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Effectiveness of Capital Controls in India: Evidence from the Offshore NDF Market

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This paper examines the effectiveness of international capital controls in India over time by analyzing daily return differentials in the nondeliverable forward (NDF) markets using the self-exciting threshold autoregressive (SETAR) methodology. The paper presents a narrative on the evolution of capital controls in India and calculates a new index of capital account liberalization using cumulative monthly changes in restrictions on inflows and outflows. It employs the de jure indices of changes in restrictions on capital inflows and outflows to identify particular policy episodes, and tests the de facto effects of restrictions by calculating deviations from covered interest parity (CIP) utilizing data from the three-month offshore nondeliverable rupee forward market. The paper estimates no-arbitrage bands for each episode using SETAR where boundaries are determined by transactions costs and by the effectiveness of capital controls. It finds that Indian capital controls are asymmetric over inflows and outflows, have changed at one stage from primarily restricting outflows to effectively restricting inflows; and that arbitrage activity closes deviations from CIP when the threshold boundaries are exceeded in all subperiods. Moreover, the results indicate a significant reduction in the barriers to arbitrage since 2009,

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suggesting that gradual liberalization of India's capital account has played an important role in integrating onshore and offshore markets. The paper also applies the methodology to the Chinese RMB NDF market and find that capital controls are strictly limiting capital inflows with the exception of two periods of regional and international financial turbulence. The intensity of Chinese controls varies over time, indicating discretion in the application of capital control policy but, unlike India, shows no sign of gradual relaxation or liberalization. [JEL G15, F32, F30]
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In the 1980s, India began to liberalize its economy to increase its market orientation. Market-oriented reforms were accelerated beginning in 1991, after a balance of payments crisis and an economic boom supported by expansionary fiscal policy and current account deficits. Key components of the reforms were removal of government licensing controls on domestic industrial activity and trade liberalization. Trade liberalization reduced tariffs dramatically and replaced quantitative trade restrictions with tariffs.

As a complement to trade liberalization, effective current account liberalization, as measured by India's acceptance of IMF Article VIII, was achieved by August 1994. However, Indian policymakers have proceeded with caution in liberalizing capital flows as there is less theoretical agreement on the economic benefits of capital account liberalization, and the recent externally triggered financial crises in emerging economies have given reason for pause. Various steps have been taken to liberalize the capital account and to allow certain kinds of foreign capital flows, but a host of restrictions and discretionary controls remain.

The relative insulation of India from the financial crisis, its apparently successful use of capital controls, and the broader reconsideration of capital controls as a valid tool of macroeconomic and macroprudential management to prevent or contain financial crises (Ostry and others, 2010), all combine to make a detailed evaluation of the Indian case an important exercise. Although India has traditionally maintained widespread and pervasive capital controls, capital control policy has not been static but rather adapted controls to changing macroeconomic conditions and gradually relaxing many restrictions over the past decade and more.

This article investigates these issues by evaluating the scope and evolution of capital controls in India, and measuring their effectiveness over time in creating a wedge between onshore and offshore financial markets as measured by deviations from covered interest parity (CIP).[1] If capital controls

[1]Studies that have estimated deviations from CIP as an indication of international financial market integration in various contexts include Frenkel and Levich (1975), Taylor (1989), Peel and Taylor (2002), Obstfeld and Taylor (2004) and others.

systemically decouple domestic and foreign financial asset prices, at least partially, then they represent a potentially useful instrument of macroeconomic policy that in principle would allow greater monetary independence. Since it is apparent that India's policy on capital controls has evolved over time, several distinct episodes of varying intensity in the application of capital controls are identified and, using a statistical model, we estimate deviations from CIP and "no arbitrage" boundaries around CIP.

The statistical model employed is the self-exciting threshold autoregressive (SETAR) model, which allows estimation of the upper and lower boundaries of "no arbitrage" bands and measures the degree of arbitrage pressure when the boundaries are exceeded for each policy episode.[2] This is a nonlinear estimation methodology that enables joint and consistent estimation of boundaries and adjustment speeds. Capital control episodes are then compared with the SETAR estimates to evaluate the effectiveness of controls during particular periods and, more generally, whether gradual de jure gradual liberalization over time is associated with indications of greater financial integration, that is, predictions of reduced de facto CIP deviations, reduced width of the no-arbitrage boundaries and increased arbitrage pressures when the boundaries are exceeded.

In order to identify particular policy episodes, we construct a new de jure index of capital controls in India using detailed data on over a 150 policy changes from 1998 to 2011. This allows us to separately examine the evolution of controls on inflows and outflows, so our index has two distinct components, calculated separately. The index indicates a significant increase in de jure openness over the period, unlike some popular indices that do not incorporate a detailed analysis of the specific changes in regulations. Our work therefore clarifies the evolution of Indian policy toward the capital account. As noted above, we also investigate the link between de jure (using our index) and de facto controls for India, which is an important issue in the debate over the appropriateness of capital controls, and has also been unclear for the Indian case.[3]

Another distinguishing feature of our empirical work is to measure the CIP relationship using the effective foreign yield from the implied yield derived from the offshore nondeliverable forward (NDF) rate and the LIBOR dollar interest rate. The offshore NDF rate is a market-determined forward rate free of capital controls and the implied yield represents the net covered rate of return that would be available on Indian short-term financial instruments in the absence of capital controls. The domestic onshore rate to which the implied NDF yield is compared is the Mumbai Interbank Offer Rate (MIBOR). We use a relatively new data set on NDF transactions, which

[2]The SETAR model is a particular class of piece-wise autoregressive models and may be seen as a parsimonious approximation of a general nonlinear autoregressive model (Hansen, 2000).

[3]Pasricha (2008), investigating interest rate differentials, also finds that India is de facto more open than de jure measures such as the Chinn-Ito index suggest.

allows us to control for currency risk premium, as both the onshore and offshore rates relate to investment in the same currency.[4, 5]

Our results indicate that Indian capital controls have been asymmetric over inflows and outflows and have changed over time from primarily restricting outflows to effectively restricting inflows. However, we also find that that arbitrage activity closes deviations from CIP when the threshold boundaries are exceeded in all subsamples. Moreover, while the pervasive capital controls have been effective in creating unexploited arbitrage opportunities between the domestic market and the NDF market, the size of the no-arbitrage zones has declined substantially over time in response to gradual capital account liberalization. Liberalization of capital controls in India has occurred in tandem with the development of domestic money and offshore markets and increases in market liquidity. Overall, we find significant reductions in the barriers to arbitrage since 2009 in India. In a parallel analysis for China, we find binding capital controls varying over time—strictly limiting capital inflows except in periods of regional or international financial turbulence. However, unlike the Indian case, we do not find a pattern indicating a gradual relaxation of controls in China.

The next section discusses NDF markets and details the calculation of deviations from CIP by using NDF markets, onshore interest rates and offshore interest rates. Section II discusses the institutions and evolution of capital controls in India, how a gradual process of capital control liberalization has occurred but that they are still binding and used as an instrument of discretionary macroeconomic policy. This section also introduces the new indices for capital inflow and outflow liberalizations and discusses switches in the application of de facto capital controls in light of deviations from CIP, changes in capital controls and macroeconomic conditions. Section III presents the SETAR nonlinear model and reports our main empirical results, that is, estimates of the upper and lower threshold points of the no-arbitrage bands and the speed of adjustment to bands. Section IV presents a robustness test of the SETAR methodology to deviations in CIP, again using NDF market data, applied in this case to China. Section V presents our conclusions.

[4]Ma and others (2004) and Misra and Behera (2006) have used data from NDF markets to examine variations in deviations from CIP arbitrage conditions in India over time using simple summary statistics and qualitative methods, but not with more formal statistical modeling. (See Appendix II for differences in alternative measures of CIP deviations.) They find that smaller deviations from covered interest parity are an indication of greater capital account openness since the advent of India's capital control liberalization.

[5]Most inter-dealer transactions in the NDF market are concentrated in two- to six-month maturities, and we follow Ma and others (2004) in focusing on the three-month maturity. We considered one- and three-month maturities, but focused on the latter, as better capturing significant transaction volume. The data on NDF contracts is from Bloomberg and the MIBOR rates and spot rates are from Global Financial Database and LIBOR rates are from Federal Reserve Board's online database.

I. Nondeliverable Forward Markets and Covered Interest Parity

A consequence of India's capital controls has been the development of an NDF market. An NDF market develops when the onshore forward markets either do not exist or have restricted access (evidence of exposure requirements in the Indian case). These markets, which are located offshore—that is, in financial centers outside the country of the restricted currency—and involve contract settlement without delivery in the restricted currency, allow offshore agents with the restricted-currency exposures to hedge their exposures and speculators to take a position on the expected changes in exchange rates or exchange rate regimes. Also active in the NDF markets are arbitrageurs who have access to both forward markets. Volumes in the NDF market increase with investor interest or investment in the currency and with increasing restrictions on convertibility. When currencies are fully convertible, NDF markets are generally not observed.[6]

The Indian rupee NDF market is most active in Singapore and Hong Kong SAR, though there is also trading in places such as Dubai. Average daily turnover of NDF contracts in the Indian rupee increased from about U.S. $35 million in mid-2001 to U.S. $3.7 billion in early 2007 (Ma, Ho, and McCauley, 2004; Misra and Behera, 2006),[7] indicating that market liquidity has increased markedly, with presumably stronger pressures for market arbitrage. According to the April 2010 data from the BIS triennial survey of the foreign exchange market, spot and derivative average daily turnover in the USD/INR currency pair grew from $3 billion in 2001 to about $39 billion in 2010 (BIS, 2010).[8] Transactions in April 2010 in markets located in India were $27.4 billion, indicating that almost $12 billion daily average turnover was transacted offshore, a substantial amount of which is in NDF instruments.

The dominant players in this market are the speculators who want to take a position in the currency, and the arbitrageurs, mainly Indian exporters and importers who have access to both the onshore forward market[9] and the NDF market (Misra and Behera, 2006). The NDF rate, therefore, serves as

[6]Lipscomb (2005) provides a useful overview of NDF markets.

[7]Although Misra and Behera's work is officially dated 2006, they include data for early 2007. The rupee NDF market reportedly grew further to U.S. $19 billion a day in April 2010, and U.S. $43 billion a year later, as reported in a newspaper opinion piece (www.business-standard.com/india/news/jamal-mecklai-has-rbi-lost-controlthe-rupee/441038/), but the data source is not cited.

[8]To put these numbers in perspective, the growth seen in the USD/INR pair was close to the median growth in trades against USD for other large emerging markets (Brazil, China, Korea, and South Africa) for which the same BIS report provides data. For example, the USD/Brazilian Real, pair, which saw trading volumes growth from 5 billion USD in 2001 to 26 billion in 2010 and in South African rand, which saw the volumes grow from 7 billion USD to 24 billion USD over the same period.

[9]In August 2008, the Reserve Bank of India allowed trading on a domestic currency futures exchange to begin. Prior to this innovation, trading for those permitted to do so was over-the-counter. Restrictions remain on participation in the exchange; for example, only Indian residents can participate.

an important indicator of the expected future exchange rate of the rupee. This rate also implies a corresponding interest rate, which is called the NDF implied (domestic) yield, calculated as follows:

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

where S is the spot exchange rate of the U.S. dollar in terms of rupee, F_N is the NDF rate of a certain maturity and $i_\$$ is the interest rate on dollar deposits of corresponding maturity (LIBOR rates).[10] Then, r is what the onshore yield would be, if there were no capital controls and if CIP held. The (annualized) difference between the actual onshore yield (i, the MIBOR rate for the corresponding maturity) and r is our measure of the CIP differential.

Without restrictions on capital flows between two countries, deviations from CIP, which is basically a "no-arbitrage" condition, would be small and simply reflect transactions costs. Large and persistent positive onshore-offshore differentials ($i-r$), on the other hand, reflect effective stemming of capital inflows and a negative differential suggests an effective stemming of capital outflows. The minimum deviation needed to induce arbitrage and speed with which deviations from CIP are eliminated are then indicators of how effective that arbitrage is between the two markets, and therefore a measure of the effectiveness of capital controls.

Indian banking regulations and capital controls restrict banks and other financial institutions' ability to arbitrage deviations from CIP. Although importers and exporters are allowed to use the onshore forward market ("permitted hedgers"), they presumably do not have the capabilities to conduct arbitrage as effectively as banks and other financial institutions, had the latter been permitted to do so freely. Hence, deviations from CIP may be expected to persist systematically.[11] At the same time, if there are *some* arbitrage avenues for market participants, then the speed with which

[10]In practice, the formula is modified a bit, because each forward contract is valid for a given number of days (depending on the maturity of the contract, in this case, 3-months, but also on the value and settlement dates for the contract) and the LIBOR rates are annualized, i.e. refer to percentage per annum. We computed the actual number of days in each forward contract based on the market conventions about the forward contracts, de-annualized the LIBOR rate for that number of days (assuming 360 days in the year, as done in LIBOR) and expressed the de-annualized rate in percentage points. The resulting r is then re-annualized based on the number of days for which it is computed and assuming 365 days in the year and is expressed as a percentage.

