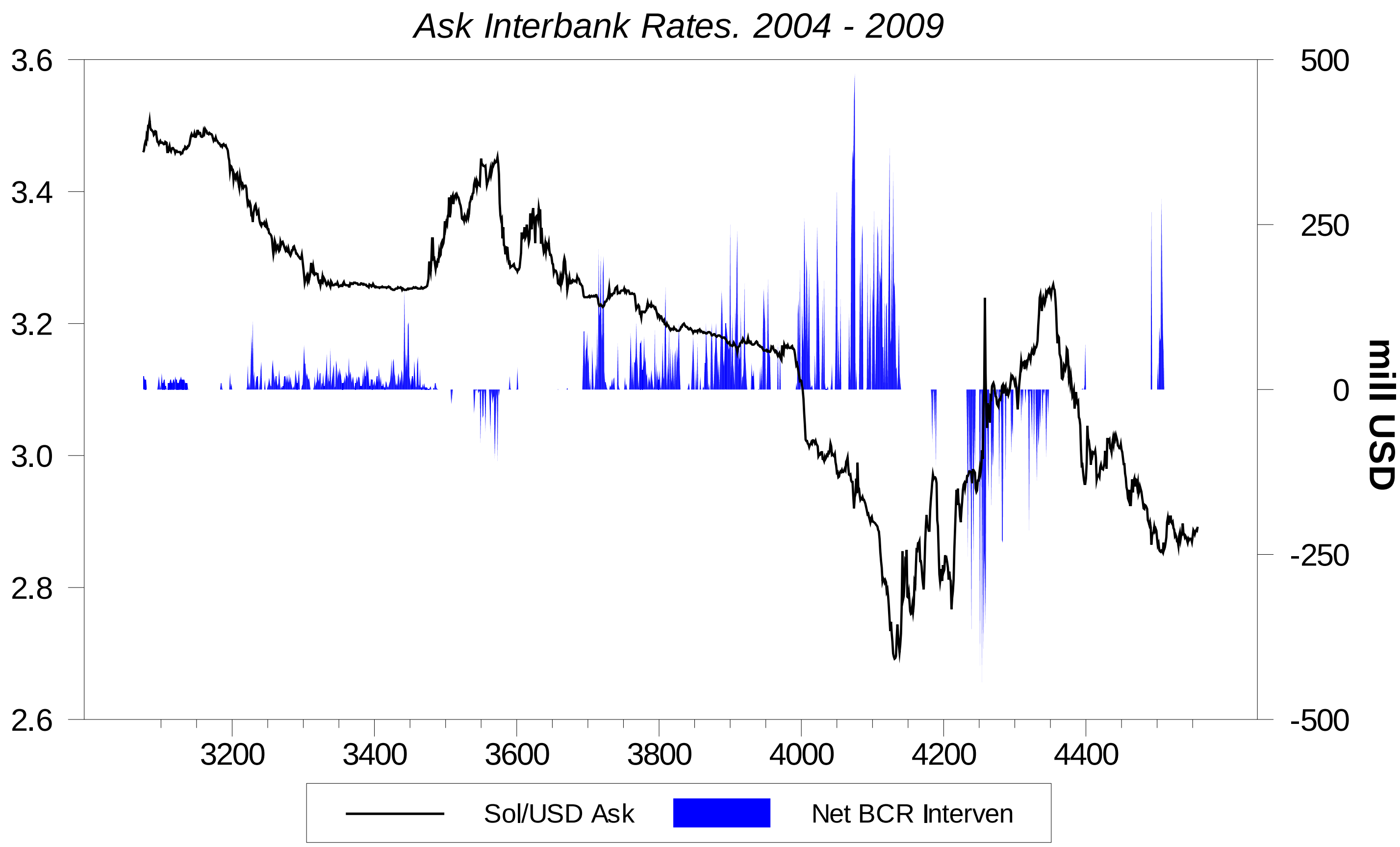
$$M_t^S = \delta_{21} deprec_{t-1} + \delta_{22}(X_t^{11am} - \bar{X}_{t-1}^{5days}) + \delta_{23} Spread_{t-1} - \mu_t^S \quad (4.2)$$

