

Capital Controls in India and Interest Rate Arbitrage

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What are the broader issues?

- How do capital controls affect
 - Growth
 - Financial development
 - Inflation
 - Macroeconomic volatility?
- How do capital controls affect financial market behavior?
- How does one measure capital controls?
 - De jure
 - De facto

A good place to start

- How do capital controls affect interest rate arbitrage in practice?
- Can deviations from arbitrage conditions reveal information about the effectiveness of controls?
- Measure this by deviations from covered interest parity (CIP), which is an arbitrage condition in the absence of frictions from
 - Market institutions
 - Policy restrictions
- Exchange rate expectations and macroeconomic fluctuations should not affect CIP, just components of the parity relationship

Covered interest parity

- Absent market imperfections or transaction costs, the interest differential between financial assets of the same term denominated in different currencies will equal the cost of covering in the forward market the currency risk from arbitrage between the two assets (arising from possible movements of the exchange rate before the assets mature).

$$\frac{F - S}{S} = \frac{i - i_{\$}}{1 + i_{\$}}$$

Non-deliverable forward market

- Non- deliverable forward (NDF) markets allow
 - offshore agents with the restricted-currency exposures to hedge or
 - to take positions on expected changes in exchange rates
- Located offshore- i.e. in financial centers outside the country of the restricted currency
- Involve contract settlement without delivery in the restricted currency
- When currencies are fully convertible, NDF markets are not observed

NDF implied yield

- When access to an onshore forward market is restricted, an offshore NDF market may develop, with a corresponding NDF forward rate, say F_N
- This rate implies a corresponding interest rate, called the NDF implied yield

$$r = \frac{F_N}{S} (1 + i_{\$}) - 1$$

Proxying for CIP deviations

- A large and persistent positive onshore-offshore differential ($i-r$) reflects effective stemming of capital inflows
- A negative differential suggests an effective restriction of capital outflows
- When access to local currency securities markets is limited, the NDF forward rate will reflect the expected future spot rate of the currency
 - The differential ($i-r$) **could** reflect differences in onshore and offshore expectations

Indian Rupee NDF markets

- Most active in Singapore and Hong Kong, with Dubai as an emerging center
- Volume increasing rapidly

Average daily turnover of NDF contracts in Indian Rupee

Period	US \$ million
June 2001	35
2003 Q1	38
Mid 2003	100
2006 Q2	500
2007, Jan - Apr	3,736

Sources: Ma et. al (2004), Misra and Behera (2006), Debelle et. al. (2006)

Indian Rupee Spot, Forward and NDF Markets

Average daily turnover, Jan-Apr 2007

(US \$ million)

Spot	16,381
Forward/Swap	15,378
NDF	3,736
<i>Of which</i> 1 Month	993
2 Month	735
3 Month	990
6 Month	913
1 Year	1,018

Note : Turnover for NDF is the average daily volume of NDF bidding for the period January 5 to April 20, 2007. Turnover of spot, forward and swap is for January-April, 2007.

Source: Misra and Behera (2006)

Volume comparisons

Average daily NDF turnover in Asia

In millions of US dollars

Sources of estimates	HSBC (mid-2003)	Deutsche Bank (2003–04)	EMTA (1st quarter 2003)	Lehman Brothers (June 2001)	April 2001 forwards and FX swaps ¹
Chinese renminbi	1,000	50	150	50	55
Indian rupee	100	20–50	38	35	1,628
Indonesian rupiah	100	50	65	50	301
Korean won	500	700–1,000	1,350	500	4,025
Philippine peso	50	20–30	38	35	301
New Taiwan dollar	500	300–500	250	250	922
Asian six total	2,250	1,140–1,680	1,890	920	7,232
<i>As a percentage of April 2001 forwards, FX swaps and NDFs¹</i>	25.1	13–19	20.7	11.3	

¹ Daily turnover of the forwards and FX swaps is based on BIS (2002).

Source: Ma, Ho McCauley (BIS, 2004)

Previous work with NDF data

- Ma, Ho McCauley (BIS, 2004)
 - Six Asian currencies (China, India, Indonesia, South Korea, Philippines, Taiwan)
 - India data Jan. 1999 – Feb. 2004
 - Onshore-offshore differential is negative till late 2003, then switches to positive
 - Onshore rate is 91-day T-bill auction yield
 - Average absolute spread and volatility both fell between first and second half of period
 - Average absolute spread about 300 basis points
 - NDF volatility greater than in spot market

Previous work with NDF data

■ Mishra and Behera (2006)

- Causality relationships among different rates
 - Spot and forward rates Granger caused NDF rates
 - No reverse causality
 - “Such a result seems obvious in the Indian context”
- Volatility spillovers (GARCH model)
 - Spillover from spot to NDF market but not from forward to NDF
 - Small but significant volatility spillover from NDF to spot and forward markets
- Onshore-offshore differential is almost always positive for Oct. 2004 – Jan. 2007
 - Implied onshore yield on Rupee using onshore deliverable forward premium

Capital controls and financial market behavior

- Has the behavior of the onshore-offshore differential changed over time?
- Are any changes related to observable changes in capital controls?
- Methodological contribution
 - ***Go beyond graphing and summary statistics to examine time series properties of differential***
- Hypothesis:
 - ***Relaxation of capital controls will be reflected in **smaller** differentials that are **quicker to revert to the mean*****

Time series methodology

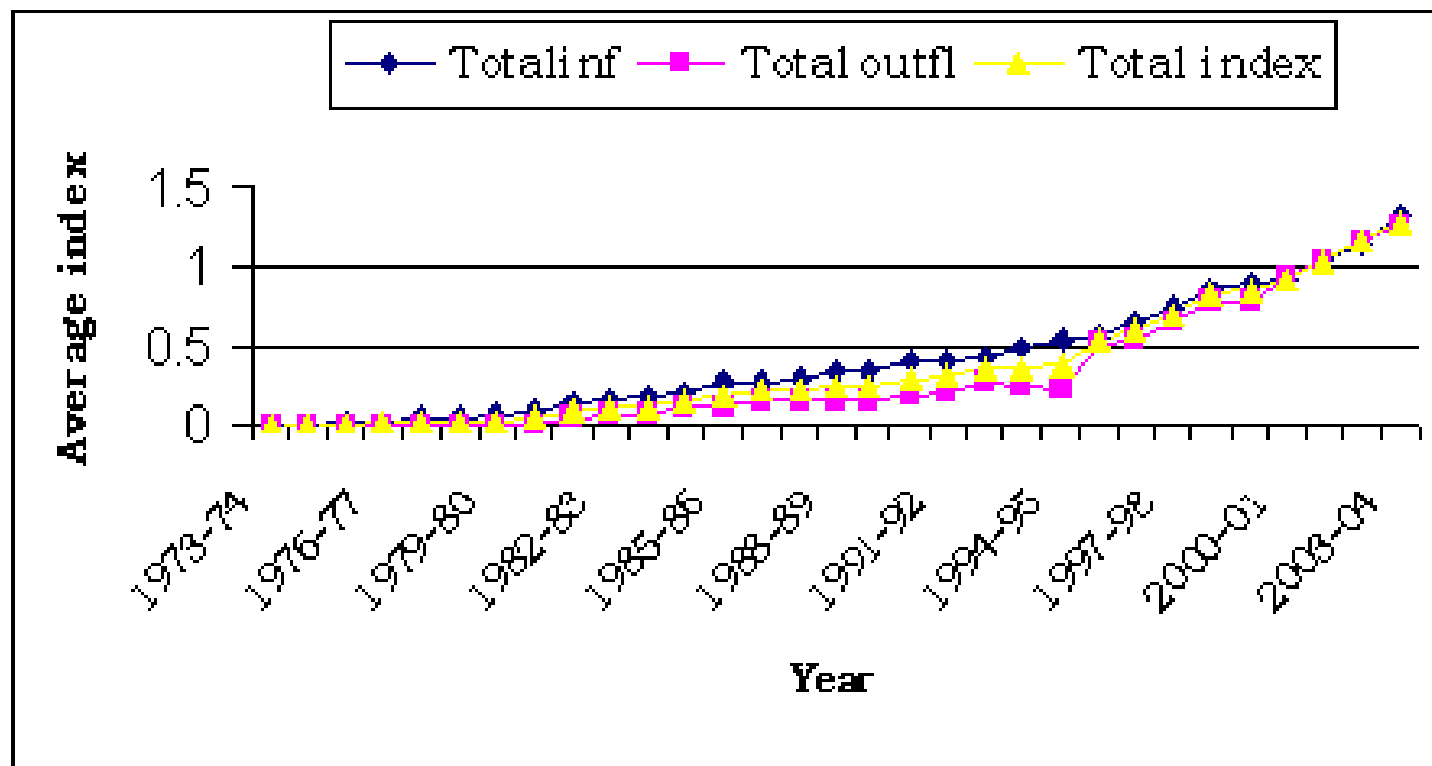
- Times series properties of underlying series and onshore-offshore differential
 - Is the differential stationary?
 - What is the rate of mean reversion and how does it change over time?
 - What is the steady state value of the differential and how does it change over time?
- Use rolling regressions and subsample regressions

India's capital controls

- Complex, piecemeal restrictions on asset trading, outflows and inflows (what, who, how and how much)
- Mostly a trend of gradual liberalization, but sometimes tightening measures introduced
- De jure Index (Chinn-Ito) suggests highly restrictive regime
- De facto (market behavior) suggests that regime may be less restrictive in practice (Pasricha, 2007)

Index of capital account openenness

Aggregate rule based indices (average)



Source: RBI Publications, various issues and Economic Survey, various issues

Source: Lekshmi Nair, Degree of Capital Account Openenness and Macroeconomic Volatility in India, October 2006, Figure A1