[11]If forward rates are determined primarily by expected future currency needs from importers and exporters, rather than by pure arbitrage by currency traders or others, the direction of deviation from CIP can be an indicator of market expectations with respect to future currency appreciation or depreciation. Patnaik and Shah (2005) give examples in India in 1993–94 and 1997–98 where expectations as implied by the direction of CIP deviation turned out to be incorrect. However, their regression analysis indicates that, barring some outlier events, expectations of the direction of currency movements as implied by CIP deviations have been correct on average. A related point is that variation in deviations from CIP may reflect changing counterparty risk premiums. However, these risk premiums are

deviations from CIP are eliminated (or reduced) should be an indicator of how effective that arbitrage is in the actual working of the market.

II. Capital Controls and Covered Interest Parity Deviations in India

This section presents a qualitative description of the evolution of capital controls in India from 1998 to 2011, enumerates policy changes with respect to these controls, and constructs new indices of the evolution of controls on inflows and outflows. Table 1 describes a general process of capital control liberalization over more than a decade. However, substantial restrictions remain and have been applied differentially to outflows and inflows as an instrument of discretionary macroeconomic policy. In some cases, there have been reversals of the liberalization process at certain points in time.

Of course, CIP deviations also vary over the sample period as a result of changes in macroeconomic policy, global economic conditions and, particularly during the global financial crisis, market dislocations, counterparty risks and USD liquidity shortages. In the next subsection, we seek to disentangle some of the impacts of these broader factors from the impact of capital controls. We end this section with an identification of several distinct periods reflecting changes in capital controls intensity and application as well as the macroeconomic factors.

Evolution of Capital Controls

While measures aimed at current account convertibility were implemented early in the economic reform process in the late 1990s, policymakers remained concerned about possible linkages between capital account and current account transactions, such as capital outflows masked as current account transactions through mis-invoicing. As a result, certain foreign exchange regulations have stayed in place, including requirements for repatriation and surrender of export proceeds (allowing some fraction to be retained in foreign currency accounts in India for approved uses), restrictions on dealers and documentation for selling foreign exchange for current account transactions, and various indicative limits on foreign exchange purchases to meet different kinds of current account transactions.[12]

In 1997, a government-appointed committee on Capital Account Convertibility (CAC) provided a road map for liberalization of capital transactions. The committee's report (Tarapore Committee, 1997) emphasized various domestic policy measures and changes in the institutional framework

unobservable: our maintained hypothesis that the source of variation is changes in controls is consistent with the data and our estimated model.

[12]For example, the period for repatriation of export proceeds currently stands at 12 months. This was extended from six months in March 2011, but the extension is operative only through September 2012. Restrictions on net open positions of banks, often used to serve current account transaction needs of clients, were tightened in December 2011 in response to a sharp depreciation of the rupee, and were begun to be relaxed in February and April 2012.

Table 1. Summary of Capital Control Policy Changes in India, 1998–2011

Year	No. of Changes	No. of Liberalizations	No. of Changes Affecting Inflows	Description of Capital Control Policy Changes	Macroeconomic Conditions and Policies	Begin Date of Subperiods
1998	11	10	10	Minor relaxations of FDI in June and November. Major restriction on FDI in December, through Press Note 18, which gave existing domestic joint venture partners veto power. From April through October, a series of liberalizations of aspects of debt and equity flows, from NRIs and FIIs, pertaining to categories of allowed investments and investment ceilings.	GDP growth: 6.2, CPI Inflation: 13.2, Current Account: −1.7 Interest rates first raised as response to Asian crisis (defending exchange rate) and then lowered gradually.	
1999	9	8	9	Some streamlining of specific FDI procedures, one case of tightening norms through minimum capitalization requirement for some Nonbank Financial Services. Easing of several restrictions related to trade. Reduction in reserve requirements for nonresident deposits and of number of investors for an FII.	GDP growth: 7.4, CPI Inflation: 4.7, Current Account: −0.7 Further easing of interest rates. Beginnings of a sustained increase in capital flows and sterilized intervention by RBI.	1/8/1999
2000	8	8	8	Several significant relaxations of FDI limits in SEZs, e-commerce, insurance. Expansion of sectors qualifying for automatic route, NBFC subsidiaries allowed. Significant relaxation of FII rules (percent limits), especially that allowing use of subaccounts.	GDP growth: 4.0, CPI Inflation: 4.0, Current Account: −1.0 Alternation of monetary easing and tightening, partly to manage the exchange rate.	
2001	6	6	6	Significant relaxation of FDI limits in several sectors, and by automatic route. Relaxations of caps on FII ownership. Restriction placed on foreign ownership of print media sector.	GDP growth: 5.2, CPI Inflation: 3.7, Current Account: 0.3 Gradual easing of monetary policy through the year.	

2002	5	5	4	Minor relaxation of FDI restriction in tea sector. Some procedural relaxations, including related to trade financing and export earnings. Banks allowed to invest abroad.	GDP growth: 3.8, CPI Inflation: 4.4, Current Account: 1.4 Minor monetary easing in second half of year.	
2003	12	9	9	Relaxation pertaining to ECB. Sequence of steps liberalizing hedging and some caps raised. Tightening of restrictions on Overseas Corporate Bodies (NRI controlled companies) investing in India. (ECB and hedging relaxations potentially major changes before April)	GDP growth: 8.4, CPI Inflation: 3.8, Current Account: 1.5 Rupee allowed to fluctuate more; some rupee appreciation. Minor monetary easing. Modification to sterilization program (RBI sold bonds as agent of government).	3/24/2003
2004	23	20	15	Raising of FDI limits in several sectors, procedural streamlining. Several liberalizations related to borrowing limits and allowed investments abroad. Some tightening through interest rate caps and ceiling on corporate bond investment by FIIs.	GDP growth: 8.3, CPI Inflation: 3.8, Current Account: 0.1 Relative stability in monetary policy stance and capital flows. Exchange rate fluctuated more than previous years.	
2005	9	9	5	Significant relaxation of FDI caps in telecoms, also in construction. Relaxation of controls of Press Note 18 of 1998. Relaxation of ECB limits in some cases. (ECB relaxation in August, FDI earlier)	GDP growth: 9.3, CPI Inflation: 4.2, Current Account: −1.2 Minor monetary tightening late in year.	8/31/2005
2006	11	9	7	FDI in single brand retail up to 51 percent, also up to 100 percent in various industrial undertakings, and 49 percent in stock exchanges. Several ceilings raised on total investments. However, some interest rate caps introduced or tightened. (No policy change close to August)	GDP growth: 9.3, CPI Inflation: 5.8, Current Account: −1.0 Steady monetary tightening from August onward, accompanied by reversal of rupee depreciation that occurred earlier in year.	8/25/2006
2007	29	20	16	Minor further relaxation in telecoms FDI. Several cases of interest rate caps tightening to reduce inflows. Restriction of capital inflows to capital goods ("end use"). Several instances of loosening of restrictions on outflows (individuals, VCFs, mutual funds).	GDP growth: 9.8, CPI Inflation: 6.4, Current Account: −0.6 Surge in capital inflows; sharp rupee appreciation, some monetary tightening early in year. Sterilization effectively ends and rupee fluctuates more freely.	

Table 1 *(concluded)*

Year	No. of Changes	No. of Liberalizations	No. of Changes Affecting Inflows	Description of Capital Control Policy Changes	Macroeconomic Conditions and Policies	Begin Date of Subperiods
2008	25	24	19	Minor tightening of FDI in stock exchanges. Long list of relaxations in various aspects of inflows and outflows, including portfolio and ECB, both in overall quantity caps and interest rate caps (currency futures trading phased in from August to October; ECB relaxations in September). "End use restrictions" rescinded October 23.	GDP growth: 4.9, CPI Inflation: 8.4, Current Account: −2.5 Monetary tightening mid-year, followed by sharp reversal from October onward. Reversal of capital inflows and fall in rupee.	10/8/2008
2009	9	8	8	Some tightening of share transfer rules related to FDI. Seemingly major relaxation of foreign technology agreement policy. Several relaxations of ECB, overall foreign investment caps, and other investment routes and actions. (Several major relaxations came in January)	GDP growth: 9.1, CPI Inflation: 10.9, Current Account: −1.9 Continued monetary loosening early in year. Slow recovery of rupee and return of capital inflows.	4/2/2009
2010	1	0	1	Reinstated interest rate caps on some ECBs at end of 2009.	GDP growth: 8.7, CPI Inflation: 9.5, Current Account: −3.1 Beginning of gradual monetary tightening; rupee fluctuates around recent levels.	
2011	3	3	3	Some loosening of portfolio investment and of overall rupee-denominated debt. FDI in LLPs allowed.	GDP growth: 8.2, CPI Inflation: 7.5, Current Account: −3.6 Steady monetary tightening through year so far.	
	Total	161	139	120		

Notes: Liberalization of FDI in multiple sectors announced as a package is counted as a single policy change. Data Sources: For capital controls: IMF Annual Report on Exchange Arrangements and Exchange Restrictions, various issues; Pasricha (2011); Reserve Bank of India press releases. For GDP, Inflation and Current Account Balances: World Bank World Development Indicators, except 2011—IMF World Economic Outlook estimates.

as preconditions for full CAC. These included fiscal consolidation, low inflation, adequate foreign exchange reserves, and development of a more robust domestic financial system. While the Asian crisis and subsequent contagion that spread through 1997–98 derailed the committee's recommended timetable, significant liberalization of the capital account occurred in the last decade, particularly with respect to inward foreign investment, aided in part by improved macroeconomic indicators and financial sector reform.[13] In this period, a second committee with a similar title and the same chairman (Tarapore Committee, 2006) also submitted a report, which was similar in tenor to the first, recommending a gradual, incremental approach to capital account liberalization.[14]

Indeed, Indian policymaking in this domain has very much had this flavor. We examined policy changes with respect to capital flows from 1998 to the present, and enumerated 161 such changes over the period of 13-plus years (Table 1). In many cases, several individual changes were packaged together, so the number of announcements was somewhat lower. The changes included modifications of quantitative limits, of interest rate caps, of categories of allowed investments for specific classes of investors, and procedural changes with respect to required approvals. The great majority of these changes pertained to capital inflows, and a similar majority (though not necessarily the same instances) constituted liberalizations. About a quarter of the overall policy changes related to foreign direct investment (FDI).[15]

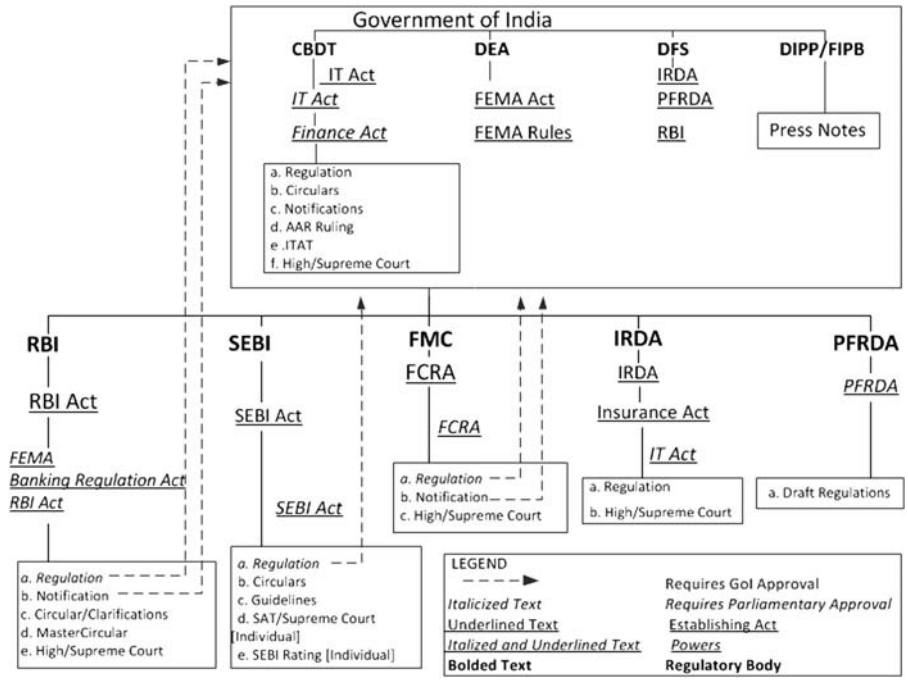
The administration and application of capital controls in India is very complex, involves multiple government agencies, shown in Figure 1, and multiple categories of restrictions and types of assets and liabilities. Therefore, enumeration of types of changes cannot fully capture the impact of capital account policy, even from a purely de jure perspective (that is, setting aside the effect of market and economic conditions). This is true in general, but particularly so for the Indian case, because of the complex nature of the existing regulations, and the manner in which changes are defined and applied. As one example of the complexity of the regulations, an announcement on April 12, 1999 had the stated goal of "further simplifying the investment procedures for downstream investment." The effective policy change was "to permit foreign owned Indian holding companies to make downstream investment in Annexure III activities." Here, the reference was to a long and detailed list of activities already qualifying for "Automatic Approval," which is another policy distinction. Furthermore, there were eight conditions imposed, of which at least two referred to consistency with other policy restrictions in place, others added reporting or approval requirements that may or may not

[13]Jadhav (2003) provides a useful "insider" review of India's experience with capital controls and capital account liberalization through 2002.

