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Abstract

This paper examines the effectiveness of international capital controls in India over time by analyzing daily return differentials in the non-deliverable forward (NDF) markets using the self-exciting threshold autoregressive (SETAR) methodology. We begin with a detailed narrative on the evolution of capital controls in India and calculate deviations from covered interest parity utilizing data from the 3-month offshore non-deliverable rupee forward market. We estimate a no-arbitrage band using SETAR where boundaries are determined by transactions costs and by the effectiveness of capital controls. We identify several distinct periods reflecting changes in capital control application and intensity for India, and estimate the model over each sub-sample in order to capture the *de facto* effect of changes in capital controls on return differentials over time. We find that Indian capital controls are asymmetric over inflows and outflows, have changed over time from primarily restricting outflows to effectively restricting inflows; and that arbitrage activity closes deviations from CIP when the threshold boundaries are exceeded in all sub-samples. Moreover, our results indicate a significant reduction in the barriers to arbitrage since 2008. As a robustness test of the methodology, we also apply it 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, show no sign of gradual relaxation or liberalization.

JEL classification: F31, F32, G15
Bank classification: International financial markets; Econometric and statistical methods; International topics

Résumé

Les auteurs analysent l'efficacité des restrictions que l'Inde a imposées à la circulation des capitaux internationaux au fil du temps. Pour ce faire, ils examinent, au moyen d'un modèle à seuil SETAR, les écarts de rendement quotidiens sur les marchés des contrats à terme sans livraison physique. Ils commencent par retracer l'évolution des contrôles de capitaux dans ce pays, puis ils calculent les écarts observés par rapport à la parité des taux d'intérêt couverte en exploitant des données relatives au marché extraterritorial des contrats à trois mois portant sur la roupie. À l'aide du modèle SETAR retenu, ils estiment des fourchettes de non-arbitrage, dont les bornes sont définies par les coûts de transaction et l'efficacité des restrictions aux mouvements de capitaux. Les changements constatés dans l'application et l'intensité des mesures de contrôle permettent de distinguer plusieurs périodes. Les auteurs estiment leur modèle à partir de chaque sous-échantillon afin de cerner l'effet *de facto* que ces changements ont eu sur les écarts de rendement au fil des ans. Il ressort que les mesures mises en œuvre en Inde pèsent de manière asymétrique sur les entrées et sorties de capitaux et qu'elles se sont modifiées dans le

temps, restreignant à l'origine surtout les sorties de capitaux avant d'évoluer vers une limitation effective des entrées de capitaux. Il apparaît aussi que l'activité d'arbitrage réduit dans tous les sous-échantillons les écarts enregistrés par rapport à la parité des taux d'intérêt couverte lorsque les bornes sont franchies. De plus, les résultats obtenus signalent un abaissement important, depuis 2008, des barrières opposées à l'arbitrage. Pour vérifier la validité de leur méthode, les auteurs appliquent également le modèle au marché des contrats à terme sans livraison physique portant sur le renminbi. Ils constatent alors que le contrôle des mouvements de capitaux limite strictement les entrées de capitaux sauf lors de deux périodes de turbulences financières régionales et internationales. L'intensité du contrôle exercé par les autorités chinoises varie dans le temps, ce qui est indicateur d'une certaine latitude, mais, contrairement à l'Inde, on ne relève en Chine aucun signe d'un assouplissement graduel ou d'une libéralisation progressive.

Classification JEL : F31, F32, G15
Classification de la Banque : Marchés financiers internationaux; Méthodes économétriques et statistiques; Questions internationales

1. Introduction

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 policy-makers 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 liberalize the capital account and to allow certain kinds of foreign capital flows, but a host of restrictions and discretionary controls remain. In fact, according to the popular Chinn-Ito (2007) index of capital account openness, which relies on measured *de jure* controls, India remains one of the most closed economies on the capital account, having the second lowest score on the index in the year 2006.[1]

[1] China, Turkey, Pakistan and South Africa were other emerging markets that had the same score as India in 2006, the last for which Chinn-Ito rankings are available. Work on China that is related to our concern with de facto controls includes Cheung et al (2006) and Liu and Otani (2005).

In this paper we examine the *de facto* effects of India's capital account liberalization evident in market price signals by measuring deviations from covered interest parity (CIP) over time.[2] An extensive literature investigates deviations from CIP, inferring market segmentation due to capital controls, transactions costs and other institutional impediments to arbitrage. 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. Our approach follows one strand of this literature by measuring a no-arbitrage band for small deviations from CIP where the upper and lower threshold points are determined by the intensity of capital controls and transaction costs. Within the bands, we expect deviations from CIP to be random walks, and outside the bands we expect arbitrage (profit opportunities) pressures to systematically return deviations to the band thresholds. We divide the sample into pre- and post-liberalization periods to examine the effects of liberalization on the threshold boundaries of the no-arbitrage band and speeds of adjustment. A narrowing of the bands over time is an indication of greater de facto capital account openness, as is an increase in the speed of adjustment to the band threshold points (indicating arbitrage acts more rapidly in returning the market closer to CIP).