Data and estimation

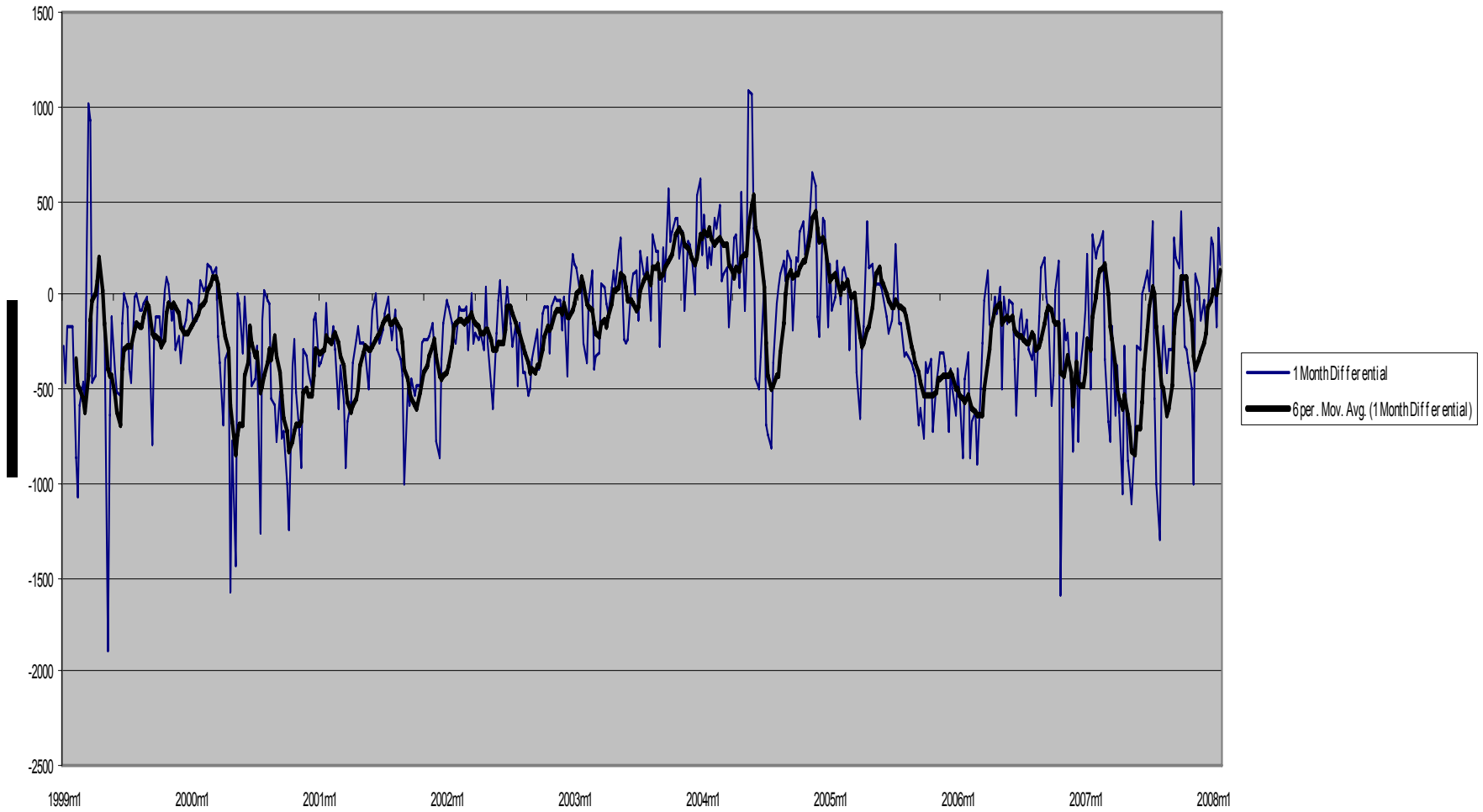
- Use MIBOR for onshore rate and LIBOR to derive implied NDF yield
- Use weekly data (Bloomberg)
- ADF tests indicate series are $I(1)$ but differential is $I(0)$
- Johansen tests for co-integration were also carried out in rolling fashion
- Information criterion suggests longer lags, but results are similar to $AR(1)$ model for differential and easiest to interpret

Interpretation

- AR(1) parameter (ρ) reveals rate of mean reversion – smaller absolute ρ indicates faster mean reversion
- Steady state value of differential is $\alpha/(1 - \rho)$
- Hypothesis is that relaxing capital controls will show up in ρ and $\alpha/(1 - \rho)$ declining in magnitude over time

