Indian Capital Control Liberalization: Evidence from NDF Markets

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Overview: Methodology

- Indian government has taken incremental steps to liberalize international capital flows
- Analyze how the effectiveness of Indian capital controls has changed over time
- Measure controls' effectiveness using covered interest parity deviations, by assessing point at which arbitrage activity appears
- Use the offshore NDF market to measure the effective foreign interest rate
- Use SETAR methodology to estimate a no-arbitrage band, whose boundaries are determined by transactions costs and capital controls

Overview: Results

- We find that *de facto* capital control barriers:
  - (1) are asymmetric over inflows and outflows
  - (2) have relaxed over time due to a relaxation in constraints on outflows
  - (3) have little measurable impact on inflows.
- We also find that arbitrage activity rapidly closes deviations from CIP when the threshold boundaries are exceeded.

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)

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).

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

Literature

- Studies that have estimated deviations from CIP as an indication of international financial market integration in various contexts
  - Frankel and Levich (1975)
  - Taylor (1989)
  - Frankel (1991)
- The Self-Exciting Threshold Autoregressive (SETAR) model is a particular class of piece-wise autoregressive models
  - Tong (1978)
  - Potter (1999)
  - Hansen (1999)
  - Levy Yeyati, Schmukler and Van Horen (2006)

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
Of which	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
As a percentage of April 2001 forwards, FX swaps and NDFs[1]	*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

Preliminary Time Series Analysis

- 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?
- Use rolling regressions and Chow tests across subsamples

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 (not reported)

ADF unit root tests

Variable	Lags *		ADF Stat.	p-value
NDF 1-mon.	BIC	4	-3.72***	0.00
	AIC	11	-1.994	0.29
NDF 3-mon.	BIC	3	-2.275	0.18
	AIC	8	-2.043	0.27
MIBOR 1-mon.	BIC	0	-2.251	0.19
	AIC	17	-1.458	0.55
MIBOR 3-mon.	BIC	0	-1.755	0.40
	AIC	0	..	..
Differential 1-mon.	BIC	1	-9.178***	0.00
	AIC	11	-3.282**	0.02
Differential 3-mon.	BIC	1	-4.955***	0.00
	AIC	8	-2.797*	0.06