A central problem in estimating bands and adjustment speeds is that it requires a non-linear estimation methodology. We employ the self exciting threshold auto-regressions (SETAR) methodology in order to obtain consistent estimates of the upper and lower threshold points of the no-arbitrage band, as well as estimates of the speeds of

[2] The Chinn-Ito index, in contrast, is a *de jure* measure, and shows no movement for India over a relatively long period, making it inappropriate for our task.

adjustment (possibly asymmetric) to the boundaries. The SETAR model is a particular class of piece-wise autoregressive models and may be seen as a parsimonious approximation of a general non-linear autoregressive model (Hansen, 1999). 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 off-shore non-deliverable forward (NDF) rate and the LIBOR dollar interest rate. The off-shore 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 in compared is the Mumbai Interbank Offer Rate (MIBOR). We considered one- and three-month maturities, but focused on the latter, as better capturing significant transaction volume. [3]

Ma et al. (2004) and Misra and Behera (2006) have examined 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. 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. 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.

Our results indicate that Indian capital controls have varied over time. They have been asymmetric over inflows and outflows and have changed over time from primarily

[3] Most inter-dealer transactions in the NDF market are concentrated in two- to six-month maturities, and we follow Ma et al. (2004) in focusing on the 3-month maturity. 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.

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 sub-samples. Moreover, our results indicate a significant reduction in the barriers to arbitrage since 2008 in India. 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. Although we find binding capital controls varying over time in China – strictly limiting capital inflows except in periods of regional or international financial turbulence – we do not find a pattern indicating a gradual relaxation of controls.

The next section discusses NDF markets and details the calculation of deviations from covered interest parity by using NDF markets, onshore interest rates and offshore interest rates. Section 3 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 discusses switches in the application of de facto capital controls in light of deviations from CIP, changes in capital controls and macroeconomic conditions. Section 4 presents the SETAR non-linear model and reports our main empirical results, i.e. estimates of the upper and lower threshold points of the no-arbitrage bands and the speed of adjustment to bands. Section 5 presents a robustness test of the SETAR methodology to deviations in CIP, again using NDF market data, to China. Section 6 presents our conclusions.

2. Non-Deliverable Forward Markets and Covered Interest Parity

A consequence of India's partial capital controls has been the development of a Non-Deliverable Forward (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 not observed.[4]

The Indian rupee NDF market is most active in Singapore and Hong Kong, though there is also trading in places such as Dubai. Average daily turnover of NDF contracts in the Indian Rupee increased from about US$35 million in mid-2001 to US$3.7 billion in early 2007 (Ma et al., 2004; Misra and Behera, 2006), 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).[5] Transactions

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

[5] 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

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[6] and the NDF market (Misra and Behera, 2006). The NDF rate therefore, serves as 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 yield, calculated as follows:

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

where S is the spot exchange rate of the US 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). 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 covered interest parity differential.

Without restrictions on capital flows between two countries, deviations from covered interest parity (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

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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.

[6] 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.

inflows and a negative differential suggests an effective stemming of capital outflows. The speed with which deviations from CIP are eliminated is then an indicator of how effective that arbitrage is between the two markets, and therefore of how effective the capital controls are.

As described by Shah and Patnaik (2005), Indian banking regulations restrict banks' ability to arbitrage deviations from CIP. Although importers and exporters are allowed to use the onshore forward market ("permitted hedgers"), they do not themselves have the financial capabilities to conduct arbitrage as financial institutions would if permitted to do so. Hence, deviations from CIP persist systematically.[7] At the same time, if there are *some* arbitrage avenues for market participants, then the speed with which deviations from CIP are eliminated (or reduced) should be an indicator of how effective that arbitrage is in the actual working of the market.

3. Capital Controls and Covered Interest Parity Deviations in India

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. The analysis of this section, summarized in Table 1, shows a general process of capital control liberalization has taken place over more than a decade. However, substantial restrictions remain and have been applied

[7] 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. Shah and Patnaik (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 relative risk premia for the two currencies. However, these risk premia are unobservable: our maintained hypothesis that the source of variation is changes in controls is consistent with the data and our estimated model.

differentially to outflows and inflows as an instrument of discretionary macroeconomic policy. We find these controls have been effective, judging by CIP deviations, which vary over the sample period as a complement to macroeconomic policy and economic conditions. However, comparing the early to the later part of the sample (daily data 1999 to 2011) suggests that capital account liberalization has been effective in reducing impediments to international financial market arbitrage and that institutions have developed this capacity.

3.1 Evolution of Capital Controls

While measures aimed at current account convertibility in India 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 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.[8]

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

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

changes in the institutional framework 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. 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.[9]

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 thirteen-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).[10]

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

[10] In some cases, changes in FDI policy covered multiple sectors – these cases are each counted as a single change.

Of course, enumeration of types of changes cannot fully capture the impact on 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, due to the complex nature of the existing regulations, and the manner in which changes are defined. As one example, 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 have been covered by general corporate law, and several were phrased in qualitative terms that could be subject to later bureaucratic discretion.