[14]This committee, like its predecessor, also commented on desired complementary changes in fiscal, monetary, and exchange rate policies.

[15]Our main numerical analysis omits FDI changes for reasons described in the main text.

Figure 1. Organizational Structure of Capital Controls in India



Abbreviations: Central Board of Direct Taxes ("CBDT"), Department of Industrial Policy and Promotion ("DIPP"), Department of Revenue and Department of Economic Affairs ("DEA"), Foreign Exchange Management Act ("FEMA"), Foreign Investment Promotion Board ("FIPB"), Insurance Regulatory and Development Authority ("IRDA"), Pension Fund Regulatory and Development Authority ("PFRDA"), Reserve Bank of India ("RBI"), Securities and Exchange Board of India ("SEBI"), Securities Appellate Tribunal ("SAT").

Source: Sinha (2010), Figure 2.2.

have been covered by general corporate law, and several were phrased in qualitative terms that could be subject to later bureaucratic discretion.

The overall characterization of the latest Working Group on Foreign Investment (Sinha, 2010, p. 30) was that "foreign investors face an *ad hoc* system of sometimes overlapping, sometimes contradictory and sometimes nonexistent rules for different categories of players that, in turn, has created problems of regulatory arbitrage and lack of transparency and create onerous transaction costs." The Sinha committee report provides some sense of this complicated regulatory architecture (Figure 1),[16] as well as detailed recommendations for simplifying reforms. One of its main recommendations is to abolish distinctions among different classes of investors (for example,

[16]Patnaik and Shah (2011) suggest that a unified manual on Indian capital controls would run into many thousands of pages.

Foreign Institutional Investors, Foreign Venture Capital Investors, and Nonresident Indians). Currently, each of these and other investor classes is treated differently, while being affected by rulings from multiple agencies among those shown in Figure 1. There are also different regulatory treatments of listed and unlisted equity, debt, derivatives, and FDI, but the economic logic of these is more understandable than the distinctions among investor classes. However, there is a recommendation by the Sinha committee to separate derivatives regulation from capital controls, since the former pertains to financial market stability, irrespective of whether the relevant market participants are domestic or foreign.

Further, even when the de jure policy is liberalized, substantial discretion remains in the hands of the bureaucracy in the application of that liberalization. An example comes from the Sinha committee again (Sinha, 2010), commenting on the case of the "automatic route" for External Commercial Borrowings (ECBs).

> Members [of the working group] discussed investors having to apply in writing for approval of investments under the automatic route, and meetings needing to be held by the RBI to approve the same. Further, while investments would be routinely approved at meetings, the RBI, in the past, would often not schedule meetings. (p. 74, footnote 29)

This case brings out the procedural hurdles that can remain, even when there is apparent simplicity in, or liberalization of, written rules.

On the whole, while the great majority (86 percent) of the numerous changes in de jure capital controls over the period 1999 to early 2011 constituted liberalizations, they did not change the nature of the regime—one of complex rules and discretionary processes. This explains the relative stability of some de jure measures of capital controls in India (Chinn-Ito, 2008; Schindler, 2009) that consider only the existence of certain types of restrictions, and suggests the need for a more fine-tuned measure of the changes in restrictions. We detail the construction of such a measure in the next subsection.

A New Quantitative Index of Capital Control Intensity in India

Most measures of de jure controls, including the Chinn and Ito (2008) and Schindler (2009) indices, use only information on the existence of controls under broad categories of transactions, so that as long as restrictions continue to exist, the measure does not change. However, continued existence of restrictions can go along with substantial easing or tightening of the restrictions and therefore changes in de facto controls. Other problems with existing indices are that they may not differentiate between controls on inflows and those on outflows, and they may not be calculated at a fine enough level of granularity with respect to time.

The enumeration of changes and types of restrictions for India shown in Table 1 indicates that there has been substantial liberalization on the

capital account since the late 1990s, a conclusion completely at odds with the Chinn-Ito (2008) and Schindler (2009) measures.[17] To address this issue, we construct a numerical index of cumulative changes in capital controls where rising values indicate increased liberalization and declining values indicate more restrictions.

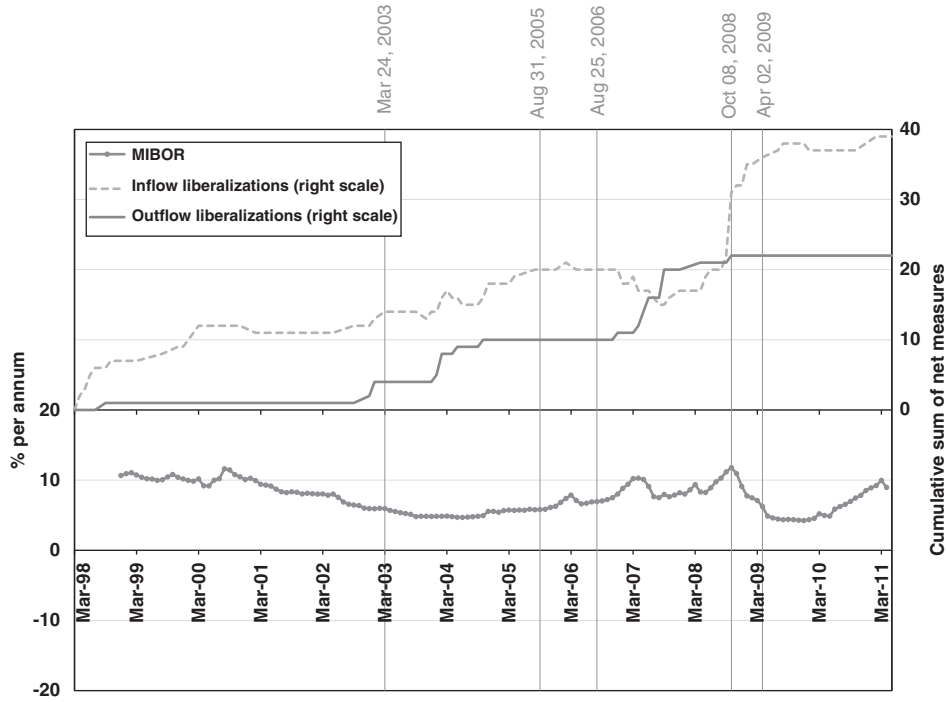
The index is based on legislated and official announcements of policy changes on capital account transactions described in the preceding section and is constructed as follows (details of construction, including caveats of interpretation are in Appendix I). We exclude changes that were related only to FDI inflows, since those are less likely to contemporaneously impact arbitrage in short-term money markets. Other capital account restrictions are much more focused on attempts to stem "hot money inflows," for example. We also perform separate calculations for controls on inflows and outflows, since these will have differential effects on the two sides of the arbitrage band, so the index has two separate components. In each case, the index itself is calculated by adding one for a liberalization move and subtracting one for a tightening move, with the accumulation done on a monthly basis. The index uses the unweighted sum of positive or negative changes since the relative impact of each change is not clear from the policy actions and, moreover, may change over time depending on the specific aspects of implementation.

Capital Control Intensity and Macroeconomic Conditions

Our numerical calculation of the cumulative effect of de jure capital control changes is illustrated in Figure 2. "Outflow liberalizations" in the figure refer to the net cumulative changes in capital account outflow liberalization, while "inflow liberalizations" refer to the net cumulative changes in capital account inflow liberalization. Several general observations may be inferred from the figure. First, the two indices are consistent with the previous narrative of substantial liberalization covering both capital inflows and outflows over the past 13 years. By early 2012 we count almost 40 specific "net" directives (liberalization measures less restriction measures) covering inflows and over 20 measures covering outflows. Second, the process of liberalization has been uneven, occasionally moving very quickly such as late 2008 with capital inflow liberalization, and early 2003 and the first half of 2007 with rapid capital outflow liberalization, and at other times moving very slowly if at all,

[17]Schindler's (2009) measure indicates that capital controls actually became more restrictive in India between 1998 (the beginning of our sample) and 2005 (the end of Schindler's sample). During this period, his index of overall capital account restrictiveness rose from 0.83 to 0.96, index of restrictions on capital inflows increased from 0.83 to 0.92, and index of restrictions on capital outflows rose from 0.83 to 1.0, where zero indicates completely free of restrictions and unity indicates completely restricted capital account. By the Chinn-Ito measure, in the most recent update posted on the website (www.web.pdx.edu/~ito/Chinn-Ito_website.htm), India's restrictiveness on capital account transactions has not changed between 1970 and 2010. (The measure stands at −1.16, indicating that capital account transactions in India are among the most restrictive in the world.)

Figure 2. Inflow and Outflow Liberalization Indices and Three-Month MIBOR

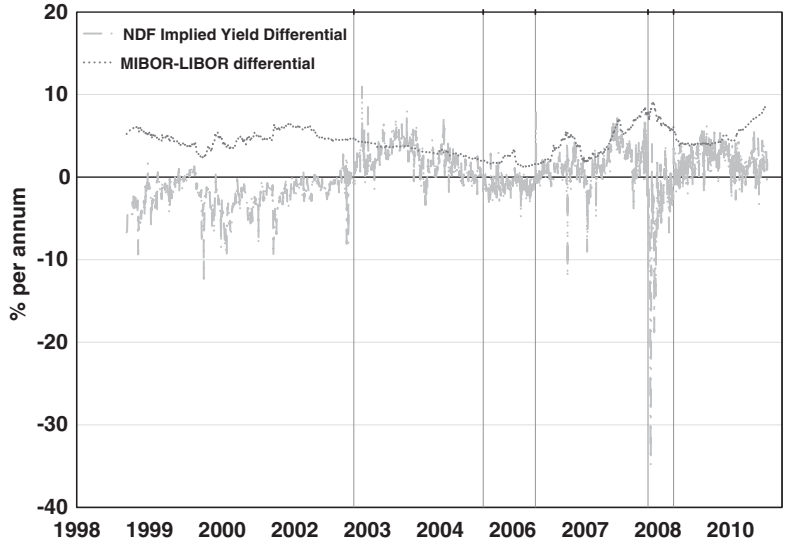


such as 1998–2003 and from mid-2009 to 2010. Finally, net increases in formal restrictive measures on capital flows have only occurred in nine months during our sample, most frequently during 2007, and only on capital inflows.

Legislative changes are only one aspect of capital controls—Indian officials have used discretion and judgment in the specific application and intensity of controls over the entire period. We therefore also consider macroeconomic conditions together with the formal capital control indices to complement our analysis on potential breakpoints in capital control regimes. To this end, Figure 2 also plots the 30-day average of daily observations of the three-month interest rate for India (MIBOR, or Mumbai Interbank Offer Rate) as one indicator of macroeconomic conditions, along with the inflow and outflow capital control change indices.[18] Further,

[18]This study uses the three-month MIBOR to measure domestic interest rates. This matches well with the three-month LIBOR rate. An alternative interest rate is the 31-day T-Bill implicit yield (Ma and McCauley, 1998) and the implied onshore yield derived from deliverable forward rates has also been used (Misra and Behera, 2006). We calculated the implied three-month onshore yield using deliverable forward rates. The correlation with our MIBOR measure was 0.60, but these implicit interest rates were much lower than the MIBOR measure (averaging 2.0 percent over the full sample period, compared with the MIBOR average of 7.5 percent). The Misra-Behera implied onshore yield approach seems conceptually

Figure 3. India: CIP Deviations and Interest Rate Differentials



in Figure 3, we plot the three-month interest rate differential between India and the United States (MIBOR less LIBOR), and the annualized deviations from CIP. Both graphs show daily observations of financial prices starting from January 1999 to January 2011. Table 2 presents summary statistics (mean, median, maximum, minimum, standard deviation, and number of observations) for each series.