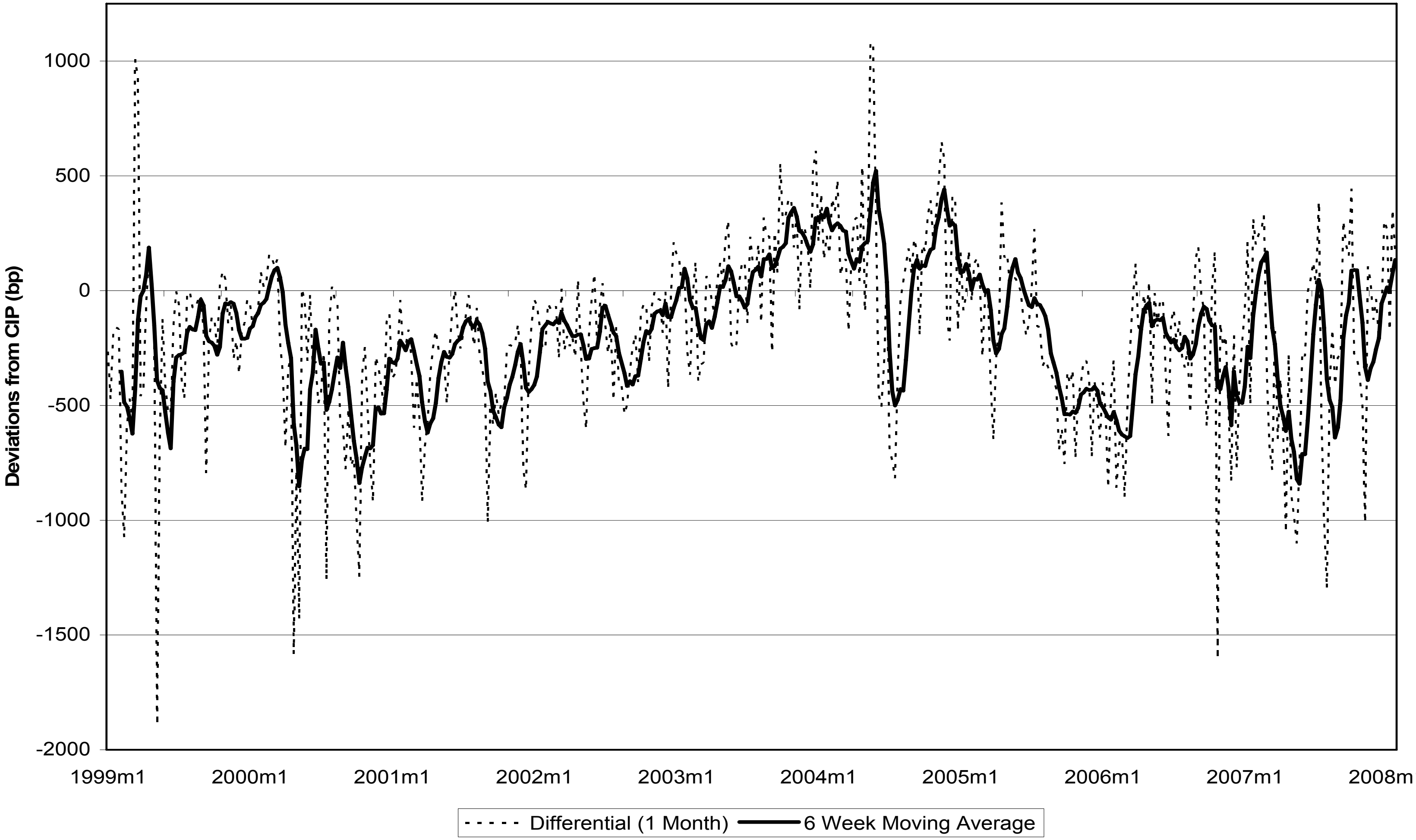
* Lags chosen by BIC and AIC criterion

* 10% ** 5% *** 1% Null = Unit Root

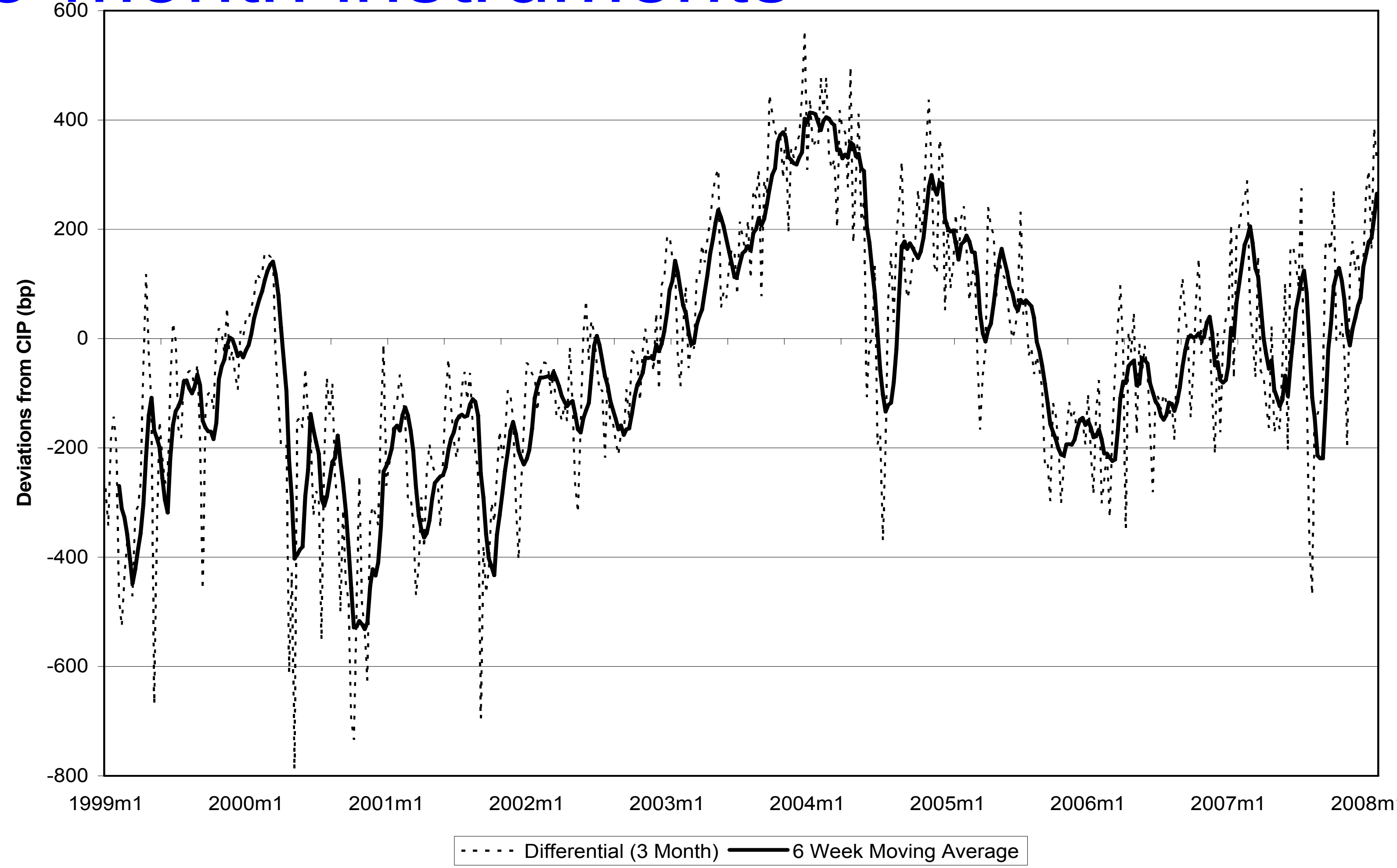
Interpretation

- The level of arbitrage activity is likely to be a function of
  - the costs to arbitrage, imposed by capital controls, and