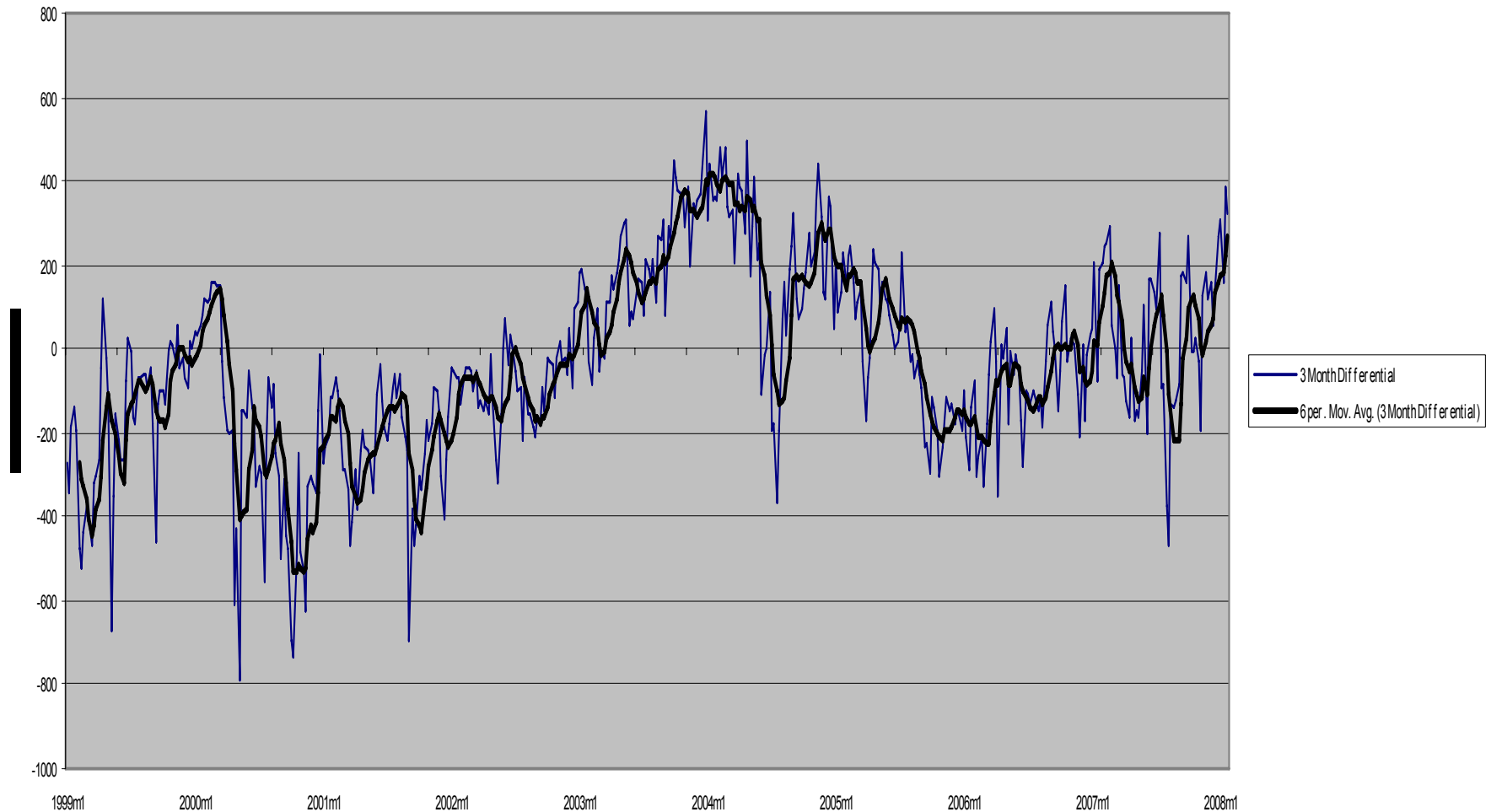
1-month differential and 6-month MA

ChartTitle



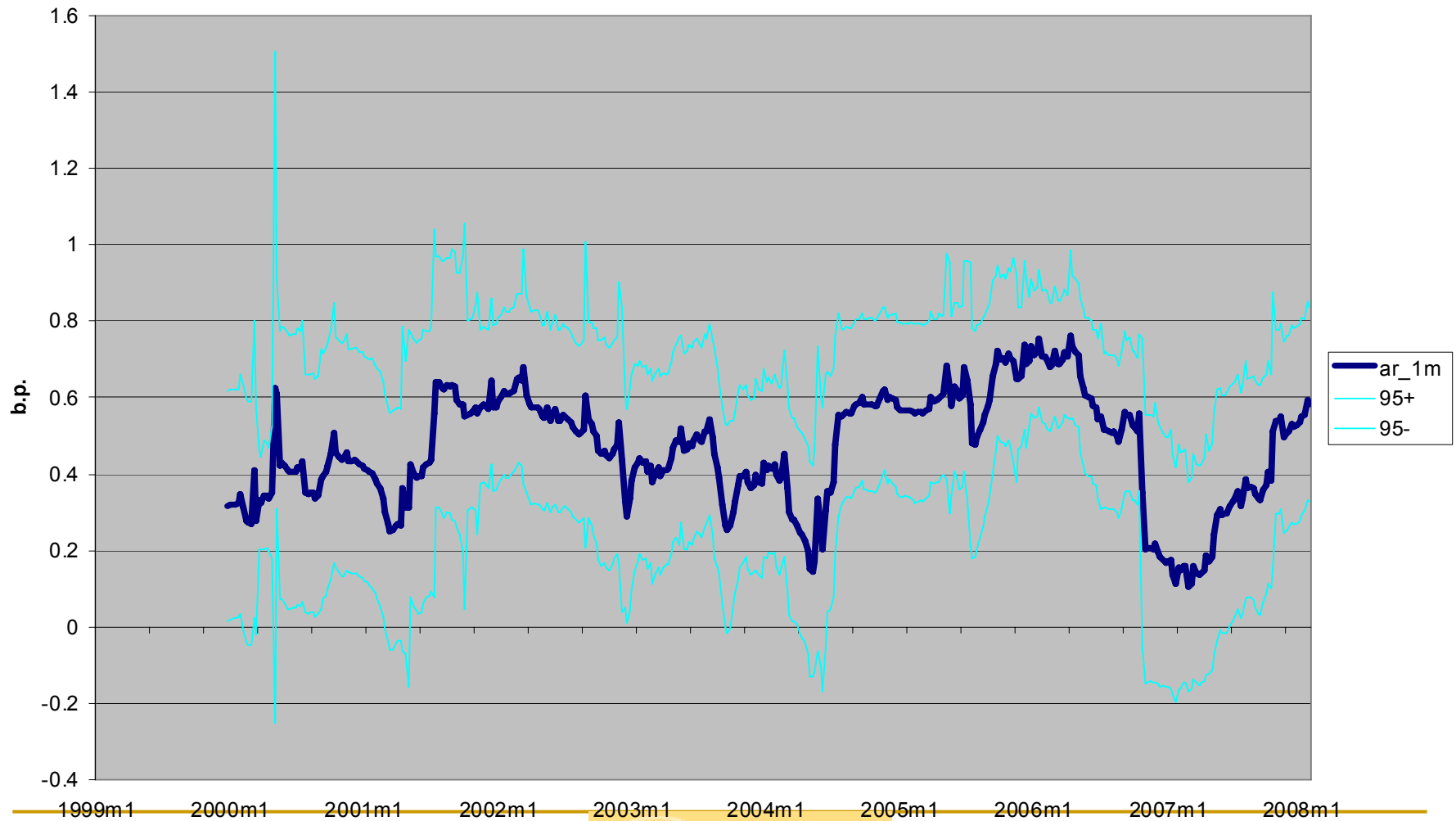
3-month differential and 6-month MA

ChartTitle



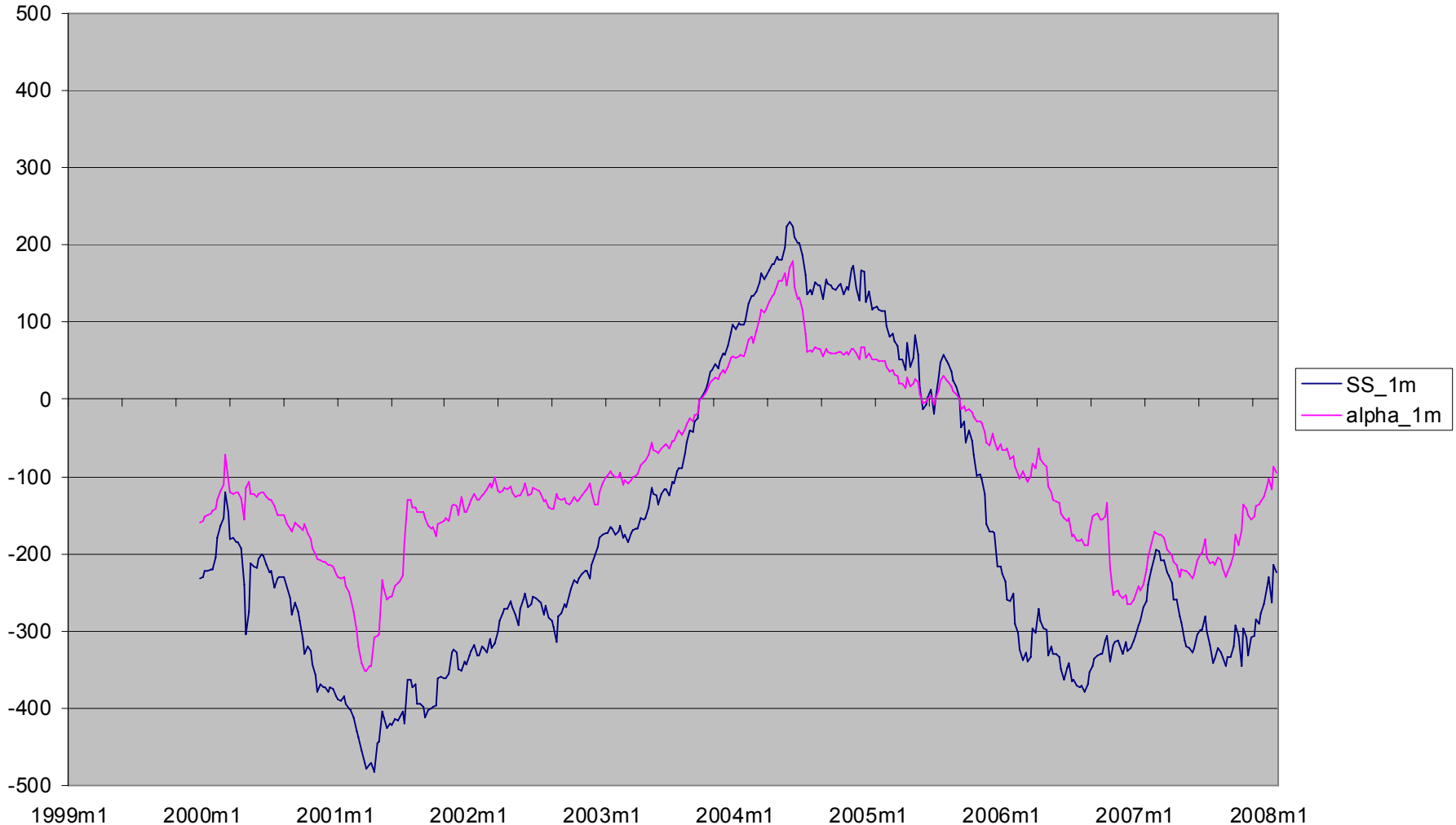
1-month rolling, 1 year window – AR(1) parameter

1 mon - AR(1) - 1 yr window



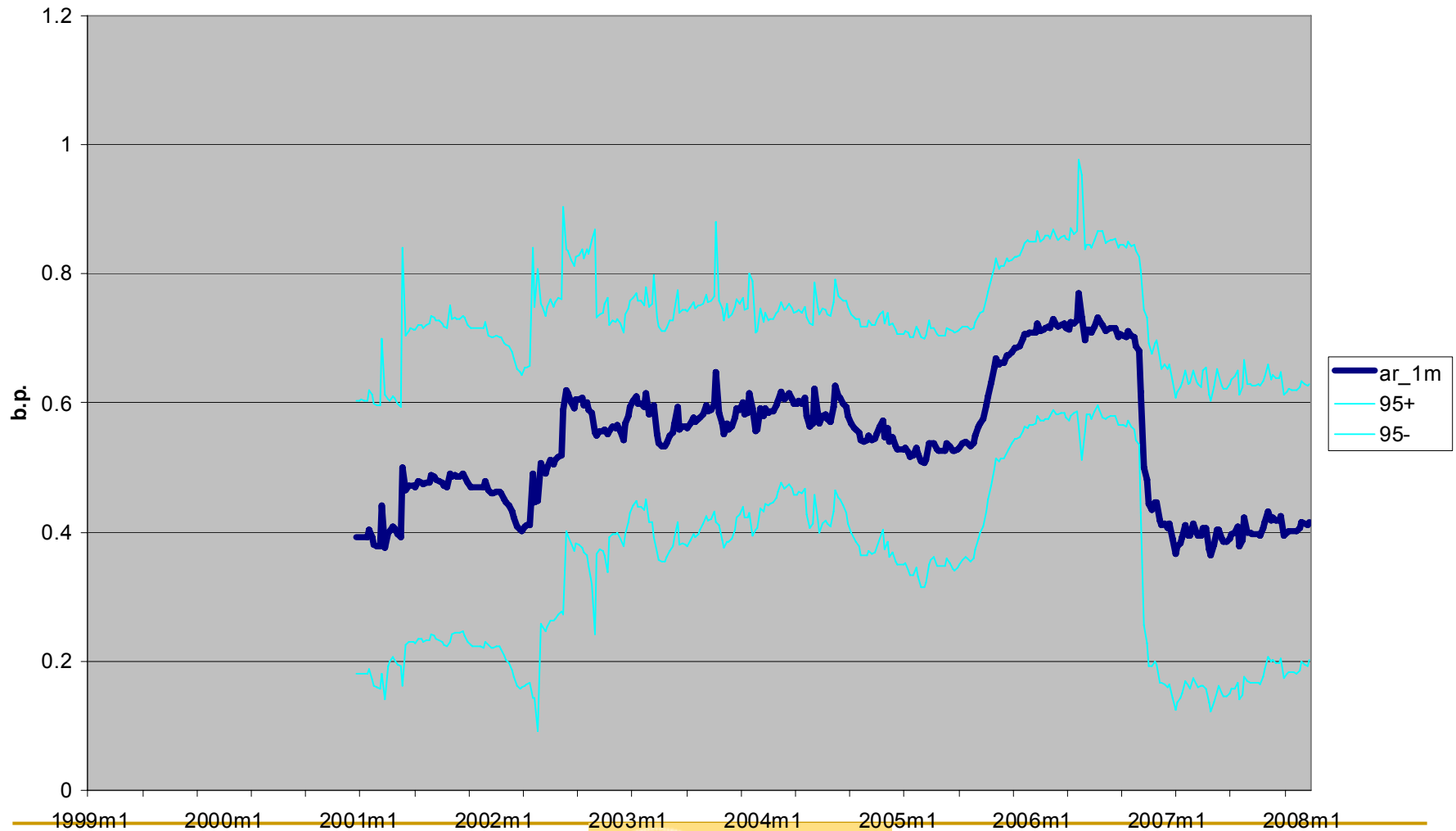
1-month rolling, 1 year window – constant and steady state