In terms of the macroeconomic conditions in India, the short-term interest rate, measured by the three-month MIBOR rate, averaged 7½ percent during the full sample, with the average fluctuating during subsamples between 5 and 9 percent, and with minimum and maximum values during the sample of 4 percent and around 13 percent, respectively. This reflects varying rates of inflation, states of the business cycle, and monetary stances in India during the more than decade-long period. Large and persistent interest rate differentials are evident between Indian rupee and USD-denominated interest rates. Short-term rates in India were always, and oftentimes substantially, higher than USD interest rates during the sample period. The mean (and median) difference was more than 400 basis points and reached a maximum difference of over 9 percent in November 2008 as the RBI lowered policy rates only gradually while the

problematic, and the levels of the interest rate it implies are not realistic. The low level means that the CIP deviations calculated from the Misra-Behera formula can easily differ in sign from those calculated in this paper. A further comparison of different measures of CIP deviations is in Appendix II.

Table 2. India: MIBOR, MIBOR-LIBOR Differential and NDF Implied Yield Differential

		Full Sample			Subsample			
Variable	Start	1/8/ 1999	1/8/ 1999	3/24/ 2003	8/31/ 2005	8/25/ 2006	10/8/ 2008	4/1/ 2009
	End	1/10/ 2011	3/23/ 2003	8/30/ 2005	8/24/ 2006	10/7/ 2008	4/1/ 2009	1/10/ 2011
MIBOR	Mean	7.46	8.98	5.21	6.69	8.68	8.98	5.48
	Median	7.44	9.29	5.17	6.7	8.36	8.57	4.83
	Maximum	12.73	12.13	6.1	8.32	12.17	12.73	8.8
	Minimum	4.08	5.82	4.64	5.75	6.91	6.78	4.08
	Std. dev.	2.10	1.63	0.42	0.64	1.18	1.78	1.30
	Observations	2949	1029	607	246	530	115	418
MIBOR–LIBOR	Mean	4.26	4.76	3.31	1.89	4.20	7.04	5.07
	Median	4.15	4.68	3.39	1.73	3.80	6.75	4.39
	Maximum	9.06	6.45	4.81	3.34	8.51	9.06	8.50
	Minimum	1.25	2.29	1.88	1.25	1.51	5.48	3.74
	Std. dev.	1.58	0.89	0.66	0.53	1.92	1.00	1.32
	Observations	2949	1029	607	246	530	115	418
NDF implied yield differential	Mean	0.04	−2.04	2.24	−1.02	1.52	−4.40	1.96
	Median	0.05	−1.71	2.05	−1.09	1.38	−2.93	2.01
	Maximum	10.96	2.77	10.96	2.98	7.84	4.47	6.31
	Minimum	−34.84	−12.89	−3.39	−4.89	−12.14	−34.84	−3.29
	Std. dev.	3.04	1.97	1.96	0.99	2.16	6.33	1.64
	Observations	2949	1029	607	246	530	115	418

Federal Reserve quickly dropped short-term U.S. interest rates to zero in response to the growing financial crisis.

Return differentials also showed up in CIP deviations, indicating that arbitragers could not take advantage of these seeming profit opportunities because of capital controls, transactions costs, macroeconomic conditions, and other impediments. The average (median) CIP deviation for the full sample period was essentially zero, but variations across the full sample were substantial, with certain periods indicating greater inflow pressures and others indicating unmet outflow pressures. In particular, the median values ranged from a high of 2.24 percent during March 2003-August 2005 to a median low of −2.9 percent during October 2008 through March 2009.

Identifying Episodes

Our index of the evolution of capital controls is our primary guide in dividing our sample period into subperiods, identified as vertical lines in

Figures 2 and 3, for the econometric analysis. However, determining these episodes, especially exact break dates, is still somewhat subjective and reflects balancing the behavior of the index with other relevant economic criteria.[19] Measured CIP deviations, interest rate movements and qualitative evidence on capital controls and macroeconomic policy and conditions also have some influence on the identification of distinct capital control regimes. In several cases, we have positioned the break slightly after what seems to be the end of a period of cumulative changes, to allow for lags in implementation. We have also isolated the crisis period in 2008–09 based on global events, rather than just Indian policymakers' choices. This reflects a broader point that sometimes capital control policy changes have been in response to global events or short-term changes in macroeconomic conditions, rather than being exogenous to them.

Early 1999 to March 2003

As shown in Figure 2, there was an initial liberalization of controls on inflows during this period, but little other change until early 2003. Given the slow and tentative nature of these initial liberalizations, we have chosen to make the first period extend to 2003. This period, our longest subsample, is characterized by gradually declining short-term interest rates, stable (positive) interest rate differentials and consistently negative CIP deviations (−2 percent average), because of the NDF discount on the rupee, indicating net controls on capital outflows. Monetary policy was either easing or neutral during the period—inflation was contained, growth was moderate and the current account fluctuated from small deficit to small surplus. The authorities *de facto* pegged the rupee exchange rate against USD during this period (Zeileis, Shah, and Patnaik, 2010).

March 2003 through August 2005

Our two indices in Figure 2 indicate that capital inflow liberalizations followed an uneven path between 2003 and 2005. Outflows were generally liberalized more consistently than inflows, and some additional restrictions on inflows were introduced, so that the overall stance of policy effectively switched to net controls on capital inflows. This was an attempt to stem the growth of capital inflows to India which had led to rising international reserves (Figure 5). The authorities also allowed greater exchange rate fluctuations against a backdrop of monetary stability, stable inflation, and strong GDP growth.[20] This period was characterized by stable domestic

[19]In related work, Hutchison and others (2010), we used Bai-Perron structural break tests on weekly data of implied yield differentials and found that break dates lay in January 2003 and April 2005, for data that ended in January 2008. The estimated no-arbitrage bands for these periods follow a similar pattern to the bands estimated here.

[20]Zeileis, Shah, and Patnaik (2010) suggest that a structural break in the degree of exchange rate rigidity occurred in May 2003, with the exchange rate becoming more flexible.

short-term interest rates, declining interest rate differentials, and positive CIP deviations (averaging above 2 percent).

Late August 2005 to mid-August 2006

Our indices indicate that this roughly year-long period in 2005–06 saw little change in capital controls on inflows or outflows. A global trend has been the increased interest of fund managers in portfolio investments in India, roughly from 2005 or 2006 onward. A related development was successive improvements in India's sovereign debt ratings and outlooks by two of the three major ratings agencies (Moody's and Fitch) between 2004 and 2006.[21] The interplay of these factors with various liberalizing policy changes would be expected to influence the minimum deviation required for arbitrage to be profitable and the speed of arbitrage once a profitable deviation arises. This period is characterized by gradually rising domestic interest rates, declining interest rate differentials, and small negative deviations from CIP (averaging around −1 percent). Minor monetary tightening was implemented, against a backdrop of rising inflation, very strong GDP growth, and a small current account deficit.

Late August 2006 to October 2008

This period is characterized by liberalization of controls on outflows and some tightening on inflows, so on balance a move toward net inflow restrictions. The inflow tightening measures included several reductions in the ceilings on interest rates that could be paid on ECBs, a ban on issuance of participatory notes by FIIs and a prohibition of use of foreign currency borrowings for rupee expenditures. These measures were in response to a booming economy, large capital inflows (peaking in 2007) and attempts by the authorities to limit exchange rate appreciation. Tightening of capital inflows were accompanied by monetary policy tightening (for example, repeated increases in the cash reserve ratio). Interest rates rose during this period, widening the interest rate differential and associated positive CIP deviations (1.5 percent average). The inflow tightening measures began to be reversed and net liberalization of inflows resumed around the end of the period.

[21]Moody's upgraded India's foreign currency sovereign longer-term debt to investment grade in January 2004, Fitch in August 2006 and Standard and Poor's (S&P) in January 2007. Fitch and S&P also upgraded India's local currency bond ratings to investment grade at the same time that they upgraded its foreign currency ratings. These changes are important as the sovereign ratings are often the ceiling for private sector ratings and some financial institutions are restricted to investing only in investment grade debt. The improvement in ratings would increase the availability of arbitrage funds in Indian markets.

Mid-October 2008 through March 2009

Our indices and narrative show that the authorities sharply reduced restrictions on capital inflows, reversing the policies from the boom period, and made no significant changes in controls on outflows during this period. This policy is not surprising since the period coincides with the global financial crisis when financial institutions in India initially faced severe USD liquidity shortages. The break point that we identify is October 2008, shortly after the collapse of Lehman Brothers, the start of rupee futures trading onshore and successive reversals of several restrictions on capital inflows introduced during the boom period. On October 22, 2008, the eligible end uses for use of foreign currency ECB were expanded, the limit for ECB by an individual corporation was increased five-fold and the ceilings on interest rates that could be paid on ECB were increased. Further, on October 23, the interest rate ceilings were increased again and the end-use restrictions of August 7, 2007 on foreign currency ECB were abolished.

These liberalizations were clearly a response to the sharp reversal of capital inflows at this point. This was a short period of very volatile international financial markets, initially rising and then falling short-term domestic interest rates and interest rate differentials. CIP deviations are substantial and negative (mean −4.4 percent, median −2.9 percent), the largest during our period of study. However, this was an extraordinary period during which domestic forward rates and offshore NDF rates moved quite differently over a week-long period, giving substantially different indications of CIP deviations (Appendix II). It appears that linkages between onshore markets (for example, spot and forward markets), as well as onshore-offshore markets substantially weakened and these markets became "dislocated" for several days (Patnaik and Shah, 2009; Baba and Shim, 2010). Overall, this period is characterized by aggressive monetary easing in the immediate aftermath of the global financial crisis in order to offset sharp declines in international trade, a fall in global economic activity, an international liquidity shortage, and a sharp deceleration in Indian GDP growth.

April 2009 through Early January 2011

The height of the global financial crisis had passed by April 2009. Indian officials made few changes in liberalizing controls on capital inflows during the last period of our study and, by our index shown in Figure 2, no detectable changes at all in controls on capital outflows. The substantial liberalizations of the previous period remained in place. Monetary tightening started during this period amidst a sharp rise in inflation, resumption of strong GDP growth, and growing current account deficits. A rebound of the exchange rate (rupee appreciation) and return of international capital inflows also occurred. This period is also characterized by rising domestic interest rates and interest differentials, as well as positive CIP deviations (averaging around 2 percent).

III. Self-Exciting Threshold Auto-Regression Tests of Capital Controls

SETAR Methodology

Deviations from CIP may exhibit nonlinear properties that linear statistical methods are not able to model. In particular, the presence of transaction costs and capital controls are likely to create bands within which arbitrage will not be profitable. Outside of the no-arbitrage boundaries, or threshold values, arbitrage profit opportunities will be operative, with the strength of the return to the no-arbitrage boundaries depending on the specifics of capital controls and other institutional factors. The band threshold values and the speeds of adjustment above and below the bands may be asymmetric, reflecting the institutional specifics.

Linear models of deviations from CIP fail to take into account the possibility of bands, with random deviations from CIP within the bands and systematic adjustment toward CIP outside of the bands. The SETAR model is a particular class of piece-wise autoregressive models attributed to Tong (1978). Surveys of TAR and SETAR models,[22] respectively, are given by Potter (1999) and Hansen (1999b). The SETAR model may be seen as a parsimonious approximation of a general nonlinear autoregressive model (Hansen, 1999b), and is an appropriate statistical methodology for the problem we face in terms of bands and adjustment parameters. Various SETAR models have been used in studying industrial production, GDP, unemployment and, in work closest to our own, on interest rate parity conditions (Pasricha, 2008) and cross-market premiums (Levy Yeyati, Schmukler, and Van Horen, 2006).[23]

The model that we estimate in this section allows for three regimes with differing autoregressive parameters and estimates the upper and lower thresholds which divide the three.

Specifically, we implement the following model:

$$\delta_t = \rho_i \delta_{t-1} + \varepsilon_t; \qquad \kappa_n < \delta_{t-1} < \kappa_p,$$

$$\delta_t - \kappa_n = \rho_n(\delta_{t-1} - \kappa_n) + \varepsilon_t; \quad \delta_{t-1} \leq \kappa_n,$$

$$\delta_t - \kappa_p = \rho_p(\delta_{t-1} - \kappa_p) + \varepsilon_t; \quad \delta_{t-1} \geq \kappa_p$$

where δ_t is our onshore-offshore differential, $\varepsilon_t \sim N(0, \sigma^2)$ and κ_n and κ_p are the negative and positive thresholds respectively. Furthermore, within the

[22]As the names indicate, the SETAR model is a special case of the TAR model, in which regime-switch thresholds depend on lagged values of the autoregressive variable itself.

