Japanese Foreign Exchange Intervention and the Yen/Dollar Exchange Rate: A Simultaneous Equation Approach Using Realized Volatility

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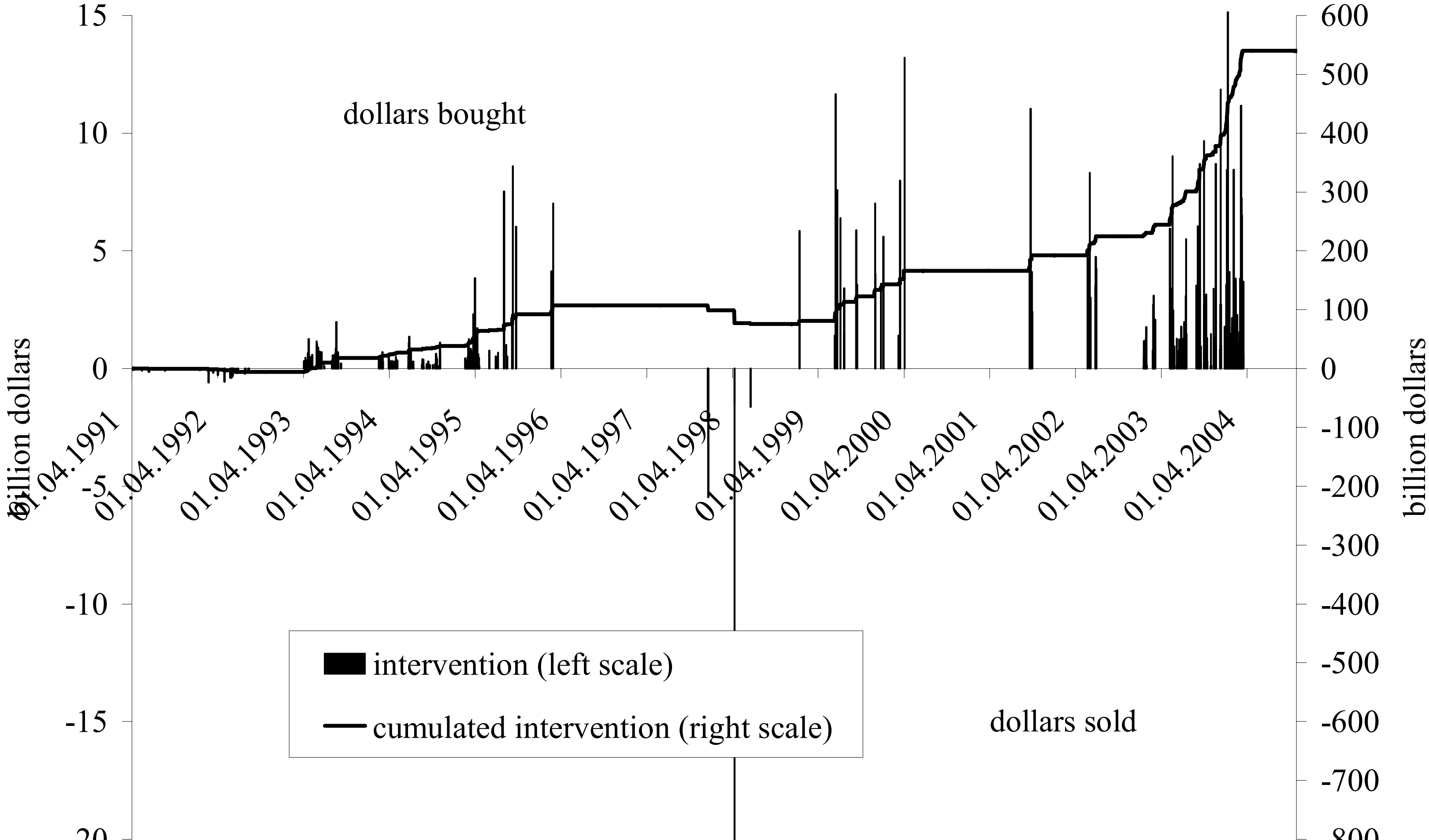
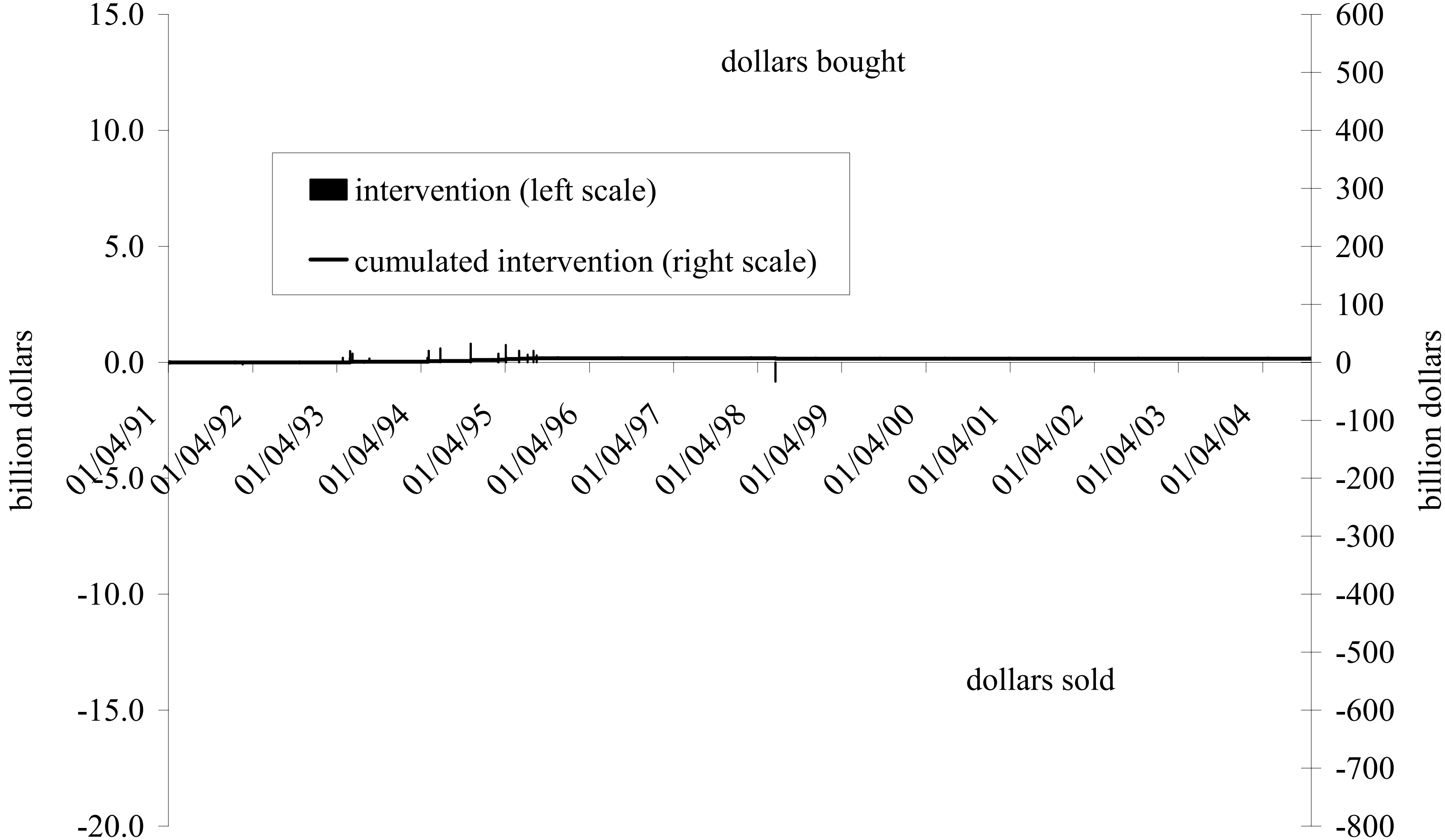
The “Syndrome of the Ever Higher Yen”