Steady State and Constant



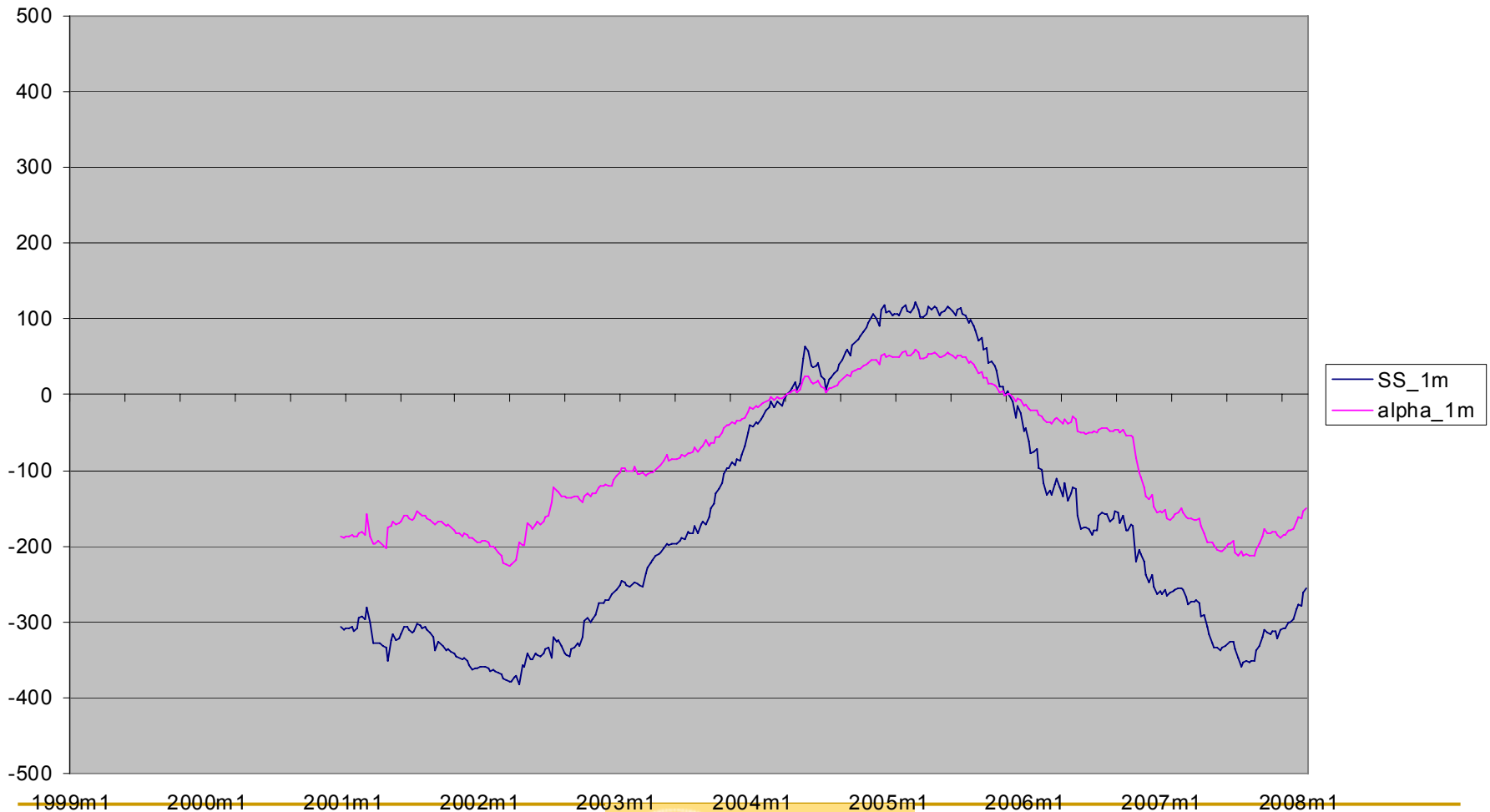
1-month rolling, 2 year window – AR(1) parameter

1 mon - AR(1) - 2 yr window



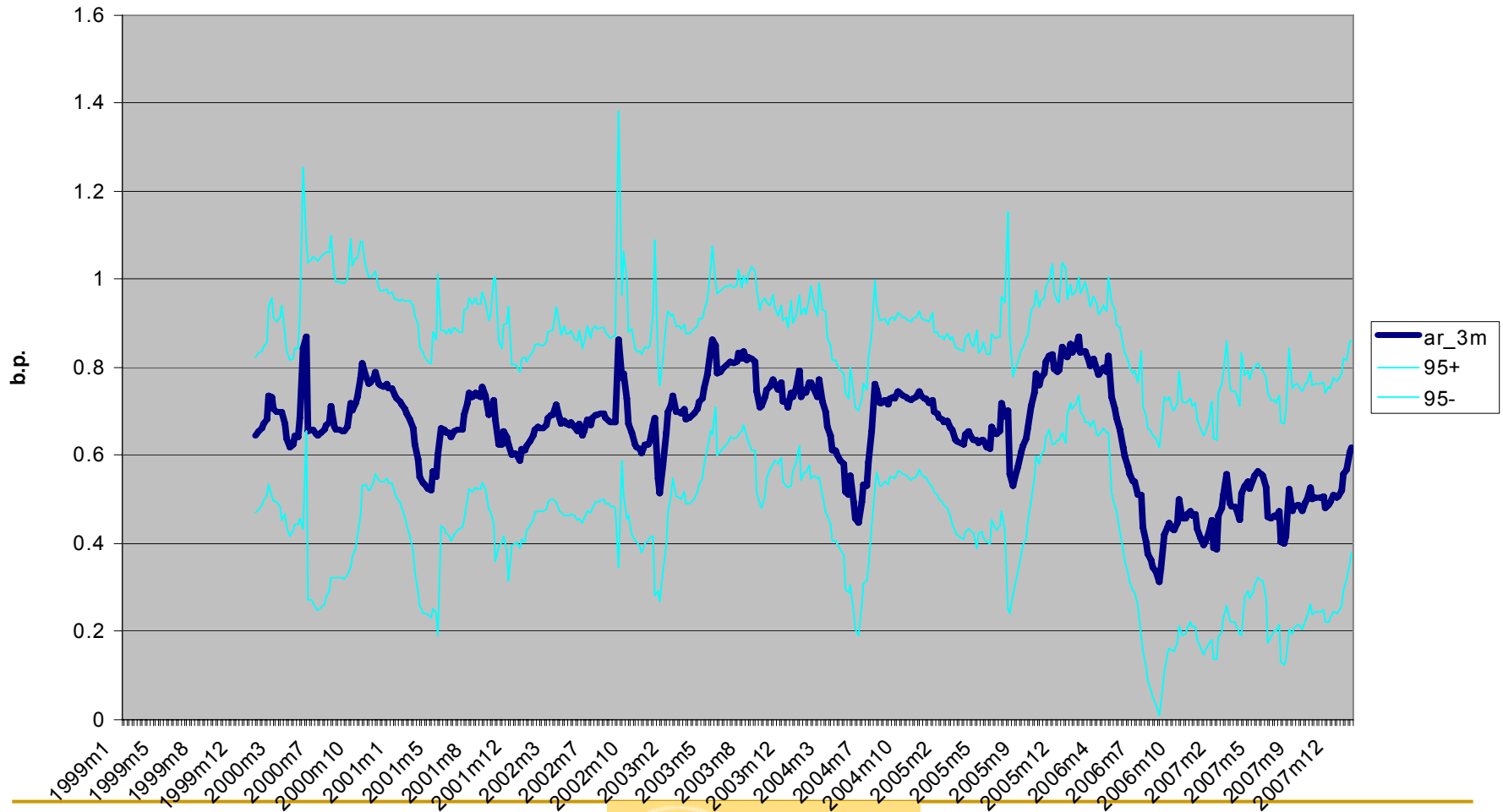
1-month rolling, 2 year window – constant and steady state