[23]Pasricha's study (2008) uses SETAR models to measure deviations from interest rate parity in 11 emerging market economies and, outside of crisis periods, assumes parameter stability. Levy Yeyati and others (2006) use data from nine emerging market economies to examine the ratio between the domestic and the international market price of cross-listed stocks, thereby providing a valuable measure of international financial integration. Note that the latter paper uses the general term TAR, but the model is in fact a SETAR model.

bounds defined by κ_n and κ_p, speculative activity is not profitable because of transactions costs and capital controls, so the differential inside the band may follow a unit root or otherwise nonstationary process.

With sufficiently strong arbitrage activity, however, the AR(1) process outside the bands will be stationary. This model assumes that speculative activity outside the band will push the deviations to the edges of the band, rather than to its center. If the thresholds were known, the model could be estimated by ordinary least squares applied separately to the inner and outer regime observations. The thresholds are not known, however and are estimated by a sequential grid search method suggested in Hansen (2000) that also yields confidence intervals for the thresholds. In this method, a grid search is first made for a single threshold, yielding a minimum residual sum of squares, say $S_1(\widetilde{\kappa_1})$, where the function S everywhere denotes the residual sum of squares function. In a two-regime model, the first search would yield the stronger of the two threshold effects. Fixing the first-stage estimate $(\widetilde{\kappa_1})$, the second-stage criterion is:

$$S_2(\kappa_2) = \begin{cases} S_1(\widetilde{\kappa_1}, \kappa_2) & \text{if } \widetilde{\kappa_1} < 0 \\ S_1(\kappa_2, \widetilde{\kappa_1}) & \text{if } \widetilde{\kappa_1} > 0 \end{cases}$$

and the second-stage threshold estimate is the one that minimizes the above function, that is:

$$\widehat{\kappa_2} = \arg\min\ S_2(\kappa_2).$$

The estimate of the first threshold is then refined as follows:

$$S_1^r(\kappa_1) = \begin{cases} S_1(\widehat{\kappa_2}, \kappa_1) & \text{if } \widehat{\kappa_2} < 0 \\ S_1(\kappa_1, \widehat{\kappa_2}) & \text{if } \widehat{\kappa_2} > 0 \end{cases}$$

and the refinement estimator for the first threshold is:

$$\widehat{\kappa_1} = \arg\min\ S_1^r(\kappa_1).$$

All values between the 5th and 95th percentiles are taken and separated into sets of negative and positive threshold candidates.[24] This process of optimization also yields confidence intervals for the thresholds. Define

$$L_2^r(\kappa_2) = \frac{S_2(\kappa_2) - S_2(\widehat{\kappa_2})}{\widehat{\sigma}^2}$$

[24]Thus, 5 percent was trimmed on each side. Every actual value of the CID between the 5th and 95th percentiles was used as a possible threshold in the unrestricted model. In addition, the number of observations in each regime was restricted to be at least 5 percent of sample.

and

$$L_1^r(\kappa_1) = \frac{S_1^r(\kappa_1) - S_1^r(\widehat{\kappa_1})}{\widehat{\sigma}^2}$$

where $\widehat{\sigma}^2$ is the estimated error variance. The asymptotic $(1-\alpha)$ percent confidence intervals for κ_1 and κ_2 are the set of values of each such that $L_1^r(\kappa_1) \leq c(\alpha)$ and $L_2^r(\kappa_2) \leq c(\alpha)$. Hansen (1999b) also shows that

$$c(\alpha) = -2\ln(1 - \sqrt{1-\alpha})$$

Model Choice

As indicated in the previous section, standard diagnostic tests have the maintained hypothesis of linearity, or do not take full account of the implications of the nonlinear alternative. In particular, the threshold parameter is not identified under a null hypothesis of linearity, so classical tests have nonstandard distributions. Hansen (1996, 1999a) has developed a bootstrapping procedure to simulate the asymptotic distribution of the likelihood ratio test.

Using Hansen's approach, we test for the number of thresholds in the SETAR model. The possibilities are no thresholds (the standard linear model), one threshold, or two (the full model given in the expressions above). The tests are conducted pairwise, with the zero threshold null first being evaluated against the alternative of one threshold. If the null is rejected in that test, a second test is conducted for the null of one against the alternative of two thresholds. We only report the estimates from the selected model.

SETAR Estimation Results

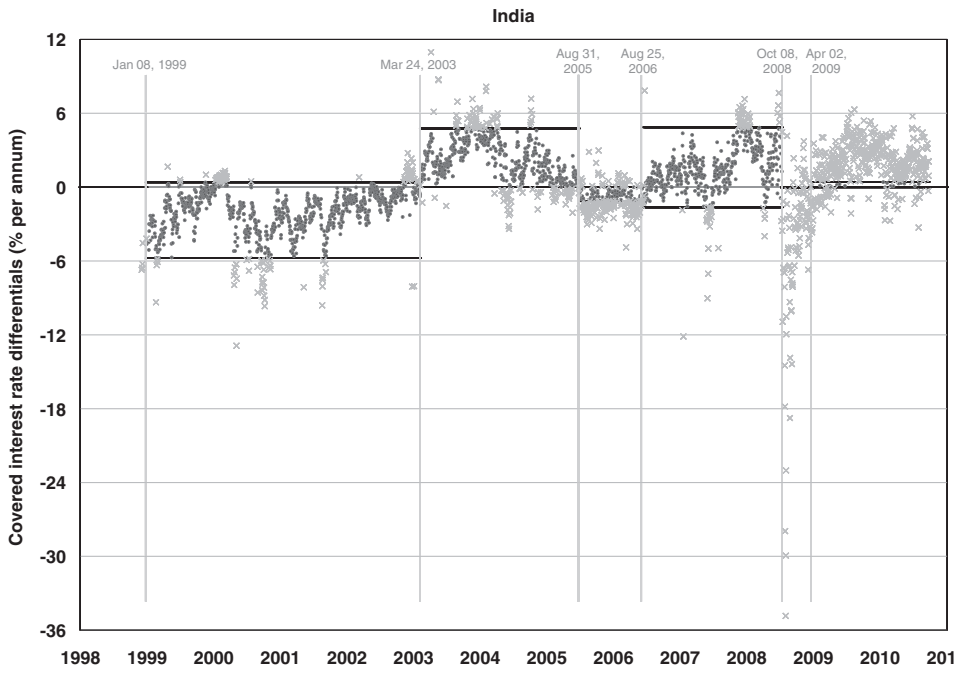
The SETAR estimates for India are reported in Table 3 and Figure 4 for the six subperiods identified in the previous section. For each subperiod, the table shows the beginning and end dates, the number of observations, whether the selected model is a two-threshold or one-threshold model, and the SETAR estimates.[25] The SETAR estimates consist of a negative (lower boundary) threshold, a positive threshold (upper boundary), confidence intervals around the thresholds and the estimated autoregressive parameters for observations inside the no-arbitrage zone, for observations below the lower (negative) boundary, and for observations above the upper (positive) boundaries. Figure 4 displays the CIP deviations and the boundaries for each regime. The observations coded in blue denote CIP deviations within the no-arbitrage zone, and the observations coded in red denote the deviations

[25]Where the model selected is a 1-threshold model, the three-regime framework may still apply, if the other threshold is interpreted to be beyond the observed deviations.

Table 3. India: SETAR Estimation Results

Begin Date	End Date	No. Of Obs.	Model Selected	Confidence Interval (Negative Threshold)	Negative Threshold	Positive Threshold	Confidence Interval (Positive Threshold)	Estimated AR Coefficients (Standard Error)		
								Inside Zone	Below Boundary	Above Boundary
8-Jan-99	20-Mar-03	1023	2-Threshold	[−5.77 −5.39]	−5.77	0.39	[0.11 0.67]	0.98 (0.01)	0.23 (0.07)	0.19 (0.16)
24-Mar-03	26-Aug-05	606	2-Threshold	[−0.68 −0.005]	−0.005	4.77	[4.14 5.42]	0.98 (0.02)	0.25 (0.13)	0.10 (0.10)
31-Aug-05	23-Aug-06	245	2-Threshold	[−1.64 −0.73]	−1.11	0.01	[0.01 −0.55]	1.19 (0.14)	0.27 (0.10)	−0.37 (0.17)
25-Aug-06	6-Oct-08	529	2-Threshold	[−1.64 −0.31]	−1.64	4.86	[4.24 5.26]	0.91 (0.03)	−0.15 (0.10)	−0.42 (0.21)
8-Oct-08	30-Mar-09	114	1-Threshold	[−14.5 2.30]	−0.08			−0.61(0.46)	0.50 (0.05)	
2-Apr-09	7-Jan-11	421	2-Threshold	[−0.12 −0.01]	−0.01	0.43	[0.43 3.24]	6.13 (1.55)	−0.55 (0.18)	0.75 (0.03)

Figure 4. India SETAR Estimation Results: CIP Deviations and Estimated Boundaries



Note: Dark grey indicates observations within the no-arbitrage zone; Light grey indicates observations outside the no-arbitrage zone.

outside the boundaries, that is, where arbitrage pressures are sufficiently strong to reduce the CIP deviations within the zone.

Several broad observations are noteworthy. First, the estimated strength of controls and size of the no-arbitrage zones vary substantially across the subsamples. In three periods—August 2005 to August 2006, October 2008 to March 2009, and April 2009 to January 2011—net controls appear to be very weak (both boundaries around zero) and the zones are quite narrow despite, at times, large average CIP deviations. Second, the boundary thresholds defining the no-arbitrage zone for three periods—January 1999 to March 2003, March 2003 to August 2005, and August 2006 to October 2008—point to clearly distinct applications of capital controls, as introduced in the previous section, and discussed in the next subsection. Also, the SETAR model estimates suggest that capital account liberalization progressed so that controls were not effectively binding from late 2008 onward.[26]

[26]This result is somewhat different from Ma and McCauley (2008) who regress the mean absolute deviations (weekly data) from CIP (12-month instruments) on three dummy variables representing different periods of time. Their most recent period (July 2005-June 2008) has the lowest coefficient estimate, that is, the lowest mean absolute value.

Third, the LR test selects two thresholds (a no-arbitrage zone) in five subperiods, and a single threshold model in one subperiod (October 2008 to March 2009). In this latter case, the threshold is essentially zero (−0.01) and the strength of mean reversion is strong. However, this is the shortest subsample (114 daily observations during a very turbulent period) and, with limited observations, the results may not be robust. Fourth, with the exception of the last sub-sample, all of the AR coefficients for observations inside the no-arbitrage zones of the two-threshold models are very close to unity, indicating random walk movements within the zone, i.e. no effective arbitrage due to capital controls, transactions costs and institutional impediments. The no-arbitrage zone of the last sub-sample (April 2009 to January 2011) is very narrow, [−0.12 to 0.43], and this may account for the seemingly large AR parameter within the zone.

Finally, when CIP deviations exceed the boundaries, the strength of reversion judging by the autoregressive parameters (AR coefficients below the low boundary and above the high boundary) varies by sub-sample and is asymmetric above and below the no-arbitrage band. However, in all cases, the AR parameters outside the band are statistically significantly less than 1 in absolute value, indicating the presence of strong arbitrage forces moving the deviations back to the boundary.[27] The changes in the speed of adjustment reflect the interaction of both capital controls and market structure/liquidity, but clearly indicate that strong forces for market arbitrage are evident that eliminate CIP deviations once they exceed a particular threshold. Moreover, we would expect volume or quantity restrictions on capital inflows and outflows to have a larger impact on the speed of adjustment, while taxes on flows are more likely to increase bandwidths. The complex nature of Indian capital controls, discretionary application over time and their lack of transparency, do not allow us to disentangle these effects.

SETAR Results, Application of Capital Controls, and Gradual Liberalization

Two broad questions remain to be addressed. Are the SETAR results consistent with the descriptive narrative and quantitative indices presented in Section II that point to substantial relaxation of capital controls in India over the past 13 years? And, are the episodes identified as having distinct de jure applications of capital controls consistent with the SETAR results?

While the capital controls regime remains complex and discretionary in India, as Table 1 and Figure 2 indicate, the overall trend since 1999 has been one of de jure liberalization. The liberalization process has reduced the barriers to arbitrage and closely linked onshore and offshore markets in recent years. In particular, the estimated effectiveness of capital controls appears negligible during the last two episodes, starting with the global

[27]Negative AR parameters for outer regimes are interpreted to mean instantaneous arbitrage.

financial crisis and continuing through early 2011. In these two subsamples, the threshold boundaries were quite narrow and very close to zero, indicating arbitrage pressures start with small deviations on either side of the CIP condition. Prior to the financial crisis, however, our estimates show that capital controls were binding and time-varying, suggesting limited effects of earlier liberalization measures. Moreover, the autoregressive parameters covering these two periods are statistically significantly less than one in absolute value, indicating strong pressure for mean reversion once the (narrow) boundary thresholds are exceeded.