Another example comes from the latest committee to evaluate capital account restrictions (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)

While the first example illustrates the complexity of dealing with overlapping, often minutely detailed regulations, this case brings out the procedural hurdles that can remain, even when there is apparent simplicity in written rules.

The joint features of complex rules and discretionary processes are more pervasive than just a few examples. 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 non-existent 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),[11] as well as detailed recommendations for simplifying reforms. One of its main recommendations is to abolish distinctions among different classes of investors (e.g., Foreign Institutional Investors, Foreign Venture Capital Investors, and Non-Resident 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.

Returning to Table 1, the forgoing discussion should make clear that any attempt to reduce Indian capital controls to a single numerical index is fraught with difficulties. Most measures of de-jure controls, including the Chinn-Ito (2008) and Schindler (2009) measures, use only information on the existence of controls under broad categories of

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

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. Our enumeration of changes and types of restrictions for India does indicate that there has been substantial liberalization on the capital account and that this is somewhat at odds with the stability of the commonly used Chinn-Ito index.[12]

3.2 Capital Control Regimes and Macroeconomic Conditions

The pattern of policy adjustments is also connected to the macroeconomic conditions that prevailed at different times during the overall period. For example, 2007 saw robust growth, and fears of overheating, as well as surging capital inflows. These were accompanied by monetary policy tightening (e.g., repeated increases in the cash reserve ratio). On the exchange rate front, 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 thereafter, and still more flexible from March 2007. In other cases, global conditions have played a significant role. One of our break points is clearly in October 2008, right after the collapse of Lehman Brothers. Patnaik and Shah (2009) provide an analysis of the impacts of this event on Indian markets through the liquidity effects on corporate treasuries of Indian multinationals. There was clearly a sharp reversal of capital inflows at this point, and only a slow return of those flows. Another, harder to quantify global trend has been the increased interest of fund

[12] This conclusion with respect to liberalization (de jure and de facto) is borne out by our empirical analysis of CIP deviations and arbitrage bands. It is also worth noting that the greater frequency of policy adjustments in the latter part of our period is consistent with the more frequent breaks observed in capital control applications and subsequently used for our SETAR analysis after 2003.

managers in portfolio investments in India, roughly from 2005 or 2006 onwards. The interplay of these factors with various liberalizing policy changes would be expected to influence the arbitrage bands of the SETAR models.

To identify possible changes in the application of capital controls in the context of macroeconomic environment more systematically, Figure 2 shows the 3-month interest rate for India (MIBOR, or Mumbai Interbank Offer Rate), the 3-month interest rate different between India and the U.S. (MIBOR less LIBOR), and the annualized deviations from covered interest parity (CIP) for interest rates and NDF of 3-month maturity. The graph shows daily observations starting from January 1999 to January 2011. Table 2 presents summary statistics (mean, median, maximum, minimum, standard deviation and number of observations) for the full sample and the six sub-samples identified from the narrative and observing variations in CIP deviations as having distinctly different capital control regimes.[13]

The short-term interest rate in India, measured by the 3-month MIBOR rate, averaged 7 ½ % during the full sample, with the average fluctuating during sub-samples between 5% - 9%, and with minimum and maximum values during the sample of 4% and around 13%, respectively. This reflects varying rates of inflation, state of the business cycle and monetary stance in India during the more than decade-long period.

Large and persistent interest rate differentials are evident between India rupee and USD denominated interest rates. Short-term rates in India were always, and oftentimes

[13] This study uses the 3-month MIBOR to measure domestic interest rates. This matches well with the 3-month LIBOR rate. An alternative interest rate is the 31day T-Bill implicit yield (Ma and McCauley, 1998) and the implied onshore yield derived from deliverable forward rates (Misra and Behera, 2006). We calculated the implied 3-month onshore yield using deliverable forward rates. The correlation with our MIBOR measure was .60, but these implicit interest rates were much lower than the MIBOR measure (averaging 2.0% over the full sample period, compared with the MIBOR average of 7.5%).

substantially, higher than USD interest rates during the sample period. The mean (median) difference was more than 400 basis points and reached a maximum difference of over 9% in November 2008 as the RBI maintained its policy rate steady while the Federal Reserve lowered short-term U.S. interest rates to zero.

Return differentials also showed up in CIP deviations, indicating that arbitragers couldn't take advantage of these seeming profit opportunities due to capital controls, transactions costs and other impediments. The average (median) CIP deviation for the full sample period was essentially zero, but the range across sub-samples was substantial, indicating variation in capital controls and other factors. In particular, the median values ranged from a high of 2.0% during March 2009-January 2011, indicating high yields in India and controls on inflows of international capital that limit arbitrage between onshore and offshore markets, to a low of -2.9% during October 2008 through March 2009, indicating controls on capital outflows. At some points CIP deviations exceeded 500 basis points. This indicates that, in the absence of capital controls and transactions costs, an arbitrageur could have received over $50,000 USD per year for every $1 million USD of volume transacted, without investing any money.[14] Deviations of this magnitude indicate that capital controls have affected these markets and hindered arbitrage and market integration.