The empirical model: The BCRP's reaction function

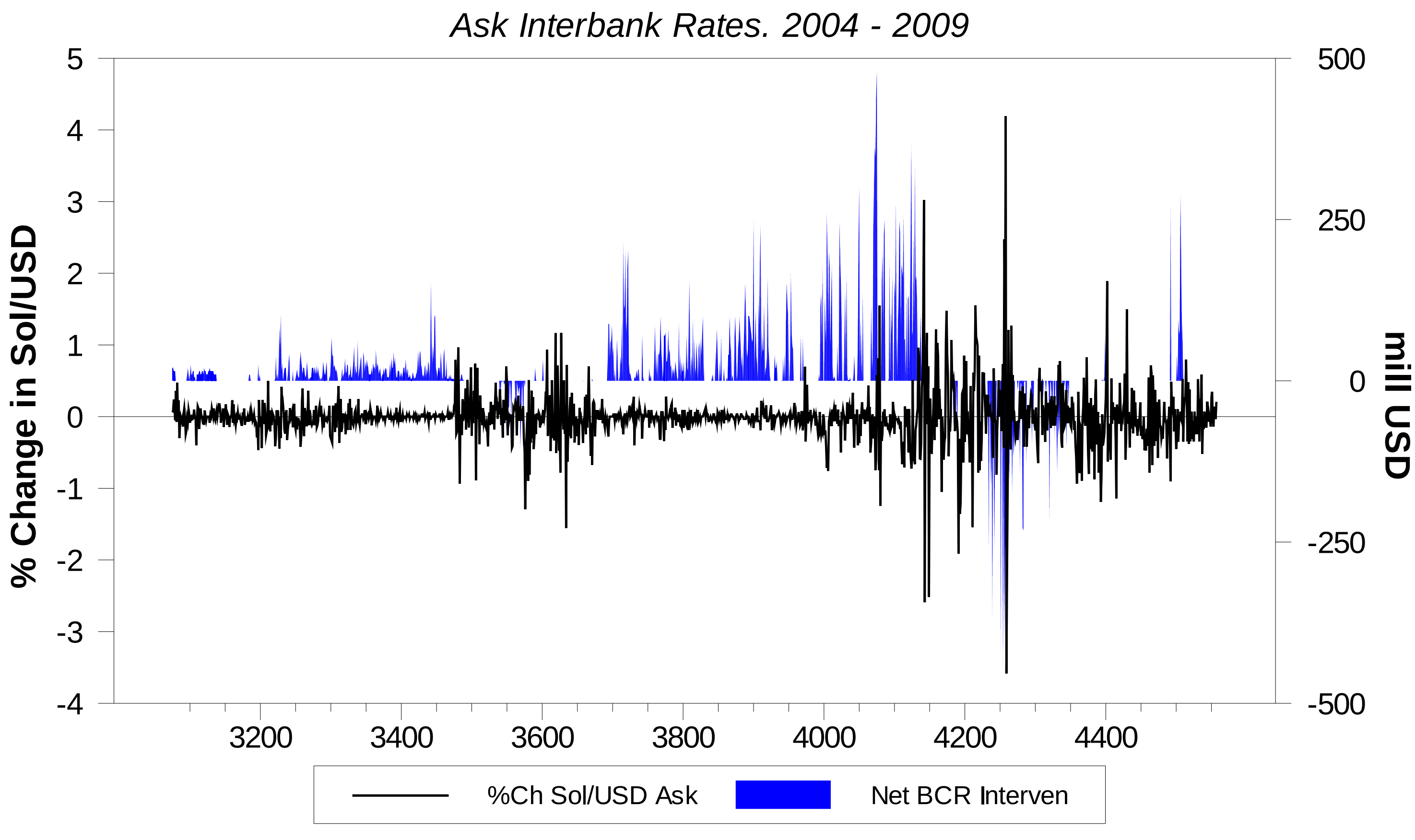
- We define the dummy variables I^B and I^S which are going to be related with M^B and M^S in the following manner:

$$
\begin{aligned}
&I_t^B = 1 \text{ iff } M_t^B > 0 \\
&I_t^B = 0 \text{ iff } M_t^B = 0 \qquad\qquad (5) \\
&I_t^S = 1 \text{ iff } M_t^S > 0 \\
&I_t^S = 0 \text{ iff } M_t^S = 0
\end{aligned}
$$