The second question concerns the effectiveness of the selective application of capital controls during particular episodes. The first and longest subsample in our study (*January 1999 to March 2003*) spans more than four years and had very substantial and binding controls on both capital inflows and outflows, despite some slow and tentative moves toward inflow liberalization. This is our "baseline" sample establishing the estimates for the initial level of capital controls at the beginning of the period, and the results indicate substantially binding restrictions on net capital outflows. In particular, the SETAR estimates suggest that CIP deviations had to be lower than −5.8 percent (foreign yields exceeding Indian yields by 580 basis points on a covered basis) before arbitrage activity would effectively induce capital outflows from India. When covered differentials exceed that point, however, strong pressure to eliminate these differences became evident with the model indicating a rapid speed of adjustment (autoregressive parameter below the lower threshold of 0.23).[28]

Our empirical estimates for the second episode, *March 2003 through August 2005*, indicate that capital controls effectively restricted incipient capital inflows. The thresholds of the no-arbitrage band were estimated between zero and 4.77 percent (annualized), indicating that very large positive CIP differentials (in favor of India) were needed to induce capital inflows into the country. The seemingly modest moves to tighten capital inflows, judging by the quantitative indices and narrative of the previous section, actually had a very large effect. This may also reflect a more rigorous application of the existing controls. Moreover, the band width continued to be very substantial, indicating that cumulative liberalization moves to date had relatively little effect in facilitating financial arbitrage.

Our estimates for the third episode, *September 2005 through late August 2006*, indicate a sharp decline in barriers to arbitrage. The no-arbitrage band estimated is quite narrow [−1.1, 0.0], indicating that negative differentials below −1.1 percent would induce profitable arbitrage opportunities and incipient capital outflows. The authorities switched from substantial restrictions on net inflows in the previous period to modest restrictions on

[28]An AR (1) parameter less than unity indicates mean reversion, that is, CIP deviations outside of the band are eliminated. A zero AR (1) parameter indicates immediate reversion to the band.

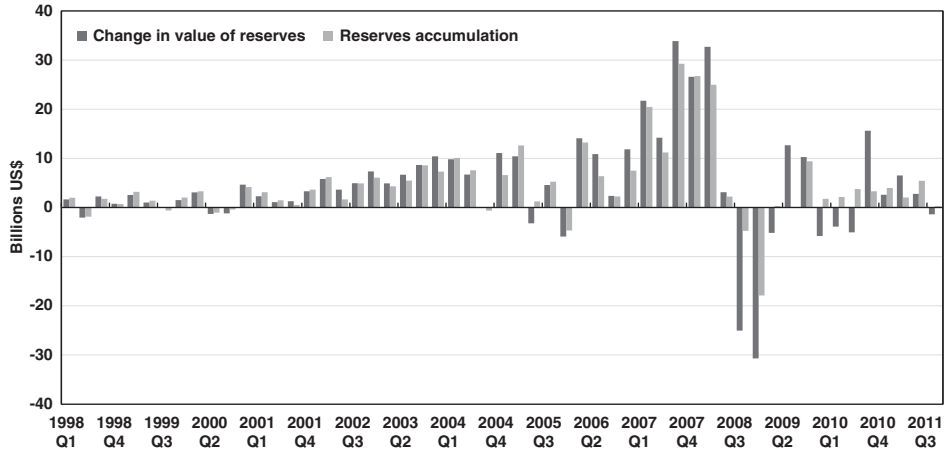
net outflows, or that other barriers such as transaction costs somewhat limited arbitrage opportunities. During this period, judging by the indices of Figure 2, there were no substantive changes in de jure capital controls on outflows, and only one net liberalization on capital inflows, indicating a modest change toward liberalizing net inflows. Although this is consistent with the change in direction of our estimated barriers to arbitrage, it is possible that in the background the authorities were using discretion in allowing freer movement of financial capital and that the institutional developments, detailed in the previous section, played a role in limiting the barriers to arbitrage and linking onshore and offshore markets. In any case, estimated barriers to arbitrage indicate that, for the first time, cumulative changes in liberalization of capital controls had the effect of increasing international financial integration.

The arbitrage band is estimated to widen very substantially again in the positive direction during the next period, *August 2006 to October 2008*. The estimated band and position is similar to the second period (March 2003-August 2005), indicating substantial barriers to capital flows, mainly restrictions on inflows but also somewhat on outflows. That is, the results indicate that positive CIP deviations above 4.9 percent would induce capital inflows and below −1.6 percent would induce incipient capital outflows.

These estimates are consistent with Figure 2 and the narrative on capital controls. Very substantial restrictive measures on capital inflows were imposed several times during this episode, while controls on capital outflows were liberalized, signaling an unambiguous shift toward net outflow liberalization. This was in the face of a sharp increase in capital inflows, along with accelerated growth and monetary policy that began to deal with fears of overheating and inflation in this period. The characteristics of this period therefore suggest that the widening of the CIP deviation arbitrage band in these years reflects macroeconomic pressures, with capital control policy reacting to these pressures. Figure 5, showing the rapid build-up of international reserves during this period, is also evidence for this interpretation.

The fifth episode, *October 2008 to April 2009*, coincides with the global financial crisis. As discussed in the previous section, this was a period of tremendous turmoil in financial markets, not least in India, where for short period USD liquidity shortages, counter-party risk and other market "dislocations" reduced effective arbitrage across onshore market instruments, and between onshore and offshore markets. As shown in Figure B1 of Appendix II, CIP deviations indicated by offshore NDF markets moved in a different direction than those indicated by onshore forward markets. On the one hand, the forward discount on the rupee rose very substantially in the offshore NDF market, pointing to expected rupee depreciations and effectively pushing the CIP deviation sharply negative, while the onshore forward discount on the rupee dropped precipitously (indicating much smaller expected depreciation), pushing the CIP deviation sharply positive

Figure 5. India: Reserves Accumulation



for several days. For this reason, the empirical results for this subperiod need to be interpreted cautiously.

With this caveat in mind, our estimates for this episode indicate almost no barriers to arbitrage, with a single threshold boundary estimated at approximately zero (−0.1 percent). The elimination of the band is consistent with very rapid liberalizations of controls so as to encourage inflows during this episode. Figure 2 shows one liberalizing change in controls on outflows and 19 net measures to liberalize restrictions on capital inflows. In addition, currency futures trading started in India in August 2008 and rapidly picked up volumes that, in principle, should facilitate arbitrage. However, seemingly huge unexploited arbitrage opportunities, denoted by the observations in light grey in Figure 4, clearly indicate that markets were not operating normally during this episode.

The estimates for the final period, *April 2009 to January 2011*, also indicate a very narrow band, ranging from zero to 0.4 percent. This suggests almost no barriers to arbitrage. Deviations from CIP are observed during this period, mainly on the positive side, but the highly statistically significant AR coefficient above the boundary suggests strong arbitrage pressures.[29] Although only modest liberalization on capital inflows occurred during this episode, it appears that the lifting of restrictions during the financial crisis had a lasting impact. In particular, this is strongest evidence to date that, after financial markets calmed by April 2009, the cumulative effect of liberalization greatly opened the capital account in India. In addition, this may be due to the currency options (in the INR/USD pair only) being

[29]The negative AR (1) coefficient (−0.55) below the boundary indicates deviations in an outer regime lasting less than one day.

allowed during this episode (October 2010). These developments led to significant improvements in price discovery and reductions in transactions costs in the domestic market. Moreover, the RBI has stopped intervening significantly in the currency market from early 2009 to the end of the sample.[30]

IV. Robustness: Application to China Offshore NDF Market

This section provides a robustness test of the SETAR methodology to evaluate the effectiveness of capital controls in China. Capital controls in China, and their application in light of the macroeconomic context, have been analyzed in several studies (for example, Ma and others, 2004; Prasad and Wei, 2005; Ma and McCauley, 2008; Glick and Hutchison, 2009). Our contribution is to estimate no-arbitrage band widths and strength of adjustment when CIP deviations move outside the bands, and thereby evaluate the effectiveness of capital controls in China using this methodology.

Figures 6 and 7 and Tables 4 and 5 present the data and our empirical estimates for China. The sample period for China, analogous to our work on India, is early 1999 to early 2011 (daily data). Figure 6 shows the three-month CHIBOR (Chinese Interbank Offer Rate), the CHIBOR-LIBOR interest rate differential, and CIP deviations derived from the NDF Implied Yield Differential. Table 4 presents summary statistics for these three series, and Table 5 presents the SETAR estimation results. Figure 7 presents the SETAR results in graphic form, with the no-arbitrage zones and observations inside and outside the zone boundaries highlighted.

The graph and summary statistics clearly indicated that Chinese capital controls were very effective in creating a wedge between onshore and offshore yield differentials. Over most of the period China's capital controls tightly restricted financial inflows, creating substantial positive CIP differentials (averaging 2.8 percent). This reflects the position of China as a large current account surplus country simultaneously attempting to maintain monetary control and exchange rate rigidity. This has been accomplished by implementing tight controls on capital inflows, and has resulted in massive accumulation of official foreign exchange reserves by China. The exceptions were periods of financial crisis and their aftermath—the Asian Financial Crisis and the Global Financial Crisis—when China reversed course and limited capital flight from the country. During these two periods of our sample (December 1998 to August 2001, and August 2008 to April 2009), China applied controls on outflows and the CIP differential turned sharply negative. For the most part, however, Chinese controls have been applied to limit financial inflows with varying intensity.

[30]The data on RBI interventions is available on a monthly basis from RBI's website, www.rbi.org.in. The information is published in the RBI Bulletin in the Trade and Balance of Payments section, in the Table on Sale/Purchase of U.S. Dollar by RBI.

Figure 6. China: CHIBOR Rate, Interest Differential and CIP Deviations (NDF Implied Yield Differential)

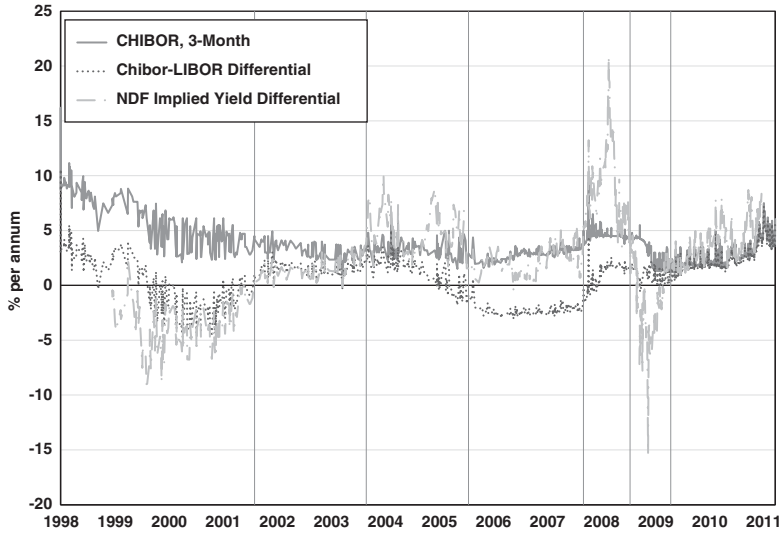
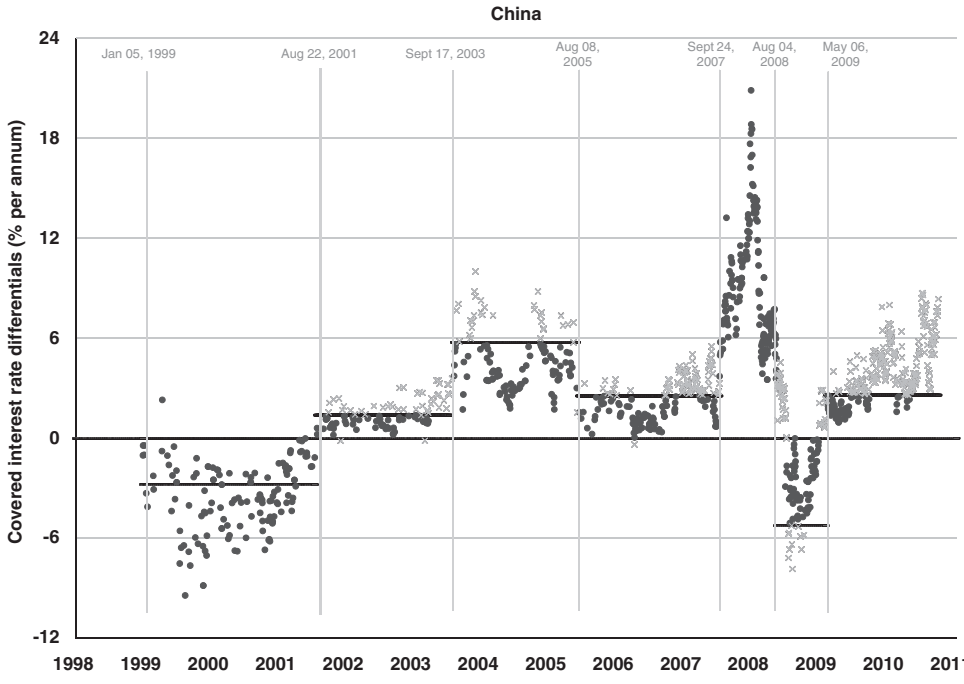


Figure 7. China: SETAR Estimation Results: CIP Deviations and Estimated Boundaries



Note: Dark grey indicates observations within the no-arbitrage zone; light grey indicates observations outside the no-arbitrage zone.