Measured CIP deviations, interest rate movements and analysis of the descriptive evidence on capital controls and macroeconomic policy and conditions from the previous section indicate several distinct capital control regimes. Determining these episodes,

[14] Differentials this large are not uncommon for emerging market currencies. As seen in Figure 4, China's yield differentials exceeded this level on several occasions. Graph 4 in Ma and McCauley (2010), which computes the NDF implied yield differential for six emerging market currencies also finds differentials at times exceeding 500 basis points. Graph 3 in their paper also shows that average absolute differentials for INR were exceeded by Chinese Yuan and Philippines Peso over the period January 2002 to February 2004.

especially exact break points, is somewhat subjective and reflects balancing all the relevant economic criteria, as explained below[15]:

- Early 1999 to March 2003. This period, our longest sub-sample, is characterized by gradually declining short-term interest rates, stable (positive) interest rate differentials and consistently negative CIP deviations (-2% average), indicating net controls on outflows. Monetary policy was either easing or neutral during the period, as inflation was contained, and growth was moderate and the current account fluctuated from small deficit to small surplus.
- March 2003 through August 2005. This period was characterized by stable domestic short-term interest rates, declining interest rate differentials and positive CIP deviations (averaging above 2%), indicating controls on inflows. Greater exchange rate fluctuations were allowed against a backdrop of monetary stability, stable inflation and strong GDP growth.
- Late August 2005 to mid August 2006. This one-year period is characterized by gradually rising domestic interest rates, declining interest rate differentials and small negative deviations from CIP (averaging around -1%), indicating modest controls on capital outflows or other impediments to arbitrage. 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 early October 2008. This period is characterized by rising domestic interest rates, reflected by a widening interest rate differential, and

[15] In related work, Hutchison et. al. (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.

generally positive CIP deviations (1.5% average) indicating some net binding controls on capital inflows. The period was characterized by monetary tightening in light of very strong GDP growth, surges in capital inflows and exchange rate appreciation.

- Mid October 2008 through March 2009. This was a short period of very volatile international financial markets, sharply falling short-term domestic interest rates and interest rate differentials. CIP deviations are substantial and negative (mean -4.4%, median -2.9%), the largest during our period of study, indicating tight and binding restrictions on capital outflows. Aggressive monetary easing in the immediate aftermath of the global financial crisis in order to offset sharp declines in international trade, fall in global economic activity and an international liquidity shortage that contributed to a sharp deceleration in Indian GDP growth.
- April 2009 through early January 2011. This period is characterized by rising domestic interest rates and interest differentials, as well as positive CIP deviations (averaging around 2%) indicating controls on capital inflows. 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 capital inflows occurred during this period.

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

4.1 SETAR Methodology

Deviations from CIP may exhibit non-linear 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 towards 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,[16] respectively, are given by Potter (1999) and Hansen (1999b). The SETAR model may be seen as a parsimonious approximation of a general non-linear autoregressive model (Hansen, 1999b). The SETAR model is an appropriate statistical methodology for the problem we face in terms of bands and adjustment parameters. Various SETAR models have been used in modeling industrial production, GDP, unemployment and, in work closest to our own, on interest rate parity conditions (Pasricha, 2008) and cross-market premia (Levy Yeyati, Schmukler and Van Horen, 2006).[17]

[16] 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.

[17] 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, Schmukler and Van Horen (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.

The Self-Exciting Threshold Autoregressive (SETAR) 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. In addition, we estimate the model over two regimes to reflect pre- and post-liberalization of capital controls. We implemented the following SETAR model:

$$\begin{aligned}
&\delta_t = \rho_i \delta_{t-1} + \varepsilon_t \; ; && \kappa_n < \delta_{t-1} < \kappa_p \\
&\delta_t - \kappa_n = \rho_n(\delta_{t-1} - \kappa_n) + \varepsilon_t \; ; && \delta_{t-1} \le \kappa_n \\
&\delta_t - \kappa_p = \rho_p(\delta_{t-1} - \kappa_p) + \varepsilon_t \; ; && \delta_{t-1} \ge \kappa_p
\end{aligned}$$

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. A model of this form assumes that within the 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 non-stationary process.

With sufficiently strong arbitrage activity, however, the AR(1) process outside the bands will be stationary. This model assumes that speculative activity 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 (1999) 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:

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

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

$$\widehat{\kappa_2} = argmin S_2(\kappa_2)$$

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

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

and the refinement estimator for the first threshold is:

$$\widehat{\kappa_1} = argmin S_1^r(\kappa_1)$$

All values between the 5th and 95th percentiles are taken and separated into sets of negative and positive threshold candidates.[18] This process of optimization also yields confidence intervals for the thresholds. Define

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

and

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

The asymptotic (1-α)% 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

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

[18] Thus, 5% 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% of sample.

4.2 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 non-linear alternative. In particular, the threshold parameter is not identified under a null hypothesis of linearity, so classical tests have non-standard 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. There 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.