Japanese Foreign Exchange Intervention



US Foreign Exchange Intervention



Previous Research - Effectiveness

Japanese foreign exchange intervention is not effective

- Schwartz (1996): „exercise in futility“ causing higher volatility
- Bonser-Neal/Tanner (1996): higher volatility (85-91)
- Dominguez (1998): higher volatility (77-94)
- Galati and Melick (1999): higher uncertainty (93-96)

Japanese foreign exchange intervention is effective

- Ramaswamy/Samiei (2000): „at least partially effective“ (90-98)
- Ito (2003): effective since 1995: (91-01)
- Beine/Szafarz (2003): effective when coordinated with US (91-01)
- Fatum/Hutchison (2003): successful (91-00)
- Watanabe and Harada (2006): lower volatility since 1995 (91-02)

Previous Research - Frameworks

GARCH and Reaction Functions
- Dominguez (1998),
- Ito (2003), Watanabe and Harada (2006),
- Frenkel, Pierdzioch, and Stadtmann (2005),
- Hillebrand and Schnabl (2006)

Event studies
- Fatum and Hutchison (2003), Neely (2005)

Multiple equation models without volatility
- Kim (2003): US
- Kearns and Rigobon (2005): Australia and Japan

Structural Break in Intervention Effects
- Ito (2003), Hillebrand and Schnabl (2005)

The Endogeneity Problem

1. The standard GARCH approach:

$$r_t = b_0 + b_1 I_t + b_2 Nikkei_t + b_3 Dow_t + \varepsilon_t$$

$$\varepsilon_t \,|_{\Omega_{t-1}} \sim N(0, h_t)$$

$$h_t = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i} + \sum_{i=1}^{p} \beta_i h_{t-i} + \gamma_1 \,| I_t | + \gamma_2 \,| Nikkei_t | + \gamma_3 \,| Dow_t |$$

2. Does a significant b_1 indicate that interventions push returns to the desired level? Or do changes in returns trigger interventions?

3. Same for γ_1: Do Interventions cause/decrease volatility or does volatility trigger interventions?

Focus on Volatility

- Since Dominguez (1998) it has become standard not to interpret the intervention coefficient in the mean equation.

- In order to interpret the volatility coefficient, a *reaction function* is estimated by probit or logit

- If volatility coefficient in reaction function is insignificant, one causal direction is ruled out.

Focus on Volatility

- Since volatility is latent and needs to be estimated, a simultaneous equations approach is impossible: The endogeneity issue cannot be addressed.
- The reaction function approach allows for only one measure of success for interventions: Reduction in volatility.
- Nothing can be said about the influence of interventions on the exchange rate level.

Concept of Realized Volatility

Itô process

$$\mathrm{dX(t)} = \mu dt + \sigma(t) dW_t$$

W(t) standard Brownian Motion, μ drift, σ(t) diffusion parameter (function of time)

$$\Pi = \left(0 = \tau_1, \tau_2, \ldots \tau_{n-1}, \tau_n = t\right)$$

The quadratic variation <X>(t) is given by:

$$\langle X \rangle(t) = \lim_{\|\Pi\| \to 0} \sum_{j=1}^{n} \left| X\left(\tau_j\right) - X\left(\tau_{j-1}\right) \right|^2$$

$$= \int_0^1 E_0 \sigma^2(s) ds$$

Concept of Realized Volatility

- Under the Itô process assumption, volatility can be measured arbitrarily accurately by

$$\langle X \rangle(t) - \langle X \rangle(t-1) = \sum_{j=1}^{n} \left| X(\tau_j) - X(\tau_j - 1) \right|^2$$

choosing the mesh

$$\Pi = \left(t-1 = \tau_1, \tau_2, \ldots \tau_{n-1}, \tau_n = t\right)$$

sufficiently small.

Realized Volatility as Solution to Endogeneity Problem

- Realized Volatility is an estimator of volatility that is less noisy than squared returns and obviates estimation of volatility as a latent variable.