Steady State and Constant



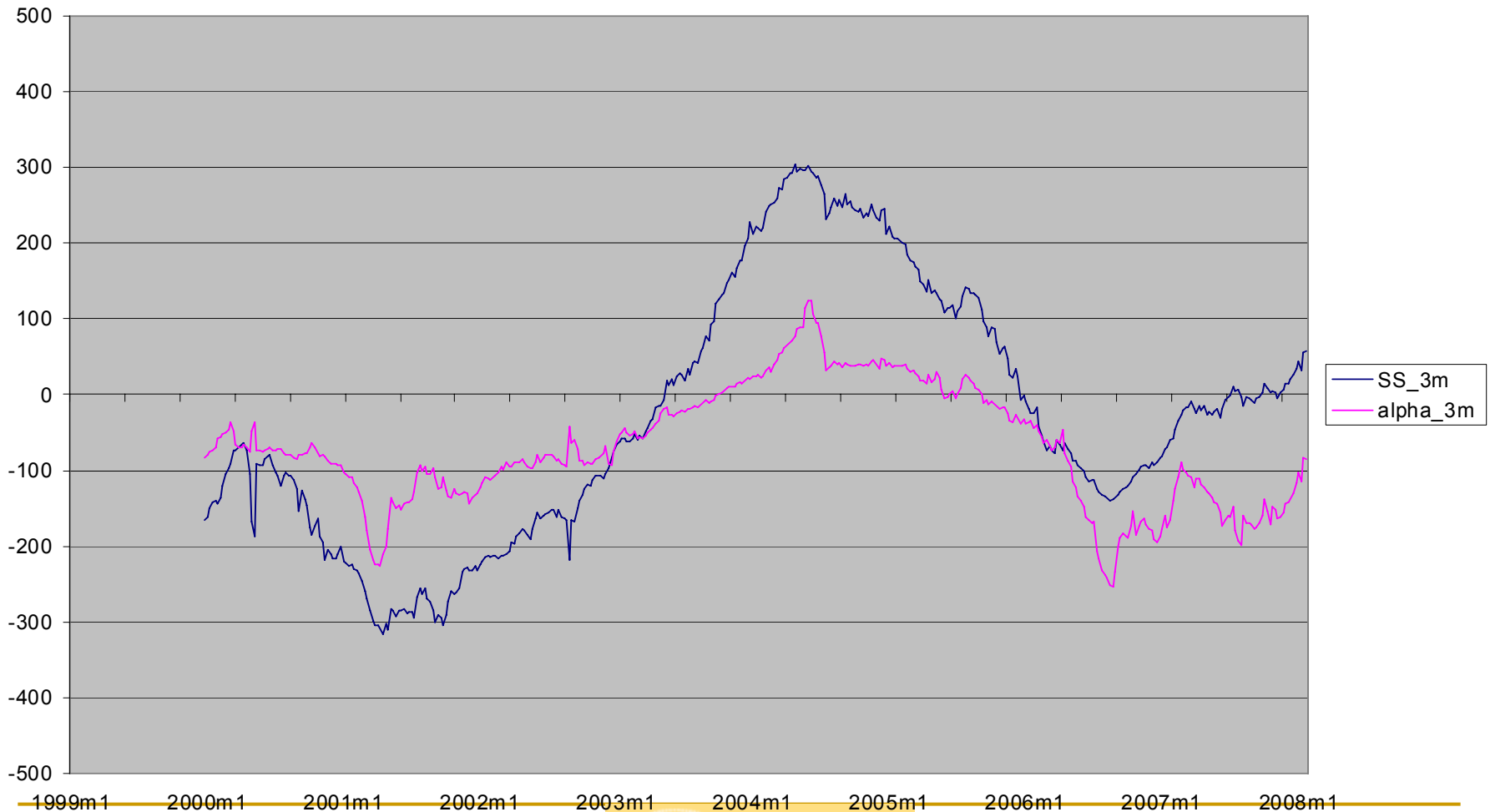
3-month rolling, 1 year window – AR(1) parameter

3 mon - AR(1) - 1 yr window



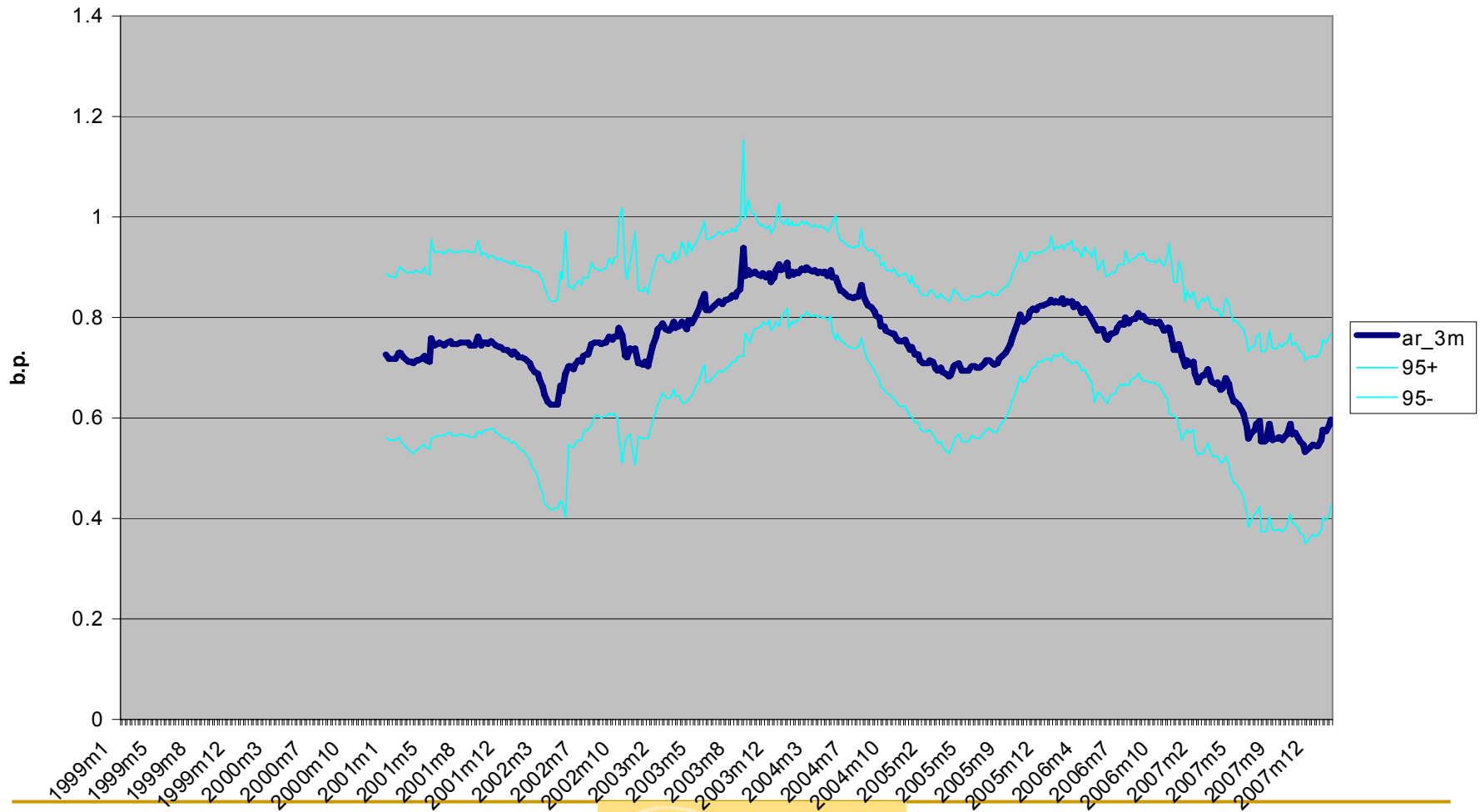
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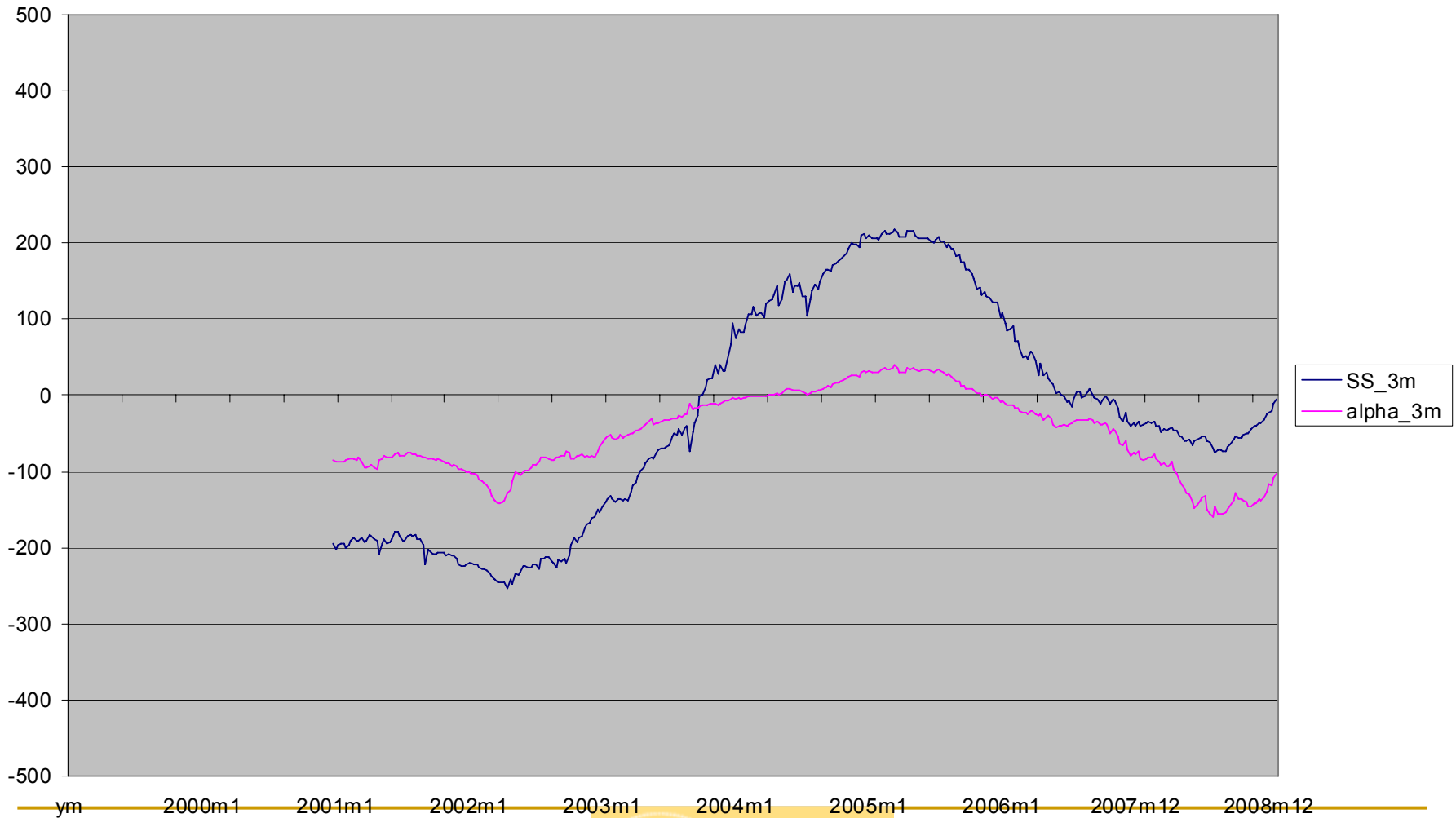
3-month rolling, 2 year window – AR(1) parameter