Table 4. China: CHIBOR, CHIBOR-LIBOR Differential and NDF Implied Yield Differential

	Full Sample				Subsample			
Start	12/11/ 1998	12/11/ 1998	08/22/ 2001	9/17/ 2003	08/08/ 2005	9/24/ 2007	08/04/ 2008	05/06/ 2009
End	01/10/ 2011	08/09/ 2001	08/23/ 2003	7/25/ 2005	9/19/ 2007	7/31/ 2008	4/28/ 2009	01/10/ 2011
CHIBOR								
Mean	3.39	4.86	3.12	3.27	2.95	4.61	3.3	2.51
Median	3.22	4.7	3	3.2	2.96	4.49	3.95	2.25
Maximum	9.4	8.82	4.93	6.14	4.38	9.4	5.5	5.8
Minimum	1	2.1	1	1.5	1.59	3.66	1.21	1.12
Std. dev.	1.27	1.72	0.72	0.82	0.48	0.56	1.2	0.87
Observations	1111	128	103	119	185	161	132	283
CHIBOR-LIBOR								
Mean	0.62	−0.89	1.43	1.24	−2.28	1.23	0.96	2.14
Median	1.34	−0.87	1.4	1.35	−2.36	1.62	1.11	1.9
Maximum	5.5	3.82	3.03	5.02	0.58	4.44	2.18	5.5
Minimum	−4.44	−4.44	−0.29	−1.81	−3	−1.57	−0.59	0.24
Std. dev.	1.89	2.04	0.61	1.37	0.41	0.96	0.68	0.92
Observations	1111	128	103	119	185	161	132	283
CIP deviations: NDF implied yield differentials								
Mean	2.83	−3.51	1.46	4.81	2.37	9.12	−1.24	3.97
Median	2.86	−3.59	1.28	4.58	2.51	7.85	−1.53	3.54
Maximum	20.88	2.3	3.48	10.01	5.52	20.88	4.55	8.72
Minimum	−15.39	−9.44	−0.16	1.73	−0.39	3.52	−15.39	0.94
Std. dev.	4.33	2.08	0.82	1.84	1.23	3.72	3.48	1.84
Observations	1111	128	103	119	185	161	132	283

More precisely, there are seven distinct episodes evident from the evolution of CIP differentials shown in Table 4 and Figure 6. The overall 2.8 percent positive average CIP differential for the full sample (December 1998 to January 2011) indicates large binding controls on capital inflows on average. However, this average masks considerable variation in the intensity of controls. We identify five periods when controls were limiting capital inflows, reflected by positive CIP deviations, but where the deviations shifted substantially (greater than 200 basis point average change): August 2001–August 2003, September 2003–July 2005, August 2005–September 2007, September 2007–July 2008, and May 2009–January 2011. As noted, two periods saw substantially negative CIP deviations.

The episodes are shown by the solid vertical lines in the figures and with specific dates in the two tables on China. Figure 6 and Table 4 show that interest rates in China have been relatively stable compared with interest rate differentials and deviations from CIP. The mean (median) values of the CHIBOR rate have only ranged from a low of 2.5 percent (2.3 percent)

Table 5. China: SETAR Estimation Results

Begin Date	End Date	No. of Obs.	Model Selected	Confidence Interval (Negative Threshold)	Negative Threshold	Positive Threshold	Confidence Interval (Positive Threshold)	Estimated AR Coefficients (Standard Error)		
								Inside Zone	Below Boundary	Above Boundary
5-Jan-99	9-Aug-01	127	1-Threshold	[−3.86 −2.35]	−2.79			1.58 (0.15)	1.58 (0.08)	
23-Aug-01	22-Aug-03	102	1-Threshold			1.39	[0.59 1.88]	1.28 (0.10)		0.46 (0.11)
17-Sep-03	25-Jul-05	118	1-Threshold			5.76	[3.69 6.65]	1.08 (0.03)		0.44 (0.13)
08-Aug-05	19-Sep-07	184	1-Threshold			2.54	[0.49 3.55]	1.09 (0.04)		0.82 (0.06)
24-Sep-07	31-Jul-08	160	Linear					0.99 (0.01)		
04-Aug-08	28-Apr-09	131	1-Threshold	[−6.66 −2.99]	−5.25			0.85 (0.06)	0.33 (0.13)	
06-May-09	10-Jan-11	282	1-Threshold			2.59	[2.50 3.39]	1.18 (0.05)		0.95 (0.02)

in the last subsample to a high of 4.9 percent (4.7 percent) in the first subsample. By contrast, interest rate differentials and CIP deviations—noted above—have varied substantially.

The SETAR estimation results are shown in Table 5 and Figure 7 for these sample periods. These estimates indicate six one-threshold models (one estimated lower or upper boundary, with the zero point interpreted as the implicit second boundary), and one linear model with no estimated boundaries, that is, large deviations in CIP (positive) with seemingly little pressure to narrow. The latter result is perhaps not surprising since the linear model best fits the data during the September 2007 to August 2008 subsample, during the run-up to the global financial crisis and a period of high net capital inflows and record accumulation of reserves, and is immediately followed by a sizable negative boundary (−5.3 percent) during the global financial crisis episode (August 2008–April 2009) when strict application of controls on capital outflows is apparent.[31]

Effective controls on net capital inflows over most of the period are evident in the SETAR estimates, that is, significant positive thresholds (estimated in single threshold nonlinear models): 1.39 percent in August 2001-August 2003; 5.76 percent in September 2003-July 2005; 2.5 percent in August 2005-September 2007; and 2.6 percent in May 2009-January 2011. When CIP deviations are above these thresholds, the AR parameter estimates indicate rapid adjustment back to the upper boundaries. (The exception is May 2009-January 2011 where more sluggish but highly significant mean reversion is indicated.)

The subsample SETAR estimates indicate that capital controls are effective in China, and vary over time. This finding is consistent with other studies using different methodologies (for example, Ma and McCauley, 2007, 2008) and also consistent with de jure measures that indicate extensive administrative measures limiting capital flows to China. Moreover, the China case is both a robustness test of the methodology and an interesting contrast with our estimates for India. In particular, there is no evidence that China's controls are less binding over time. China's controls limit capital inflows, excepting periods of regional or international financial turmoil, and the estimates do not suggest gradual liberalization of controls.[32]

[31]Another episode where strict controls on capital outflows can be measured is the first sub-sample, January 1999-August 2001. While the LR test does not reject a 1-Threshold model in this sub-sample, both regimes have AR coefficients greater than 1. We interpret this as the entire sample being under no-arbitrage regimes, with effectively no "outside" zone, and the arbitrage zone lying somewhere outside of the observed deviations. Another factor to keep in mind while interpreting these results is that the number of observations in this sub-sample is small (only 127 over a 2.5 year period) and the observations are missing for several days at a stretch.

[32]Tables A1 and A2 in the appendix present results for annual SETAR estimates for both India and China. This analysis does not rely on our precise periodization, and the results are broadly consistent with the results and interpretation presented in the main text and tables.

V. Summary and Conclusions

This paper has investigated the effectiveness of Indian capital controls in creating a wedge between domestic and foreign implied yields using NDF rates (deviations from CIP). Our objective is to test whether the discretionary application of Indian capital controls, against a background of gradual liberalization, are effective in limiting international financial arbitrage, and limiting capital inflows or outflows. We detail changes in capital controls over more than a decade, develop a new index of capital control changes over time, and analyze these moves against the general macroeconomic and international environment.

We postulate the existence of no-arbitrage bands where the boundaries are determined by transactions costs and limitations to arbitrage due to capital controls, and CIP deviations are random within the boundaries. From an analysis of the announced changes in capital controls and macroeconomic conditions, we divide the period into six subperiods and, using a SETAR model, estimate the effects of liberalization on the threshold boundaries of the no-arbitrage band and speeds of adjustment.

Our results indicate that Indian de jure and de facto capital controls have varied over the 1998–2011 period but a general trend of liberalization is clearly evident. Controls have been asymmetric over inflows and outflows and have changed over time from primarily restricting outflows to effectively restricting inflows and, most recently, to a roughly neutral stance. The changes in capital controls and the application of existing controls have responded to macroeconomic factors, leading to occasional sharp switches in the direction of de facto barriers imposed by capital controls.

Our results find strong arbitrage pressure, closing deviations from CIP when the threshold boundaries are exceeded in all subsamples. While pervasive capital controls have been effective in creating at times a substantial differential between onshore and offshore yields, the size of the no-arbitrage zones has declined substantially over time in response to gradual capital account liberalization, especially since 2009. Overall, liberalization of capital controls in India has occurred in tandem with the development of domestic money and offshore markets and increases in market liquidity, leading to significant increase in de facto openness.

We do not find a similar pattern indicating gradual relaxation of capital controls in China. Rather, Chinese controls are binding and severely restrict capital inflows and interest rate arbitrage. This allows China to run large current account surpluses, while pursuing an independent monetary policy and rigid exchange rate policy, but also results in rapid accumulation of international reserves.

APPENDIX I

Measures on the Capital Account and Their Classification

In order to analyze the evolution of capital flows policies in India, we analyze all changes in regulation influencing capital account transactions. The measures include:

- capital controls, that is, measures on the capital account that differentiate based on residency of the entity undertaking the transaction;
- currency-based measures, that is, measures that differentiate based on currency of transaction

The measures include regulations applicable to the financial sector that are relevant for capital transactions. The main source of data is the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). The AREAER provides information on member countries' exchange arrangements, exchange and trade restrictions and capital transactions. We focus on the capital transactions section which includes regulations applicable to the financial sector that are relevant for capital transactions. The AREAER data is supplemented with information on similar measures from RBI and DIPP websites, news sources, and other research papers.[33]

The IMF's AREAER breaks down the broad category, capital transactions into the following subsections:

1. Controls on capital and money market instruments:
    a) Controls on capital market securities: further classified into "controls on shares or other securities of a participating nature" and "banks or other debt securities"
    b) Controls on money market instruments
    c) Controls on collective investment schemes
2. Controls on derivatives and other instruments
3. Controls on Credit Operations:
    a) Commercial Credits
    b) Financial Credits
    c) Guarantees, sureties and financial backup facilities
4. Controls on direct investment
5. Controls on liquidation of direct investment
6. Controls on real estate transactions
7. Controls on personal capital transactions
8. Provisions specific to the financial sector:
    a) Provisions specific to commercial banks and other credit institutions, which include open foreign exchange position limits and other provisions
    b) Provisions specific to institutional investors

We take a quantitative approach to analyzing policy measures, examining the number of policy measures on the capital account that India has imposed since 1998. In doing this, we follow the IMF's Annual Report on Exchange Arrangements and Exchange

[33]The database used in this paper is an extended version of the database compiled in Pasricha (2012). Further details are provided in this source and are also available from the authors upon request.

Restrictions (AREAER), which carries out an analysis based on the number of changes in restrictive measures on capital account transactions. The number of measures is not sufficient to judge the impact of the measures or to differentiate them by their degree of restrictiveness. However, most measures in the database are of relatively homogeneous magnitude, as major policy announcement are broken up into the number of categories of transactions they influence and each change is counted separately.[34] For these reasons, this numerical approach does provide useful information about the overall direction of policy, and about the attempts to liberalize or to restrict international capital account transactions.

We classify the measures into the following categories:

1. Whether the measure (or change) impacts capital inflows (I) or outflows (O) or cannot be clearly identified as affecting only one of these categories (other).[35]
2. Whether the change represents an easing (E) or tightening (T) of policy or a neutral/institutional change. We assign a numerical value of $+1$ to each easing measure and of -1 to each tightening measure.

We have information on each change as of the date of announcement. The monthly index of inflows is defined as the cumulative sum over all past easing less tightening measures. Algebraically, the *Inflows* index in month m is:

$$Inflows_m = \sum_{t=1}^{m} (N_t^E - N_t^T) = Inflows_{m-1} + (N_m^E - N_m^T),$$

where N_t^E is the number of inflows easing measures announced in month t and N_t^T is the number of inflows tightening measures announced in month t. The outflows index is analogously defined.