  - the profitability to arbitrage, which is proportional to the magnitude of the deviation.
- The AR(1) parameter is therefore a rough measure of the strength of effective arbitrage.

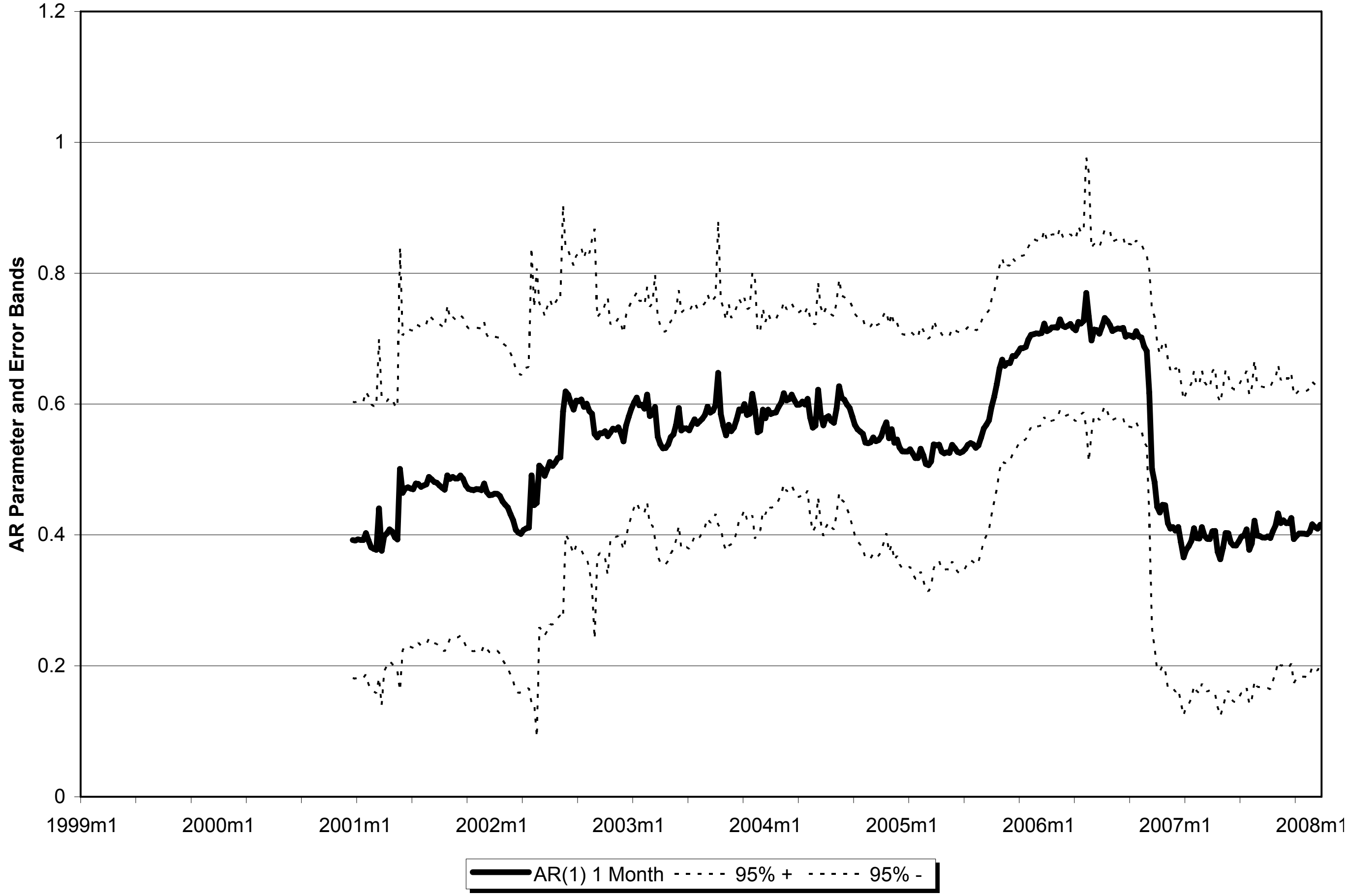
CIP deviation and 6-week MA 1-month instruments