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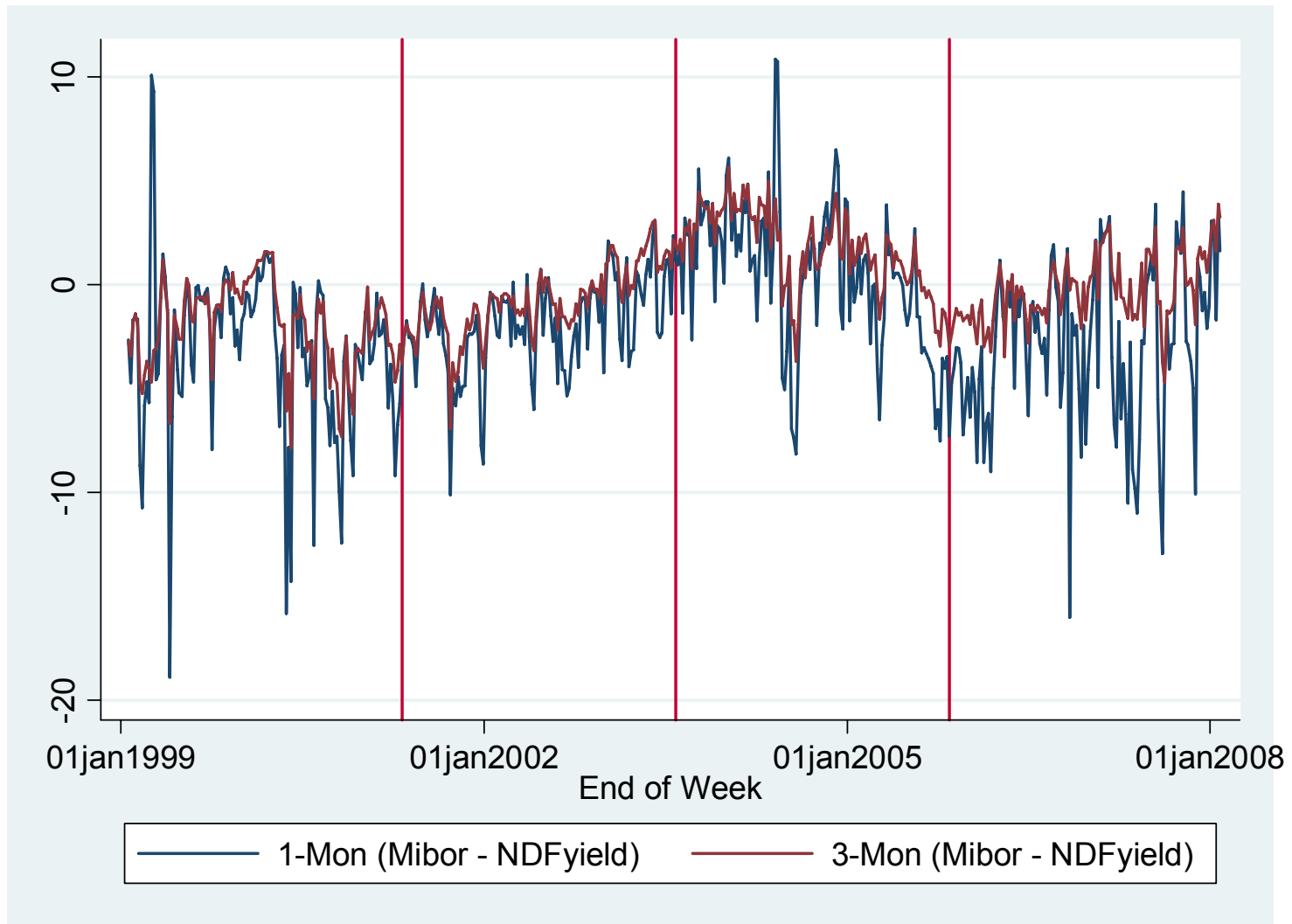


3-month rolling, 2 year window – constant and steady state

Steady State and Constant



Equal subsamples



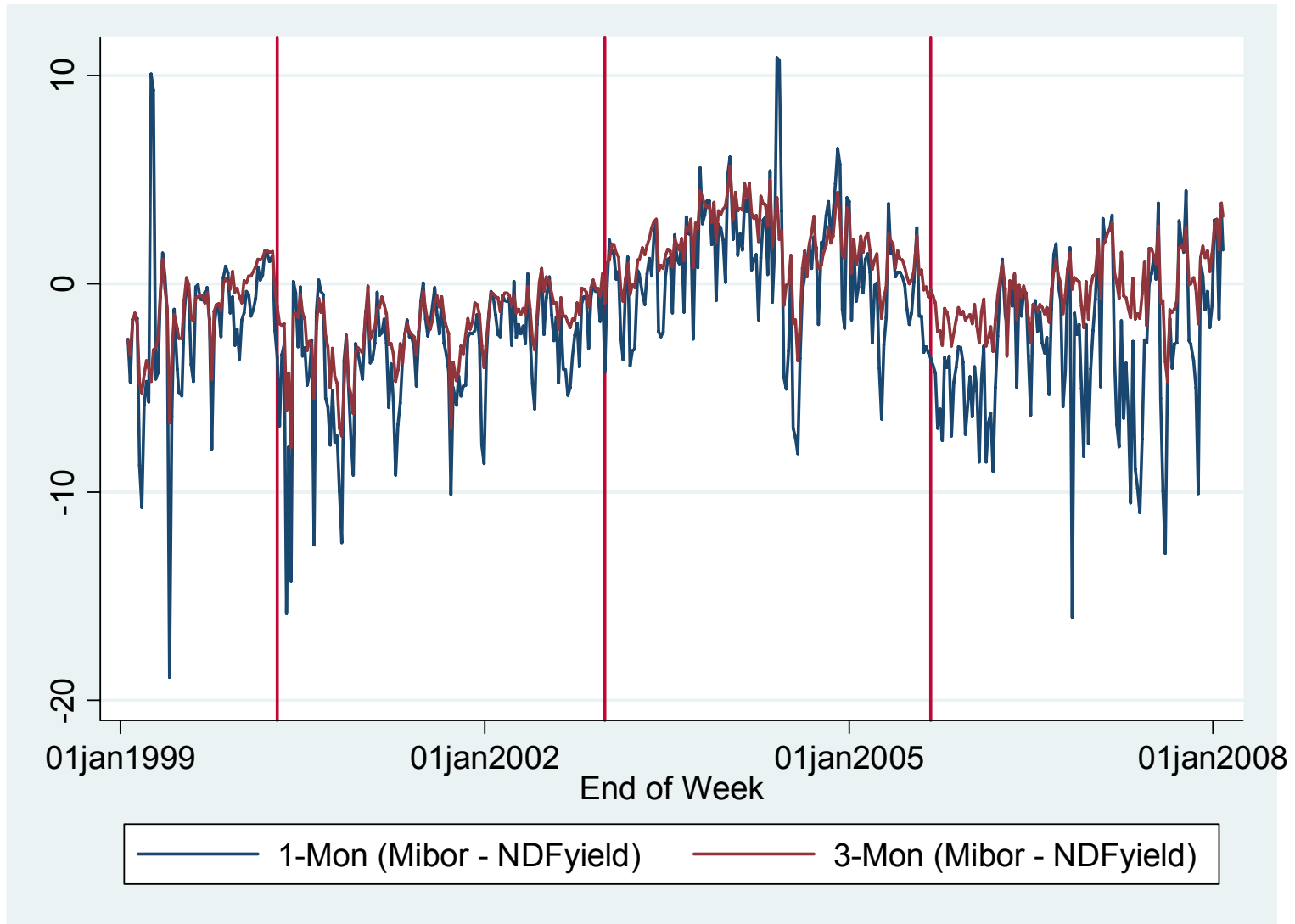
Equal subsample estimates

	Time Periods				
	jan99-apr01	apr01-aug03	aug03-nov05	nov05-jan08	<i>full sample</i>
1 Month Series					
AR(1)	0.404***	0.570***	0.640***	0.428***	0.566***
(z-stat)	(5.73)	(8.26)	(9.20)	(5.72)	(19.22)
3 Month Series					
AR(1)	0.720***	0.841***	0.791***	0.630***	0.837***
(z-stat)	(11.23)	(20.50)	(13.73)	(9.14)	(40.53)
N=	117	117	117	116	470

Structural break tests – equal

	1 month		3 month	
Constant	Coefficient	t-value	Coefficient	t-value
Subsample 1	-1.904	-5.33	-0.551	-3.48
Δ Subsample 2	1.115	2.15	0.458	2.26
Δ Subsample 3	2.053	4.51	0.869	3.94
Δ Subsample 4	0.296	0.59	0.476	2.43
AR (1)				
Subsample 1	0.407	5.85	0.726	13.21
Δ Subsample 2	0.164	1.14	0.117	1.33
Δ Subsample 3	0.238	2.23	0.072	0.89
Δ Subsample 4	0.025	0.25	-0.086	-0.97

Ocular subsamples



Ocular subsample estimates

	Time Periods				
	jan99-apr00	apr00-dec02	dec02-sep05	sep05-jan08	<i>full sample</i>
1 Month Series					
AR(1)	0.358***	0.446***	0.552***	0.438***	0.566***
(z-stat)	(3.67)	(6.84)	(8.64)	(6.15)	(19.22)
3 Month Series					
AR(1)	0.748***	0.686***	0.730***	0.647***	0.837***
(z-stat)	(7.80)	(12.71)	(12.98)	(9.99)	(40.53)
N=	64	139	139	125	470

Structural break tests – ocular

	1 month		3 month	
Constant	Coefficient	t-value	Coefficient	t-value
Subsample 1	-1.196	-2.85	-0.260	-1.43
Δ Subsample 2	-0.657	-1.15	-0.383	-1.57
Δ Subsample 3	1.481	3.00	0.734	3.09
Δ Subsample 4	-0.466	-0.86	0.149	0.70
AR (1)				
Subsample 1	0.364	3.77	0.752	9.25
Δ Subsample 2	0.081	0.62	-0.063	-0.63
Δ Subsample 3	0.187	1.46	-0.207	-0.20
Δ Subsample 4	0.077	0.65	-0.100	-0.95

Do controls on inflows and outflows bind asymmetrically?