- It provides a solution to the endogeneity problem *while volatility can remain in the system of equations.*

The Model: System of Equations

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$$r_t = \alpha_0 + \alpha_1 I_t + u_t$$

$$\log \sigma_t^2 = \beta_0 + \beta_1 \log \sigma_{t-1}^2 + \beta_2 \log \sigma_{t-1,w}^2 + \beta_3 \log \sigma_{t-1,m}^2 + \beta_4 I_t + v_t$$

$$I_t = \gamma_1 I_{t-1} + \gamma_2 r_t + \gamma_3 r_{t-1} + \gamma_3 \sigma_t^2 + \gamma_3 \sigma_{t-1}^2 + w_t$$

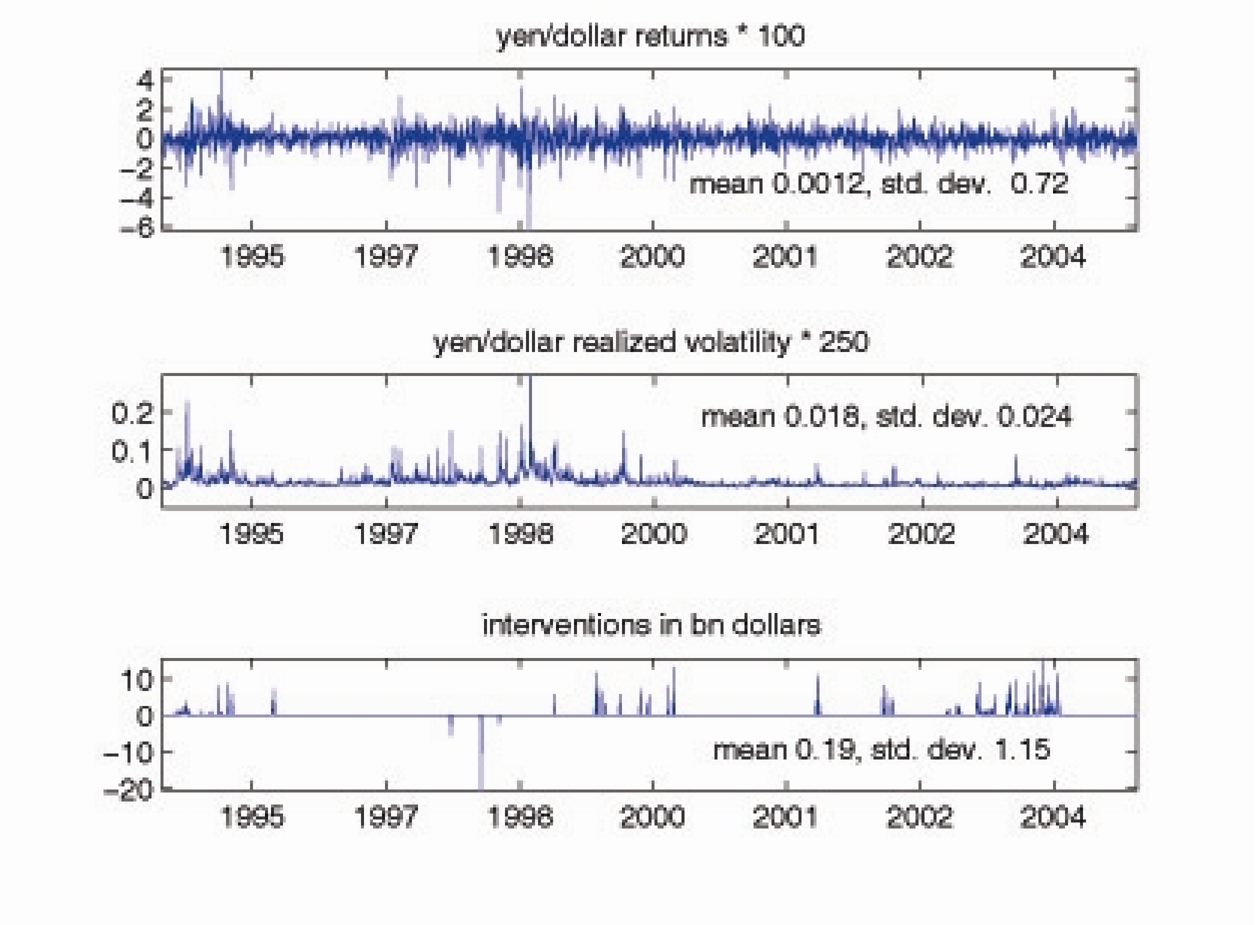
σ^2 is the realized volatility obtained from Olsen 5-minute returns of the yen/dollar rate.