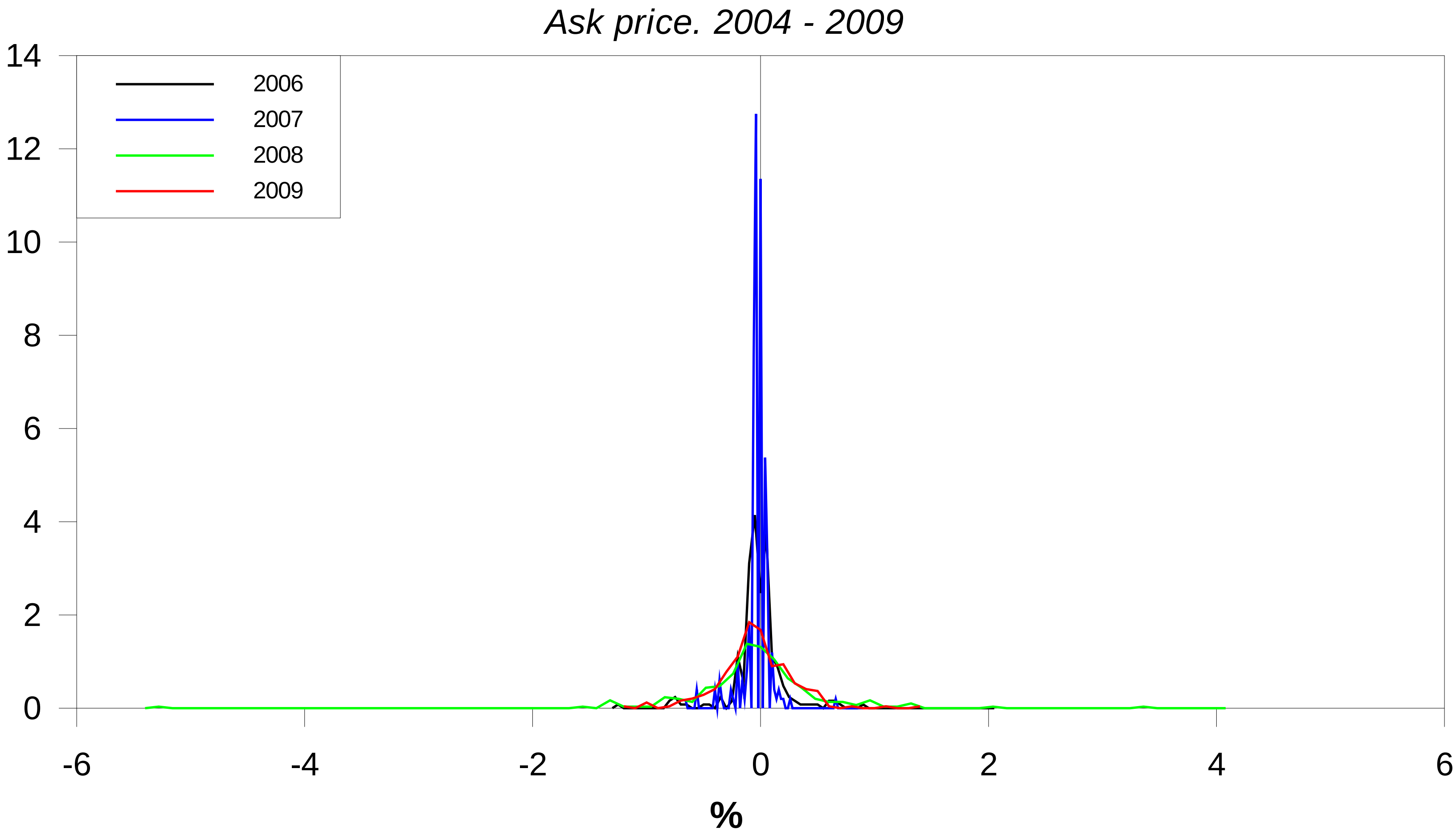
Sol/USD observed at 11.00 am