4.3 SETAR Estimation Results

The SETAR estimates for India are reported in Table 2 and Figure 3 for the six sub-samples identified from the previous section as having different regimes for the application of capital controls. For each sub-sample, the table shows the beginning and end dates, the number of observations, whether the selected model is a 2-threshold or 1-threshold model, and the SETAR estimates.[19] 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

[19] 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.

the no-arbitrage zone, for observations below the lower (negative) boundary and for observations above the upper (positive) boundaries. Figure 3 reports 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 outside the boundaries, i.e. where arbitrage pressures are sufficiently strong to reduce the CIP deviations within the zone.

Several broad observations are noteworthy. Firstly, the estimated strength of controls and size of the no-arbitrage zones vary substantially across the sub-samples. 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. Secondly, 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, complementing the descriptive analysis from the previous section. Also, SETAR model estimates suggest that capital account liberalization had progressed sufficiently so that controls were not effectively binding since late 2008.[20]

Thirdly, the SETAR model estimates two thresholds (a no-arbitrage zone) in five sub-samples, and a single threshold model in one sub-sample (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 sub-sample (114 daily observations

[20] This result is consistent with 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. The most recent period (July 2005-June 2008) has the lowest coefficient estimate, i.e. the lowest mean absolute value.

during a very turbulent period) and, with limited observations, the results may not be robust. Fourthly, 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) vary both by sub-sample and are asymmetric. For example, when CIP deviations are below the no-arbitrage zone, there appears to be much stronger arbitrage forces moving it back to the boundary, i.e. highly statistically significant AR(1) parameter estimates with values substantially less than unity. (Values equal to or exceeding unity indicate no mean reversion). Mean reversion parameter estimates when CIP deviations are above the upper boundary are frequently not statistically significant.[21]

Finally, 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 seeming strength of mean reversion within the zone. These 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

[21] This may reflect that the incentive to take money out of India is more readily satisfied than an incentive to bring money into the country.

application over time and their lack of transparency, do not allow us to disentangle these effects.

Several of the sub-samples are especially noteworthy. The first and longest sub-sample in our study (January 1999 to March 2003) spans more than four years and had very substantial and binding controls on capital inflows. The SETAR estimates suggest that CIP deviations had to be lower than -5.8% (annualized foreign yields exceeding Indian yields by 580 basis points on a covered basis) before arbitrage activity would effectively induce capital outflows from India and reduce the covered yield differential. 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).[22] Capital controls were strictly binding, limiting strong pressure for capital outflows from India despite an interest differential (MIBOR less LIBOR) of around 5% (uncovered) favoring India (Table 2). This period stands in contrast with the most recent period, March 2009 to December 2010, which had a very narrow zone. While the capital controls regime remains complex and discretionary in India, as Table 1 indicates, the overall trend since 1999 has been one of liberalization. In addition, two other factors may have played a role in the tightening of the bands in the most recent sub-sample: First, currency futures trading started in India in August 2008 and rapidly picked up volumes, and currency options (in the INR/USD pair only) were allowed in October 2010. These developments led to significant improvements in price discovery and reductions in transactions costs in

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

the domestic market. Second, the RBI has not been intervening significantly in the currency market since early 2009.[23]

On the whole, our results suggest that the path of capital account liberalization and of financial development in India has progressed substantially.

5. Robustness: Application to China Off-shore 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 (e.g. Glick and Hutchison, 2009; Ma and McCauley; 2004 and 2008; Prasad and Wei, 2005). 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 4 and 5 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 4 shows the 3-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 5 presents the SETAR results in graphic form, with the no-arbitrage zones and observations inside and outside the zone boundaries highlighted.

[23] 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 US Dollar by RBI.

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%). 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.

More precisely, there are seven distinct episodes evident from the evolution of CIP differentials shown in Table 4 and Figure 4. The overall 2.8% 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 4 and Table 4 show that interest rates in China have been relatively stable compared to interest rate differentials and deviations from CIP. The mean (median) values of the CHIBOR rate have only ranged from a low of 2.5% (2.3%) in the last sub-sample to a high of 4.9% (4.7%) 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 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, i.e. 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 sub-sample, during the run-up to the global financial crisis, and is immediately followed by a sizeable negative boundary (-5.3%) during the global financial crisis episode (August 2008 – April 2009) when strict application of controls on capital outflows is apparent.

Effective controls on net capital outflows over most of the period are evident in the SETAR estimates, i.e. significant positive thresholds (estimated in single threshold non-linear models): 1.39% in August 2001-August 2003; 5.76% in September 2003 – July 2005; 2.5% in August 2005 – September 2007; and 2.6% 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 sub-sample SETAR estimates indicate that capital controls are effective in China, and vary over time. This finding is consistent with other studies using different methodologies (e.g. 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.

6. 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, 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, macroeconomic policy and data on interest rates and CIP deviations, we divide the sample into six sub-samples and estimate the effects of liberalization on the threshold boundaries of the no-arbitrage band and speeds of adjustment.