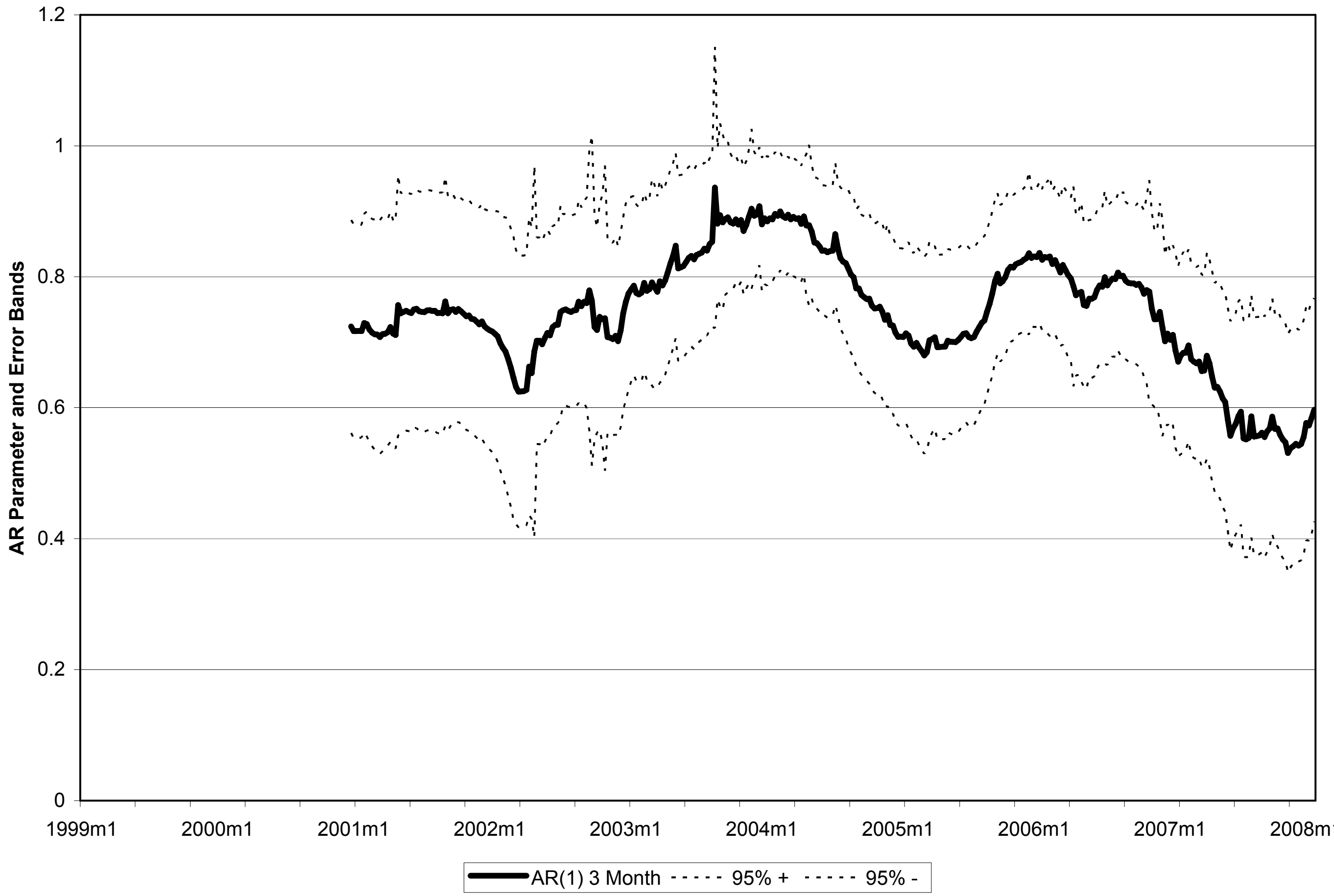
CIP deviation and 6-week MA 3-month instruments



Plot of AR(1) parameter from rolling regressions on CIP deviation series with 1-month instruments. Rolling regression windows are 2 years