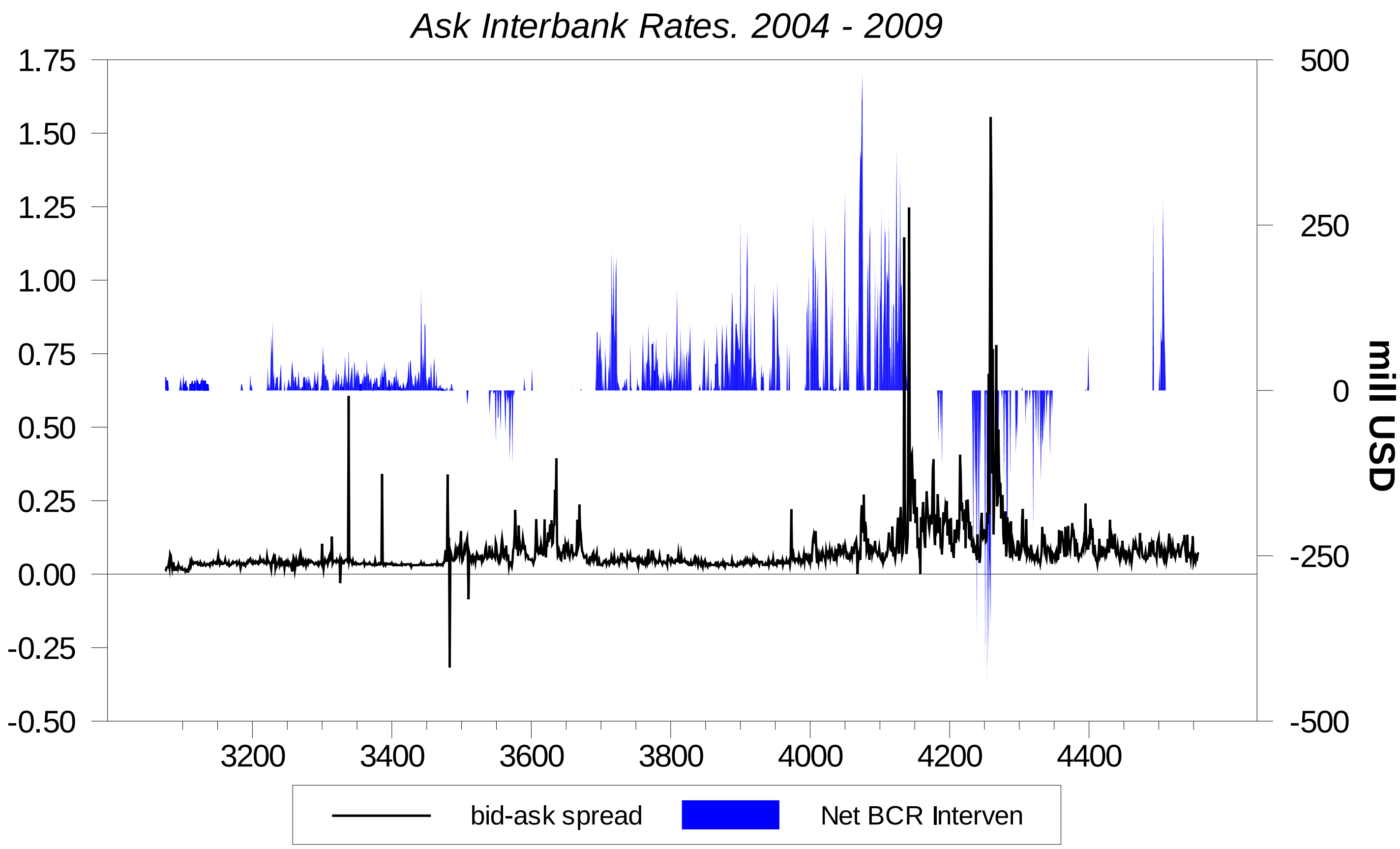
Changes in logs of Sol/USD and Net Interventions by BCRP