Volatility equation in spirit of HAR-RV (Corsi 2004).

Estimation

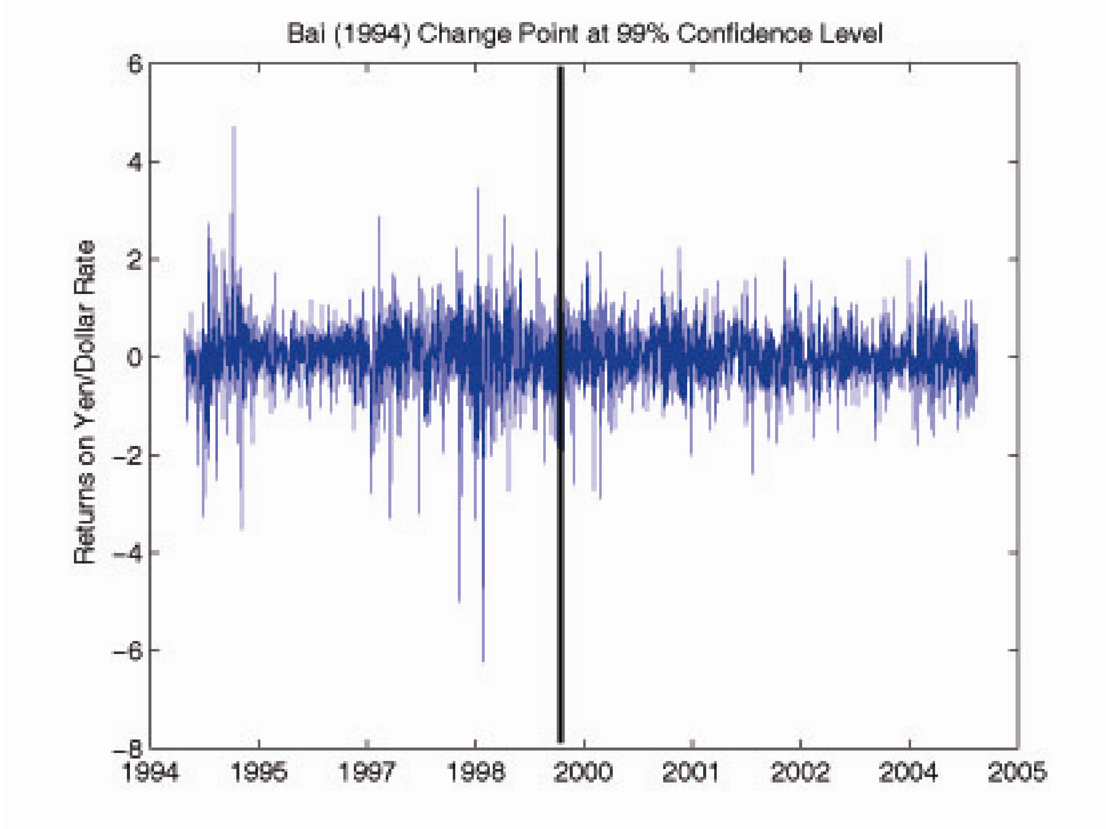
- Intervention time series has point mass at zero
- → GMM (no specific error structure required)
- Instruments: Lags 2 and 3 of interventions

Data



Yen/dollar returns and realized volatility, interventions by Japanese and U.S. authorities during 1995 to 2004.