We exclude from the indices all changes that relate to FDI, as changes in FDI policy are largely independent of the motives of macroeconomic management including maintaining exchange rate stability or managing "hot money" inflows. Further, the non-FDI related changes are likely to have the most immediate impact on arbitrage and on covered interest differentials.

[34]If a major policy announcement takes place and includes measures related to several categories above, each measure is classified in each category in which it belongs and is counted separately. For example, on March 10, 2003, two different changes were announced—overseas corporate bodies (OCBs) were no longer allowed to purchase securities under the portfolio investment scheme, and OCBs that are unincorporated entities were no longer allowed to make new investments under the FDI scheme. These changes were counted separately in the database, and the second change was not included in the index as it related to FDI only.

[35]Examples of the other measures that could not be classified as inflow or outflow measures include limits on net open foreign exchange positions of financial institutions, ban on use of foreign currency in special economic zones, restrictions on transactions that would constitute at once an inflow and outflow, for example use of external borrowing to invest abroad, and so on.

Table A1. Annual Data—India

Year	Begin Date	End Date	No. of Obs.	Model Selected	Confidence Interval (Negative Threshold)	Negative Threshold	Positive Threshold	Confidence Interval (Positive Threshold)	Estimated AR Coefficients (Standard Error)		
									Inner regime	Negative regime	Positive regime
1999	8-Jan-99	30-Dec-99	229	2-Threshold	[−5.10 −2.96]	−4.98	0.12	[0 0.12]	0.95 (0.03)	0.14 (0.18)	−0.07 (0.48)
2000	5-Jan-00	29-Dec-00	246	1-Threshold	[−7.44 −6.08]	−6.47			1.01 (0.02)	0.27 (0.11)	
2001	3-Jan-01	31-Dec-01	243	1-Threshold	[−5.52 −3.10]	−4.70			1.02 (0.02)	1.02 (0.09)	
2002	3-Jan-02	31-Dec-02	246	2-Threshold	[−2.51 −0.01]	−0.65	0.14	[0.02 0.14]	1.28 (0.18)	0.86 (0.04)	−0.68 (0.41)
2003	3-Jan-03	31-Dec-03	252	2-Threshold	[−0.61 −0.03]	−0.43	4.86	[3.68 5.38]	0.99 (0.04)	−0.22 (0.13)	−0.06 (0.16)
2004	5-Jan-04	31-Dec-04	250	2-Threshold	[−1.06 −0.09]	−0.09	4.69	[1.94 5.73]	1.00 (0.03)	0.49 (0.16)	0.34 (0.15)
2005	5-Jan-05	30-Dec-05	243	1-Threshold			2.00	[−2.08 2.37]	0.36 (0.06)		−0.67 (0.34)
2006	4-Jan-06	29-Dec-06	247	2-Threshold	[−1.70 −0.65]	−0.77	1.00	[0.55 1.23]	0.24 (0.19)	0.44 (0.10)	−0.21 (0.13)
2007	3-Jan-07	31-Dec-07	248	1-Threshold	[−2.40 −1.56]	−2.40			0.33 (0.06)	−0.32 (0.12)	
2008	3-Jan-08	31-Dec-08	250	Linear					0.89 (0.03)		
2009	5-Jan-09	31-Dec-09	236	Linear					0.71 (0.05)		
2010	5-Jan-10	31-Dec-10	238	1-Threshold			0.26	[−0.37 3.69]	−0.10 (0.22)		0.73 (0.04)

Table A2. Annual Data—China

Year	Begin Date	End Date	No. of Obs.	Model Selected	Confidence Interval (Negative Threshold)		Negative Threshold	Positive Threshold	Confidence Interval (Positive Threshold)		Estimated AR Coefficients (Standard Error)		
											Inner regime	Negative regime	Positive regime
1999	5-Jan-99	30-Dec-99	41	Linear							0.84 (0.09)		
2000	18-Jan-00	29-Dec-00	53	1-Threshold	[−3.86	−2.36]	−3.78				1.41 (0.11)	1.41 (0.16)	
2001	17-Jan-01	31-Dec-01	52	Linear							0.78 (0.08)		
2002	17-Jan-02	12-Dec-02	43	1-Threshold				1.25	[0.75	1.33]	1.36 (0.14)		−0.01 (0.20)
2003	12-Feb-03	29-Dec-03	56	Linear							0.99 (0.04)		
2004	6-Jan-04	23-Dec-04	54	Linear							0.97 (0.04)		
2005	6-Jan-05	28-Dec-05	62	1-Threshold				5.76	[2.04	6.60]	1.04 (0.04)		−0.22 (0.31)
2006	19-Jan-06	21-Dec-06	76	Linear							0.96 (0.03)		
2007	17-Jan-07	27-Dec-07	124	1-Threshold				9.49	[8.54	9.49]	1.03 (0.02)		−0.36 (0.20)
2008	8-Jan-08	30-Dec-08	212	1-Threshold	[−5.68	−3.49]	−5.25				0.53 (0.02)	0.33 (0.19)	
2009	12-Jan-09	24-Dec-09	142	2-Threshold	[−3.71	−0.08]	−0.93	2.65	[1.18	3.62]	1.11 (0.05)	0.83 (0.08)	0.31 (0.15)
2010	11-Jan-10	30-Dec-10	179	1-Threshold				2.99	[2.50	6.25]	1.25 (0.07)		0.94 (0.03)

APPENDIX II

Measuring Deviations from Covered Interest Parity

Several methods to measure deviations from CIP from been employed recently in the context of India. These methods may vary by how the onshore yield (or implied yield) is calculated, how the offshore implied yield is calculated, by the choice of the domestic and foreign interest rates, and by the maturity of the instruments.

(1) As discussed in the text, our method (Hutchison-Pasricha-Singh, HPS) measures deviations from CIP as the domestic interest rate (Mumbai Interbank Offer Rate, MIBOR) *less* the offshore implied domestic yield using NDF (F_N) We employ the three-month MIBOR rate as the domestic interest rate as it is directly comparable to the three-month USD LIBOR rate used by almost all studies. This measure is the same as Ma and others (2004), with the exception that they use the 91-day T-Bill auction yield as the domestic interest rate. We describe in the text the advantages of employing the unrestricted offshore NDF rate to measure CIP deviations.

(2) A second measure employed by Baba and Shim (BIS, 2010) measures deviations from CIP as the onshore implied foreign interest rate (using the three-month MIBOR rate and the onshore deliverable forward rate (F)) *less* the foreign interest rate (i^*). That is, they measure the implied onshore foreign yield less the observed foreign interest rate. As in our study, they also use the USD LIBOR and MIBOR rate. (Baba and Shim also define the exchange rate as the USD/rupee rate, rather than the rupee/USD rate. The formula below simply rewrites the equation to be consistent with our definition of the exchange rate.)

(3) A third measure, employed by Misra and Behera (2006), measures deviations from CIP as the implied onshore yield (using F) *less* the implied offshore yield (using NDF, F_N). They also use the USD LIBOR rate.

Algebraically, these three measures of CIP deviations may be written as:

Domestic interest rate less implied NDF off shore

$$\textit{domestic yield}(HPS) = i - \left[\frac{F_N}{S}(1+i^*) - 1\right]$$

Implied onshore foreign yield less foreign interest

$$\textit{rate (Baba and Shim)} = \left[\frac{S}{F}(1+i) - 1\right] - i^*$$

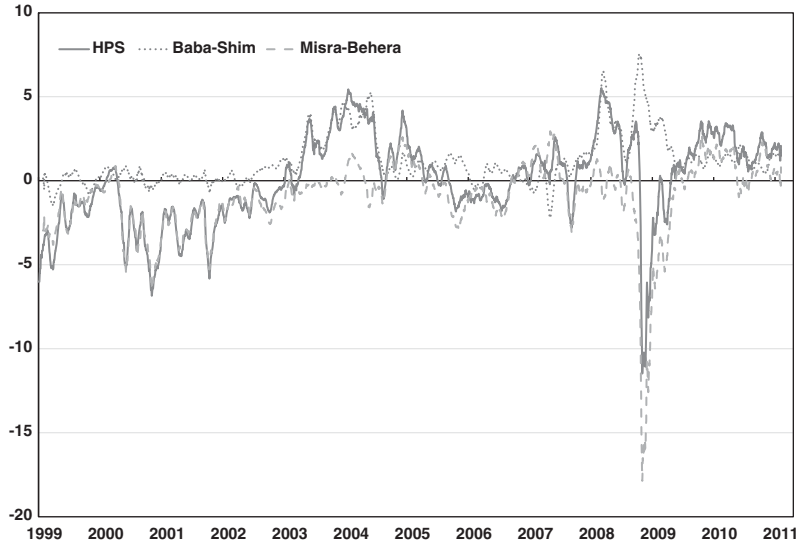
Implied Domestic less implied NDF offshore

$$\textit{domestic yield (Misra and Behera)} = \left[\frac{F}{S}(1+i^*) - 1\right] - \left[\frac{F_N}{S}(1+i^*) - 1\right]$$

where F is the onshore deliverable forward rate, S is the spot rate, i is the domestic interest rate, i^* is the USD interest rate, and F_N is the NDF rate. All exchange rates are expressed as domestic currency units per USD, and all instruments (other than S) are for a three-month maturity.

The definition of the CIP differential in terms of domestic yield (HPS) or foreign yield (Baba-Shim) is not important empirically and, *if using the same forward rate* (F), the two

Figure B1. CIP Deviation Comparisons Using Different Measures



equations are related by HPS = (F/S)*BIS. (Essentially, the HPS measures borrowing 1 rupee, investing this amount in USD, and measuring the USD return. The BIS measures borrowing 1 USD, investing this amount in rupees and measuring the return in rupees). In a high inflation environment, a substantial forward premium could emerge and give somewhat divergent measures but always the same direction of CIP deviations. However, in India during our sample period, these divergences are not large. By contrast, the significant difference between HPS and Baba-Shim is the *use of the offshore NDF rate or the onshore forward rate*. This is a critical difference and, during the global financial crisis, gave quite different measures of CIP deviations.

On the other hand, the only difference between HPS and Misra-Behera is the use of the domestic interest rate (HPS) as opposed to the implied domestic yield using the onshore forward rate (Misra-Behera).

The differences between the three measures may be substantial, mainly reflecting movements in the onshore forward or offshore NDF markets during turbulent periods which in turn may be influenced by "dislocations" (Baba and Shim, 2010), the absence of liquidity and dramatic shifts in risk assessments. Figure B1 shows how the three measures have tracked since 1998. (Daily data is presented as monthly moving averages for ease of visual presentation). The figure shows that the HPS and Misra-Behera measures shadow each other closely from early 1999 until mid-2003 showing large differentials (domestic yields are low compared with covered yields abroad), while the Baba-Shim measure shows almost no CIP deviations during this period. From 2003 onward, HPS and Baba-Shim track each other reasonably closely with the notable exceptions of several months spanning 2005–06 and several days in 2008 during the financial crisis. HPS and Misra-Behera measures diverge significantly in mid-2003, but again track closely for most of the sample after late 2004. The exception is during the run-up to the financial crisis (late 2007 to mid-2008) when the HPS and Baba-Shim measures showed substantial positive CIP deviations while the Misra-Behera measure fluctuated around zero.

Our article demonstrates that substantial structural changes have occurred in the administrative use of capital controls, and other institutional market changes have also occurred during our full sample period which can account for some of the systemic divergences between onshore and offshore market measures of CIP. The sharp deviation in the HPS (and Misra-Behera) from the Baba-Shim measures for a week-long period during the financial crisis, however, must be attributable to significant market dislocation, liquidity shortages and a sharp segmentation between onshore forward market and offshore NDF market for Indian rupee. The forward premium (USD) climbed significantly in the NDF market, pushing the CIP differential sharply negative by the HPS and Misra-Behera measure, while the domestic forward market premium declined markedly (see Patnaik and Shah, 2009–10), sharply increasing the CIP differential by the Baba-Shim measure. It is interesting to note that this price divergence also occurred for the Chinese RMB onshore and offshore markets. (Data available upon request.)

Some explanations for the decline in the domestic forward premium are given in Patnaik and Shah (2009–10) and Baba and Shim (2010), essentially attributing this phenomenon to a USD liquidity shortage that increased domestic yields substantially relative to yields abroad. Patnaik and Shah also argue that the forward market became completely decoupled from the spot foreign exchange rate market for several days, leading to extreme market segmentation. What is not clear, however, is why the opposite developments occurred in the offshore NDF markets and which measure of CIP deviations are most accurate during this period of large market fluctuations and dysfunction.

It is beyond the scope of this paper to investigate the underlying institutional causes of these price discrepancies, clearly going beyond the administration of capital controls. However, we believe that it is an important, albeit very short-term, phenomenon that sheds light on the liquidity, risk and institutional differences in the operation of onshore and offshore markets that is on our future research agenda.

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