Density functions of exchange rate changes



Bid-Ask Spread in the Interbank Rates



The empirical model: the conditional mean of the exchange rate

Equation (7):

$$E_t[\Delta X_t \mid M_t^B > 0; M_t^S > 0; \Omega_{t-1}] = \beta_1 \Delta X_{t-1} + \beta_2 \Delta X_{t-2} + \alpha Interv_{t-1} +$$

$$E_t[\varepsilon_t \mid M_t^B > 0; M_t^S > 0; \Omega_{t-1}]$$

$$= \beta_1 \Delta X_{t-1} + \beta_2 \Delta X_{t-2} + \alpha Interv_{t-1} +$$

$$\sigma_{\varepsilon\mu^B}\left(-\frac{\phi(Z_t^B \delta^B)}{\Phi(Z_t^B \delta^B)}\right) + \sigma_{\varepsilon\mu^S}\left(-\frac{\phi(Z_t^S \delta^S)}{\Phi(Z_t^S \delta^S)}\right) + \alpha Interv_{t-1}.$$

The empirical model: the exchange rate

- $\phi(Z_t^B\delta^B)/\Phi(Z_t^B\,\delta^B)$ and $\phi(Z_t^S\boldsymbol{\delta}^S\,\delta^S)/\Phi(Z_t^S\,\delta^S)$ are the conditional distributions of M_t^B and M_t^S.

- The disturbance of the mean equation (7) is assumed to have zero mean and certain conditional variance that follows an (EGARCH(1,1)).

- Here, both past interventions observed by the market and the probabilities of possible future interventions from the market's point of view are assumed to influence the conditional variance.

The empirical model: the conditional variance of the exchange rate

Equation (8):

$$\ln(h_t) = \alpha_0 + a_1 \frac{\eta_{t-1}}{\sqrt{h_{t-1}}} + \kappa \left[\left| \frac{\eta_{t-1}}{\sqrt{h_{t-1}}} \right| - \sqrt{\frac{2}{\pi}} \right] + b_1 \ln(h_{t-1}) + \varsigma_B \left[-\frac{\phi(Z_t^B \delta^B)}{\Phi(Z_t^B \delta^B)} \right] +$$

$$\varsigma_S \left[-\frac{\phi(Z_t^S \delta^S)}{\Phi(Z_t^S \delta^S)} \right] - \rho_B \left[\frac{\phi(Z_t^B \delta^B)}{\Phi(Z_t^B \delta^B)} \right]^2 - \rho_S \left[\frac{\phi(Z_t^S \delta^S)}{\Phi(Z_t^S \delta^S)} \right]^2 + \theta Interv_{t-1}$$

Estimation strategy

- The strategy to estimate (4.1), (4.2), (5), (7) and (8) consists of a two-stage method suggested by Heckman (1978) and Lee (1978).

- In the first step, we estimated (4.1) and (4.2) with observations I^B and I^S as a typical Probit model to obtain the estimates of the δ's and thereafter $\phi(Z_t^B\delta^B)/\Phi(Z_t^B\delta^B)$ and $\phi(Z_t^S\delta^S\delta^S)/\Phi(Z_t^S\delta^S)$.

- In the second step, equations (7) and (8) are estimated by numerically maximizing the likelihood function for the EGARCH(1,1) model.