A narrowing of the bands over time is an indication of greater *de facto* capital account openness, as is an increase in the speed of adjustment to the band threshold points (indicating arbitrage acts more rapidly in returning the market closer to CIP). Inside of the bands, small deviations from CIP follow a process close to a random walk. Outside the bands, profitable and feasible arbitrage opportunities exist, and we estimate an adjustment process back towards the boundaries. We allow for asymmetric boundaries and asymmetric speeds of adjustment (above and below the band thresholds), which may vary depending on how arbitrage activity is constrained by capital controls.

Using Indian data, we estimate this non-linear model with the self exciting threshold auto-regressions (SETAR) methodology in order to simultaneously obtain consistent estimates of a non-arbitrage band (upper and lower threshold points) and speeds of adjustment (possibly asymmetric) to the boundaries. Outside the thresholds, our estimates generally indicate relatively rapid or instantaneous convergence. This pattern is consistent with the contention that capital controls imply a cost of arbitrage or induce riskiness to the arbitrage position. These unseen costs or risks induce a threshold effect where arbitrage will only become profitable (on a risk adjusted basis) outside a given level of CIP deviation. A robustness application to China, using the same basic markets and methodology, indicates that Chinese capital controls have also been quite effective in limiting international financial arbitrage. However, China's controls have mainly limited

capital inflows over most of the period. The two exceptions are during the periods immediately following regional or global financial turbulence.

In terms of the effects of India's liberalization of capital controls, our results indicate a significant reduction in the barriers to arbitrage since 2008. Moreover, there have been several sharp switches in the direction of capital controls. 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. However, we do not find a pattern indicating a 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.

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Table 1: Summary of Capital Control Policy Changes in India, 1998-2011

Year	No. of changes	No. of Liberaliz-ations	No. of changes affecting Inflows	Description of Capital Control Policy Changes	Macroeconomic Conditions and Policies	Begin Date of Sub-periods
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 Non Bank 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 NDF Implied Yield indicates net controls on inflows
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.	

Table 1 (contd.): Summary of Capital Control Policy Changes in India, 1998-2011

Year	No. of changes	No. of Liberaliz-ations	No. of changes affecting Inflows	Description of Capital Control Policy Changes	Macroeconomic Conditions and Policies	Begin Date of Sub-periods
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 NDF Implied Yield indicates net controls on inflows
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 NDF Implied Yield indicates controls on outflows
2006	11	9	7	FDI in single brand retail up to 51%, also up to 100% in various industrial undertakings, and 49% 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 NDF Implied Yield indicates net controls on inflows

Table 1 (contd.): Summary of Capital Control Policy Changes in India, 1998-2011

Year	No. of changes	No. of Liberaliz-ations	No. of changes affecting Inflows	Description of Capital Control Policy Changes	Macroeconomic Conditions and Policies	Begin Date of Sub-periods
2007	29	20	16	Minor further relaxation in telecoms FDI. Several cases of interest rate caps tightening to reduce inflows. 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.	
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)	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 NDF Implied Yield indicates net controls on outflows
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 NDF Implied Yield indicates net controls on inflows
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.	

Table 1 (contd.): Summary of Capital Control Policy Changes in India, 1998-2011

Year	No. of changes	No. of Liberaliz-ations	No. of changes affecting Inflows	Description of Capital Control Policy Changes	Macroeconomic Conditions and Policies	Begin Date of Sub-periods
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.

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

		Full Sample	Sub-Sample					
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

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 -0.01]	0.00	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)

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

	Full Sample				Sub-Sample			
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

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	[-2.35 -2.79]	-3.86			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)