Plot of AR(1) parameter from rolling regressions on CIP deviation series with 3-month instruments. Rolling regression windows are 2 years



AR(1) parameter of CIP deviation series. Equal subsample estimates

	Time Periods				
	jan99-apr01	apr01-aug03	aug03-nov05	nov05-jan08	*full sample*
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 sub-periods

	1 month		3 month	
Constant	**Coefficient**	**t-value**	**Coefficient**	**t-value**
Subsample 1	-1.904	**-5.33**	-0.551	**-3.48**
ΔSubsample 2	1.115	**2.15**	0.458	**2.26**
ΔSubsample 3	2.053	**4.51**	0.869	**3. 94**
ΔSubsample 4	0.296	0.59	0.476	**2.43**
AR (1)				
Subsample 1	0.407	**5.85**	0.726	**13.21**
ΔSubsample 2	0.164	1.14	0.117	1.33
ΔSubsample 3	0.238	**2.23**	0. 072	0.89
ΔSubsample 4	0.025	0.25	-0.086	-0.97

Nonlinear adjustment

- Self-Exciting Threshold Autoregressive Model (SETAR)
  - $\delta_t = \rho_i \delta_{t-1} + \varepsilon_{it}$ 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)

Upper and lower values of excitation thresholds from SETAR estimations

Panel A: 1 Month Instruments

		AR(1) Specification	AR(2) Specification
Full Sample			
		Threshold Value	Threshold Value
	Upper Threshold	0.02	0.77
	Lower Threshold	-6.71	-6.94
	Difference:	**6.73**	**7.71**
First Period (1999-2003)			
		Threshold Value	Threshold Value
	Upper Threshold	0.08	0.84
	Lower Threshold	-7.52	-7.52
	Difference:	**7.60**	**8.36**
Second Period (2003-2008)			
		Threshold Value	Threshold Value
	Upper Threshold	0.07	0.77
	Lower Threshold	-5.91	-5.00
	Difference:	**5.98**	**5.77**

Upper and lower values of excitation thresholds from SETAR estimations

Panel B: 3 Month Instruments

		AR(1) Specification	AR(2) Specification
Full Sample			
		Threshold Value	Threshold Value
	Upper Threshold	3.49	0.74
	Lower Threshold	-4.07	-4.07
	Difference:	**7.56**	**4.81**
First Period (1999-2003)			
		Threshold Value	Threshold Value
	Upper Threshold	0.80	0.33
	Lower Threshold	-4.28	-3.13
	Difference:	**5.08**	**3.46**
Second Period (2003-2008)			
		Threshold Value	Threshold Value
	Upper Threshold	3.51	0.10
	Lower Threshold	-1.10	-0.63
	Difference:	**4.61**	**0.73**

AR(1) parameter estimates in upper and lower regimes (outside thresholds) from SETAR estimations

Panel A: 1 Month Instruments

		AR(1) Parameter	St. Err.
Full Sample			
	Upper Region	0.43	(-0.09)
	Lower Region	-0.28	(0.14)
First Period (1999-2003)		**AR(1) Parameter**	**St. Err.**
	Upper Region	0.22	(0.15)
	Lower Region	-0.37	(0.20)
Second Period (2003-2008)		**AR(1) Parameter**	**St. Err.**
	Upper Region	0.47	(0.11)
	Lower Region	-0.23	(0.18)

AR(1) parameter estimates in upper and lower regimes (outside thresholds) from SETAR estimations

Panel B: 3 Month Instruments

Full Sample	AR(1) Parameter	St. Err.
Upper Region	-0.04	(0.22)
Lower Region	-0.03	(0.21)

First Period (1999-2003)	AR(1) Parameter	St. Err.
Upper Region	0.72	(0.15)
Lower Region	-0.11	(0.23)

Second Period (2003-2008)	AR(1) Parameter	St. Err.
Upper Region	-0.06	(0.22)
Lower Region	0.29	(0.13)

Conclusions (1)

- In our data, when the series is in the interior regime its behavior is very close to a unit root indicating almost no convergence and almost no arbitrage activity.
- Outside the thresholds, all of our estimates indicate relatively rapid or instantaneous convergence.
- This pattern is consistent with the contention that capital controls imply a cost of arbitrage or induce riskiness to the arbitrage position.

Conclusions (2)

- Our results indicate a significant reduction in the barriers to arbitrage from the pre-2003 period to the post-2003 period.
- We find very asymmetric transaction costs with barriers on outflows seemingly much higher than barriers on inflows.
- Although most of the reductions have taken place on the barriers to capital outflows, these barriers nonetheless remain large.