- The relative speeds with which negative or positive onshore-offshore differentials are reduced in magnitude may depend on differences in controls on inflows vs. controls on outflows

Asymmetries in response (positive vs. negative differentials)

	1 Month	p-value of difference	3 month	p-value of difference
AR(1) pos.	0.459	0.96	0.816	0.20
AR(1) neg.	0.466		0.705	
Const. pos.	0.107	0.01	0.116	0.01
Const. neg.	-1.347		-0.373	

Do other variables matter?

- If market participants are responding to other factors besides pure arbitrage, the information set for the onshore-offshore differential time series may be larger
 - Assumes that arbitrage is subject to constraints that depend on these factors
- Broad possibilities
 - International macroeconomic conditions
 - LIBOR-MIBOR differential
 - Central bank policy responses
 - Degree of RBI intervention in FX market

Lagged change in reserves

	Constant	Differential-1	Δ reserves-1
1 Month Series			
coefficient	-2.01***	0.561***	7.353
(z-stat)	(-5.55)	(10.64)	(0.69)
3 Month Series			
coefficient	-0.314	0.838***	-1.030
(z-stat)	(-0.88)	(25.84)	(-0.28)
N=	470		

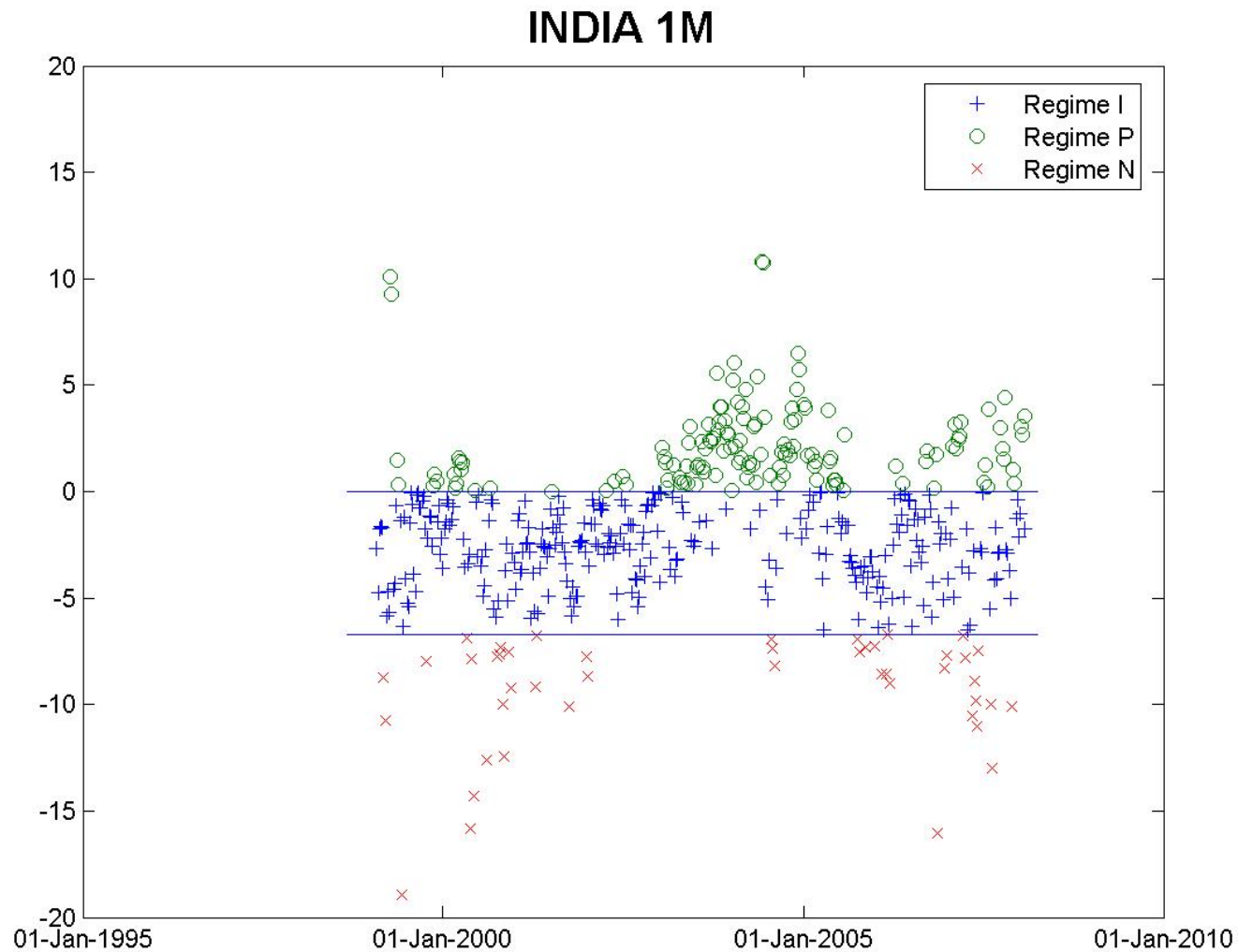
Lagged differential (MIBOR-LIBOR)

	Constant	Differential-1	$\Delta M-L-1$
1 Month Series			
coefficient	-2.14***	0.564***	0.076
(z-stat)	(-2.50)	(10.93)	(0.39)
3 Month Series			
coefficient	-0.498	0.842***	0.040
(z-stat)	(-0.51)	(22.97)	(0.19)
N=	466/470		

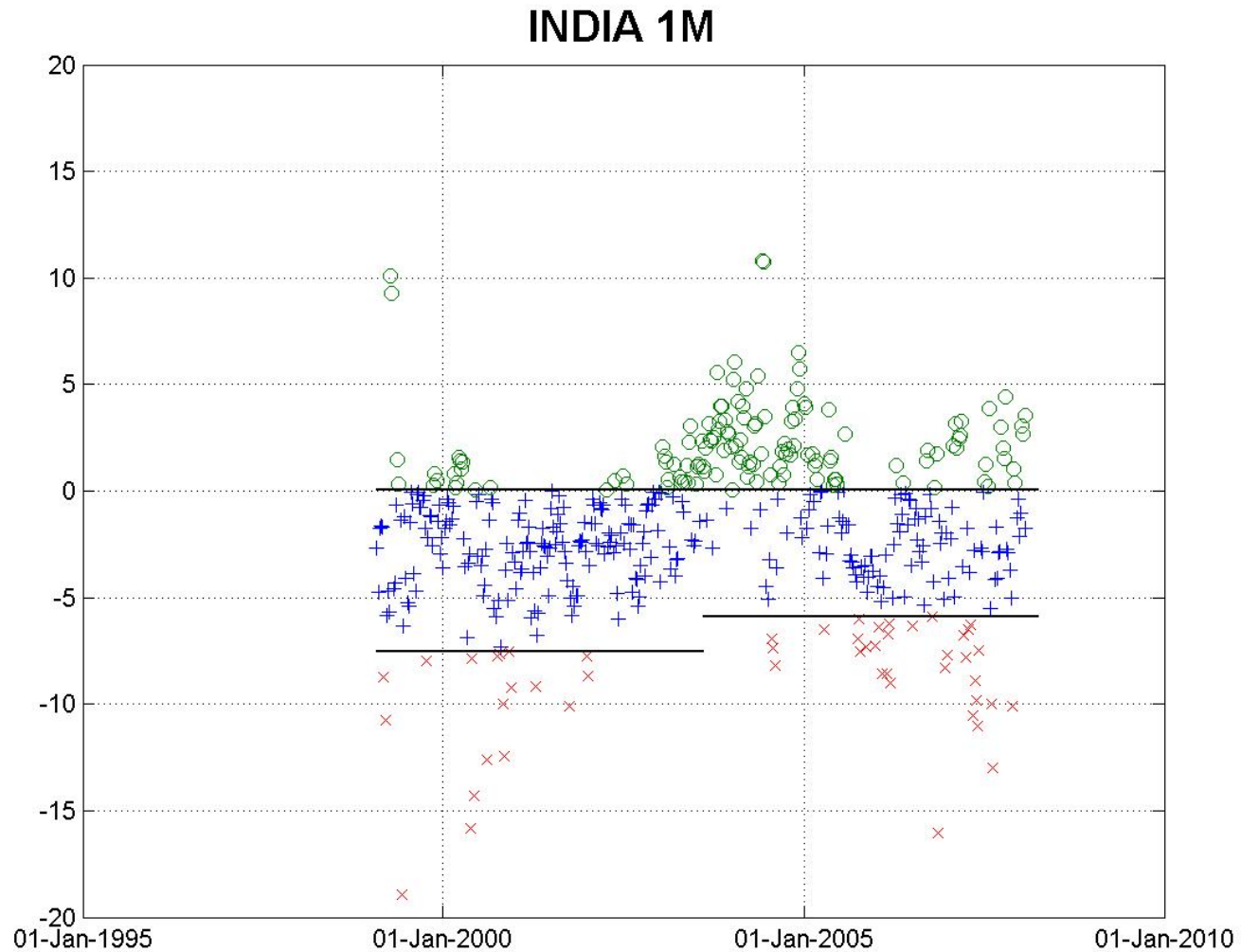
Nonlinear adjustment

- Threshold Autoregressive Model (TAR)
 - $\delta_t = \rho_i \delta_{t-1} + \varepsilon_{it}$ for $\kappa_n < \delta_{t-1} < \kappa_p$
 - $\delta_t - \kappa_n = \rho_n(\delta_{t-1} - \kappa_n) + \varepsilon_{nt}$ for $\delta_{t-1} \leq \kappa_n$
 - $\delta_t - \kappa_p = \rho_p(\delta_{t-1} - \kappa_p) + \varepsilon_{pt}$ for $\delta_{t-1} \geq \kappa_p$
- Efficient arbitrage hypothesis:
 - AR(1) process outside the bands is stationary.
- Source: Pasricha (2007)