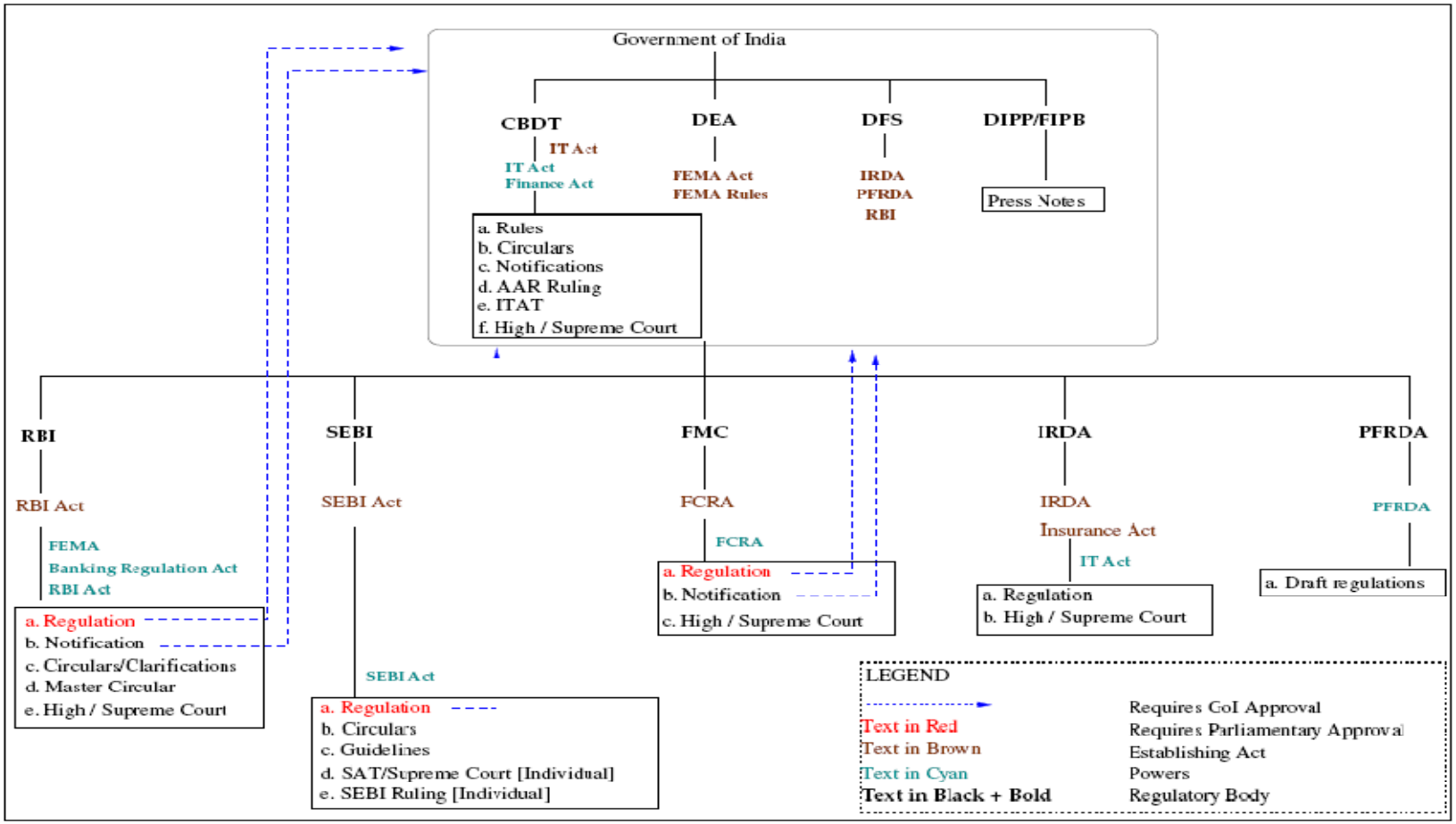
Appendix Table 1: Annual Data - India

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)

Appendix Table 2: 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)

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.

Figure 2: India: MIBOR Rate, Interest Differential and CIP Deviations (NDF Implied Yield Differential)