Estimation Results: central bank reaction functions

Dependent Variable M_t^B	**Estimates**	***Dependent Variable M_t^S***	**Estimates**
apprec	0.3092 (0.0647)	***deprec***	-1.1548 (0.0875)
X - $\bar{X}^{5d}$	-0.4821 (0.0872)	X - $\bar{X}^{5d}$	1.2148 (0.1005)
Spread	-7.7412 (0.5882)	Spread	-4.6493 (0.3689)

Empirical Results: conditional mean of sol/USD

$$E_t[\Delta X_t \mid M_t^B > 0; M_t^S > 0; \Omega_{t-1}] = \underset{(0.0304)}{0.1539}\,\Delta X_{t-1} + \underset{(0.0272)}{0.2636}\,\Delta X_{t-2}$$

$$-\underset{(0.0076)}{0.0339}\left(\frac{\phi(Z_t^B \delta^B)}{\Phi(Z_t^B \delta^B)}\right) + \underset{(0.0057)}{0.0297}\left(\frac{\phi(Z_t^S \delta^S)}{\Phi(Z_t^S \delta^S)}\right) - \underset{(0.00004)}{0.0001}\,Interv_{t-1}.$$

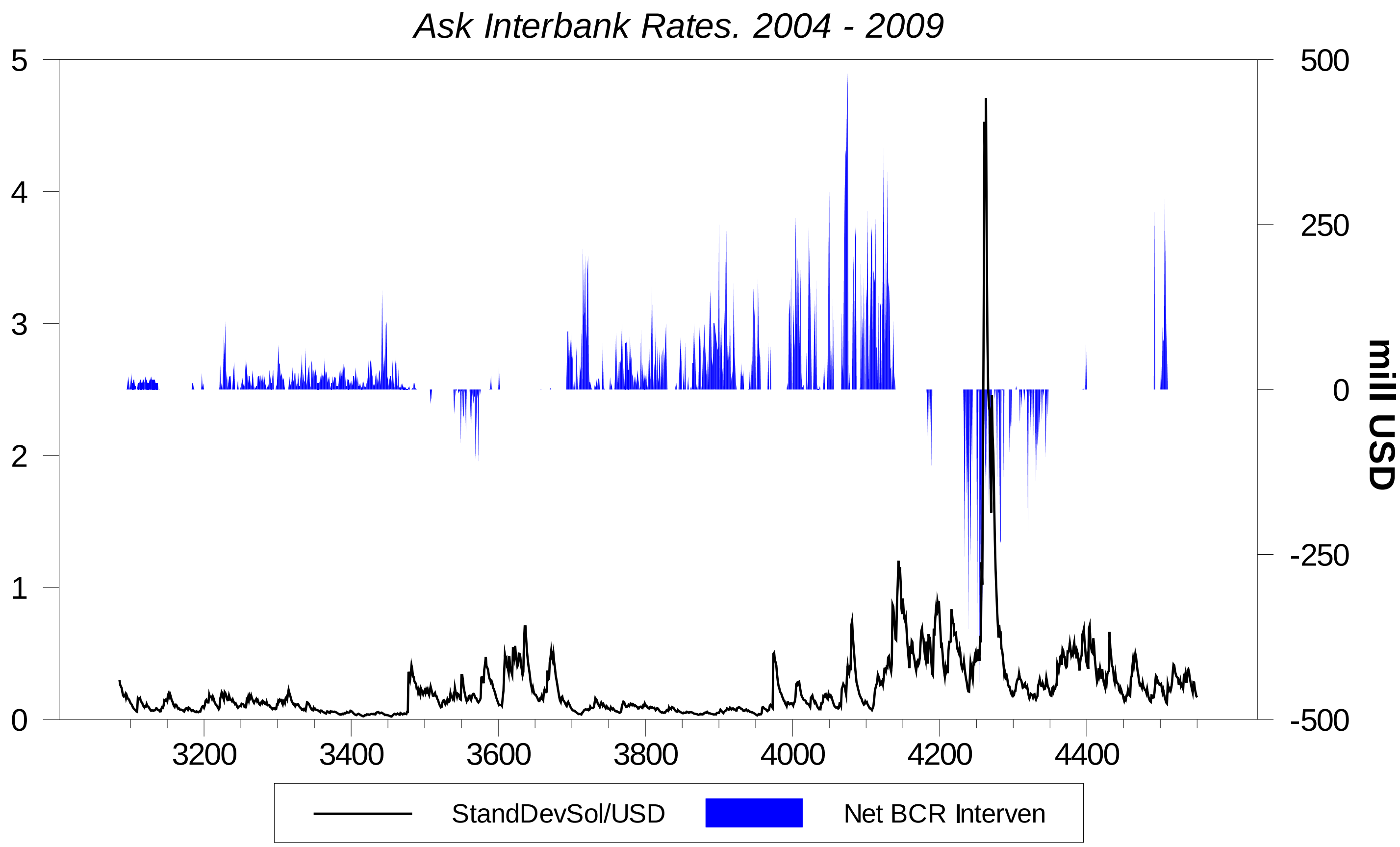
Empirical Results: conditional variance of sol/USD