1-month whole sample

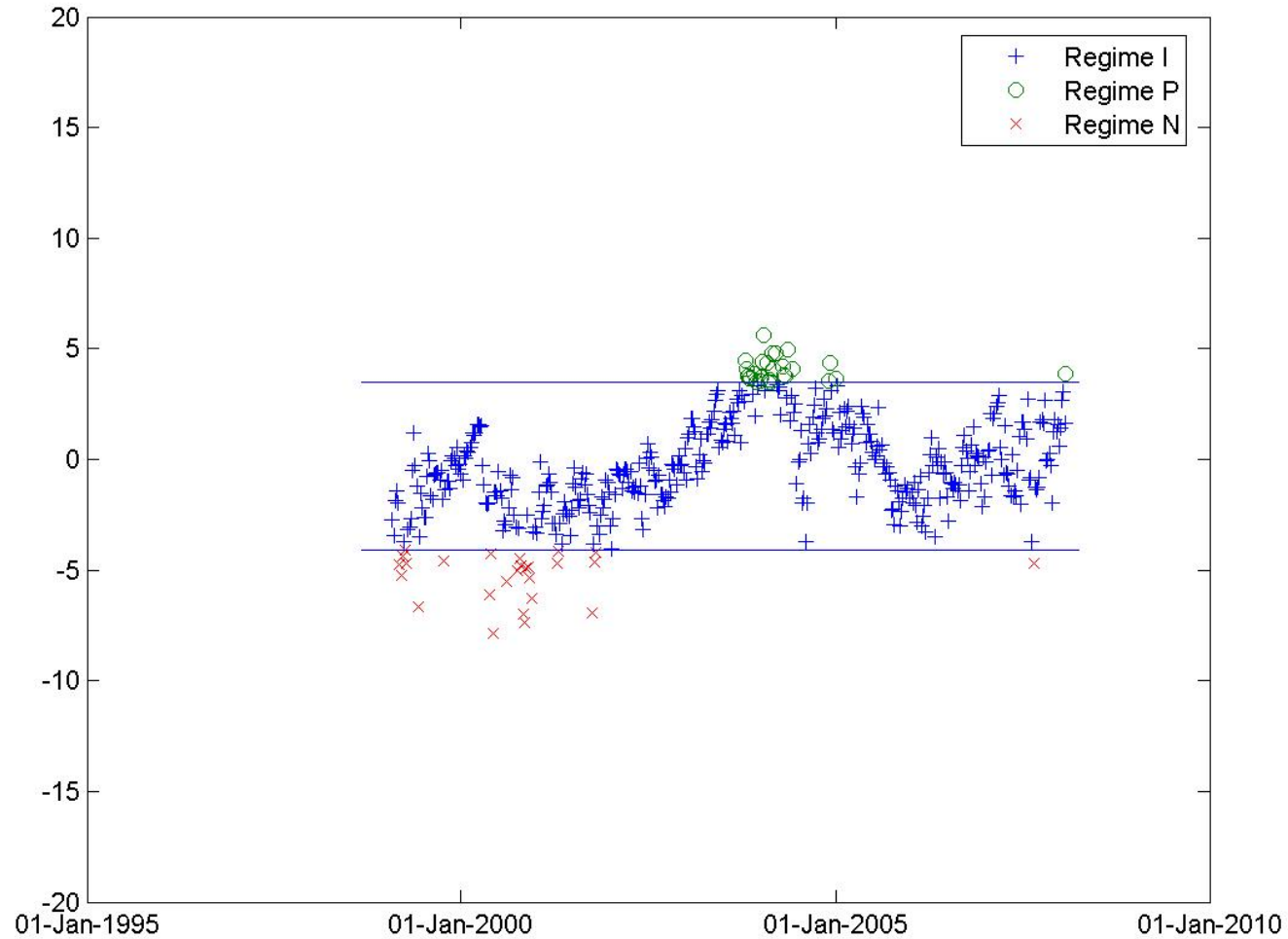


1-month equal subsamples

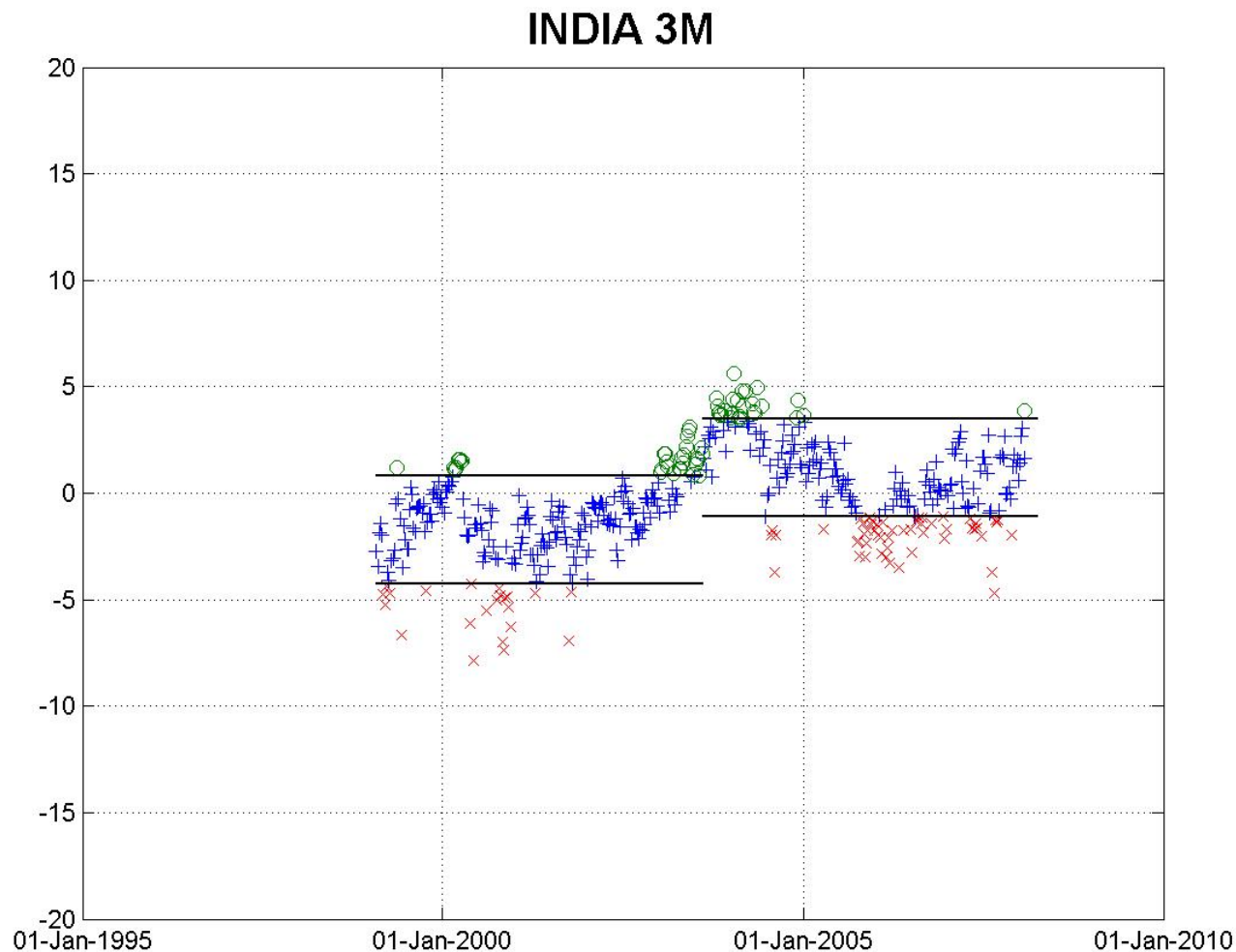


3-month whole sample

INDIA 3M



1-month equal subsamples



Conclusions (1)

- While broad de jure indices of capital controls in India suggest steady if gradual liberalization, financial market behavior tells a different story
- Average deviations from an implied arbitrage equality do not come down smoothly over the period studied
- Nor does the rate of mean reversion increase smoothly
- However, the most recent period appears to show the impacts of capital account liberalization

Conclusions (2)

■ Research directions

- An event study may help to identify precisely which forms of relaxation of controls improve financial market efficiency
- Transaction data may also identify more precisely the factors that affect deviations from parities implied by arbitrage opportunities