Change Point in Realized Volatility



Change point detector of Bai (1994, 1997): structural break at 1-Dec-1999 at 99 % confidence level

Results: 1995 - 1999

LHS var.	coeff	RHS var	estimate	std err	t-stat	p-value
r_t	α_0	const	0.0421	0.0203	2.0771	0.0379
	α_1	I_t	-0.3218	0.1078	-2.9863	0.0028
	α_2	$r_{t, Nikkei}$	-0.0262	0.0171	-1.5335	0.1252
log σ_t	β_0	const	-0.8706	0.0815	-10.6825	0.0000
	β_1	$\log \sigma^2_{t-1}$	0.3986	0.0317	12.5770	0.0000
	β_2	$\log \sigma^2_{t-1,w}$	0.2556	0.0423	6.0475	0.0000
	β_3	$\log \sigma^2_{t-1,m}$	0.1489	0.0350	4.2593	0.0000
	β_4	I_t	0.3950	0.1053	3.7517	0.0002
	β_5	$r^2_{t, Nikkei}$	0.7708	0.1341	5.7478	0.0000
I_t	γ_1	I_{t-1}	0.2226	0.0713	3.1204	0.0018
	γ_2	r_t	1.7675	0.8200	2.1554	0.0312
	γ_3	r_{t-1}	-0.1167	0.0665	-1.7533	0.0796
	γ_4	σ^2_t	0.0439	0.1993	0.2200	0.8259
	γ_5	σ^2_{t-1}	-0.0246	0.1967	-0.1248	0.9007
	γ_6	$r_{t, Nikkei}$	0.0535	0.0440	1.2164	0.2239
	γ_7	$r^2_{t, Nikkei}$	0.3501	0.5551	0.6307	0.5283

Results: 2000-2005

LHS var.	coeff	RHS var	estimate	std err	t-stat	p-value
r_t	α_0	const	0.0029	0.0166	0.1776	0.8590
	α_1	I_t	0.0302	0.0158	1.9132	0.0558
	α_2	$r_{t, Nikkei}$	-0.0374	0.0147	-2.5491	0.0108
$\log \sigma_t$	β_0	const	-1.0477	0.1868	-5.6082	0.0000
	β_1	$\log \sigma^2_{t-1}$	0.2560	0.0401	6.3889	0.0000
	β_2	$\log \sigma^2_{t-1,w}$	0.3039	0.0754	4.0331	0.0001
	β_3	$\log \sigma^2_{t-1,m}$	0.2252	0.0573	3.9316	0.0001
	β_4	I_t	-0.1198	0.0246	-4.8777	0.0000
	β_5	$r^2_{t, Nikkei}$	0.5346	0.1411	3.7884	0.0002
I_t	γ_1	I_{t-1}	0.3470	0.0526	6.5987	0.0000
	γ_2	r_t	0.1526	1.7858	0.0854	0.9319
	γ_3	r_{t-1}	-0.1170	0.1295	-0.9035	0.3663
	γ_4	σ^2_t	0.1224	0.1713	0.7141	0.4752
	γ_5	σ^2_{t-1}	-0.1427	0.1721	-0.8293	0.4070
	γ_6	$r_{t, Nikkei}$	0.0094	0.0516	0.1818	0.8557
	γ_7	$r^2_{t, Nikkei}$	-0.0238	0.4762	-0.0501	0.9601

Conclusions

1. Between 1994 and 1999, interventions seem *unsuccessful:* Interventions in the return equation are significant but have the wrong sign.
2. Between 1994 and 1999, interventions coincide with increases in volatility.
3. Between 1999 and 2004, interventions seem *successful:* Interventions in the return equation are marginally significant with the right sign.
4. Between 1999 and 2004, interventions *decreased* volatility.

5. Realized volatility allows us to estimate a system of simultaneous equations in yen/dollar returns, volatility, and central bank interventions, thus avoiding endogeneity bias.

6. Not accounting for the structural change in 1999 blurs the picture: interventions seem insignificant in the return equation and negatively significant in the volatility equation.