$$\ln(h_t) = \underset{(0.0343)}{-1.0203} + \underset{(0.0228)}{0.3944}\frac{\eta_{t-1}}{\sqrt{h_{t-1}}} + \underset{(0.0262)}{0.0442}\left[\left|\frac{\eta_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{\frac{2}{\pi}}\right] + \underset{(0.0051)}{0.9372}\ln(h_{t-1}) +$$

$$\underset{(0.0688)}{0.0418}\left[\frac{\phi(Z_t^B\delta^B)}{\Phi(Z_t^B\delta^B)}\right] + \underset{(0.0529)}{0.4582}\left[\frac{\phi(Z_t^S\delta^S)}{\Phi(Z_t^S\delta^S)}\right] -$$

$$\underset{(0.0163)}{0.0232}\left[\frac{\phi(Z_t^B\delta^B)}{\Phi(Z_t^B\delta^B)}\right]^2 + \underset{(0.0138)}{0.0759}\left[\frac{\phi(Z_t^S\delta^S)}{\Phi(Z_t^S\delta^S)}\right]^2 - \underset{(0.00017)}{0.00057}\,Interv_{t-1}$$

EGARCH(1,1) Conditional Standard Deviation of the Sol/USD and BCRP interventions



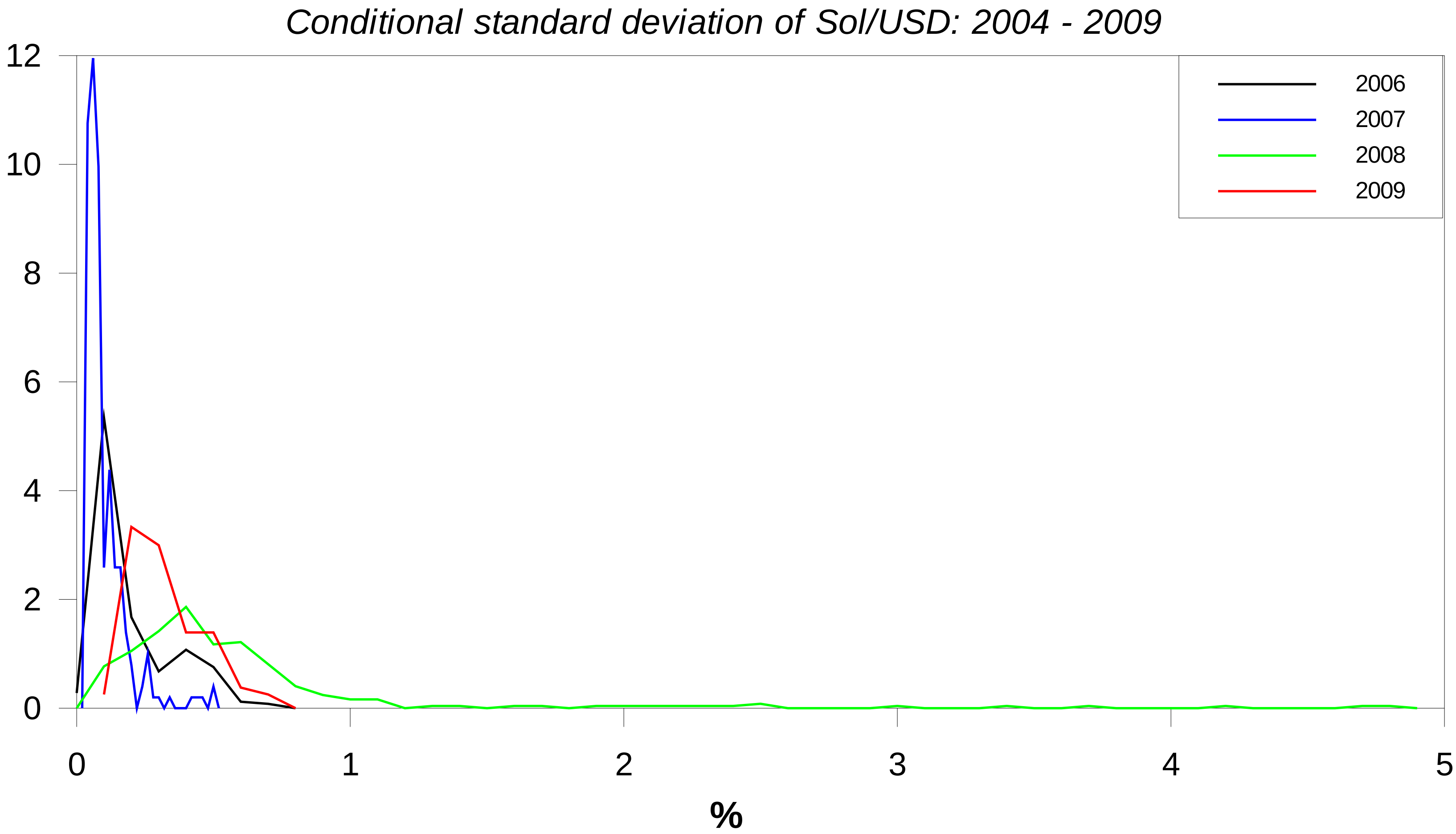
Empirical Results: conditional variance of sol/USD

- There is evidence of asymmetric effects of the shocks on the conditional volatility.

- For given h_{t-1}, a one-unit decline in ε_{t-1} (e.g. an appreciation in the sol) induces a decrease in the log of conditional variance by **– 0.3503** units (= (0.3945)*(-1) + (0.0442)*(|-1|)) = - 0.3503).

- For given h_{t-1}, if ε_{t-1} rises by one-unit (e.g. the sol depreciates), it causes an increase in the (log) conditional volatility by **0.4387** units (= (0.3945)*(1) + (0.0442)*(|1|)) = 0.4387).

Densities of conditional standard deviations



Conclusions

- BCRP seems to attempt to move market in the correct direction: the central bank intervenes buying and selling foreign exchange currency to prevent drastic appreciation or depreciation of the sol by intervening buying and selling foreign exchange.

- It seems however difficult for the BCRP to move the exchange rate along the intended path.

Conclusions

- We found that making common knowledge past BCRP participation in the forex has the advantageous effect of reducing the volatility of the sol, exactly as the BCRP intents.

- Such information however does not reduce markets uncertainty about the BCRP intentions. In particular, there are no favorable effects of future expected intervention on the sol volatility.

- One could of course appeal to the work of Morris and Shin (2006) who demonstrate that public information can be easily interpreted differently by each market participants and fail to coordinate on what public information really means.

Conclusions

- Should the BCRP be concerned about the bid-ask spreads?

- Naranjo and Nimalendran (2000) find that dealers increase exchange rate spreads around interventions and suggest that in doing so they protect themselves against the greater information asymmetry around interventions.

- Should the BCRP be consistent in sterilizing all interventions?

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