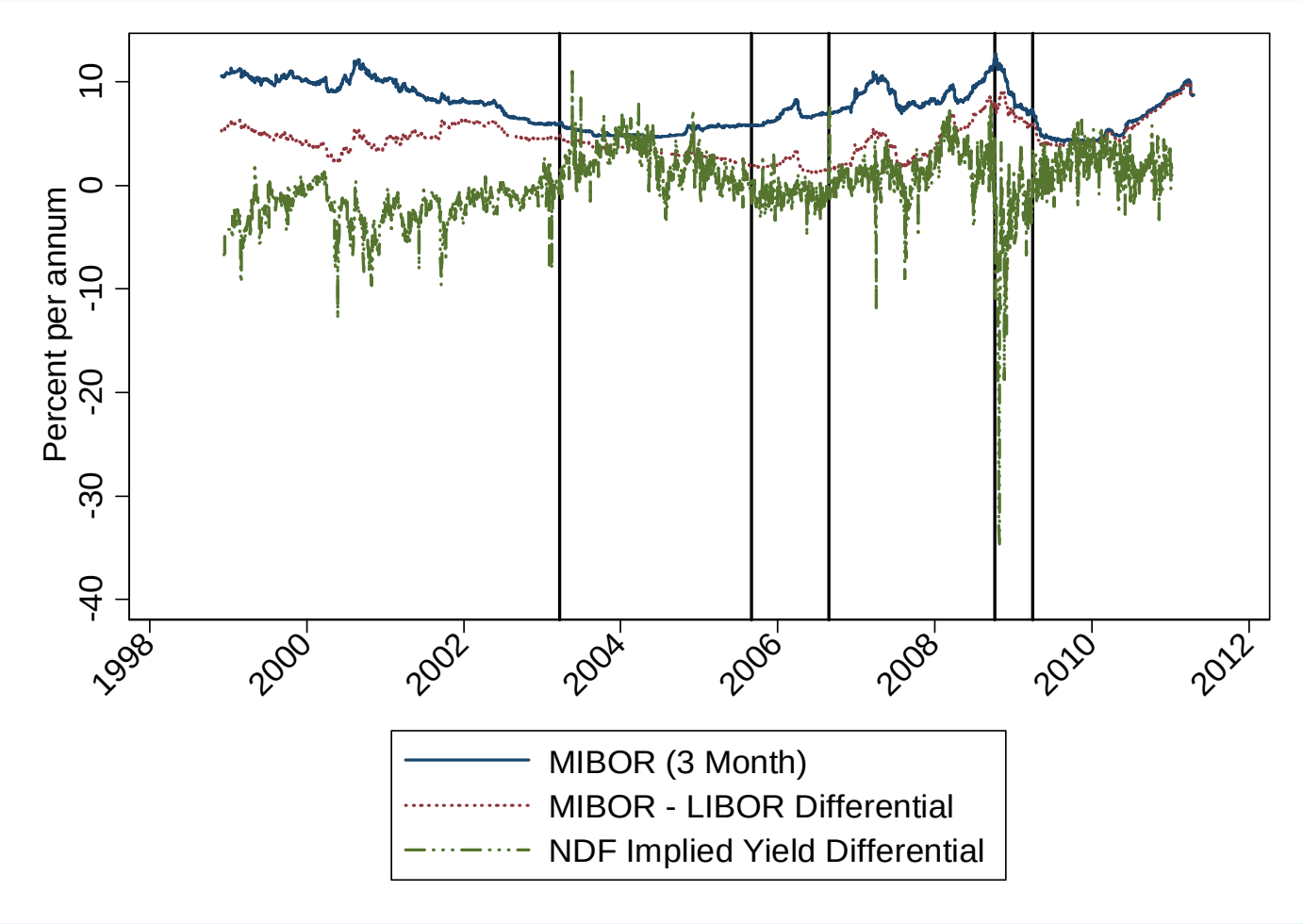


Figure 3: India SETAR Estimation Results: CIP Deviations and Estimated Boundaries
(Blue indicates observations within the no-arbitrage zone; Red indicates observations outside the no-arbitrage zone)

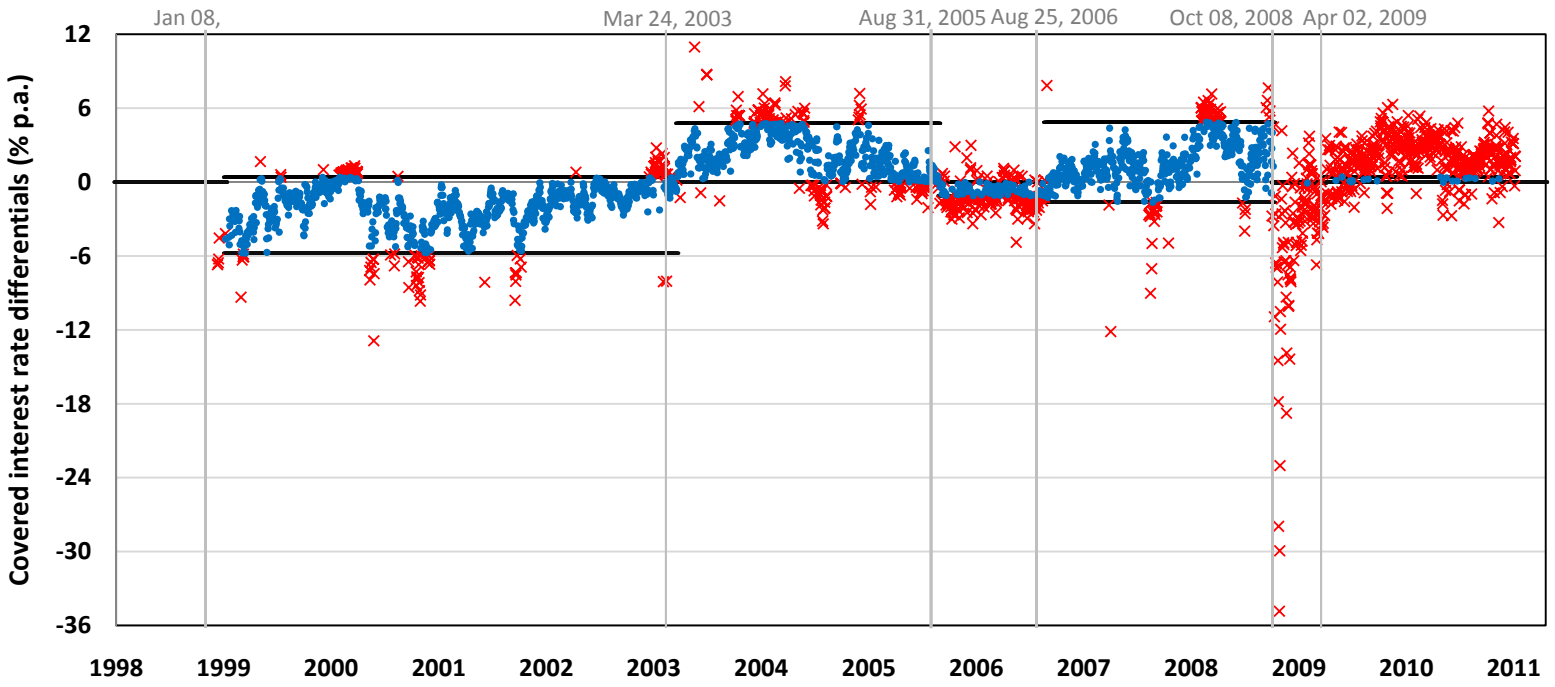


Figure 4: China: CHIBOR Rate, Interest Differential and CIP Deviations (NDF Implied Yield Differential)

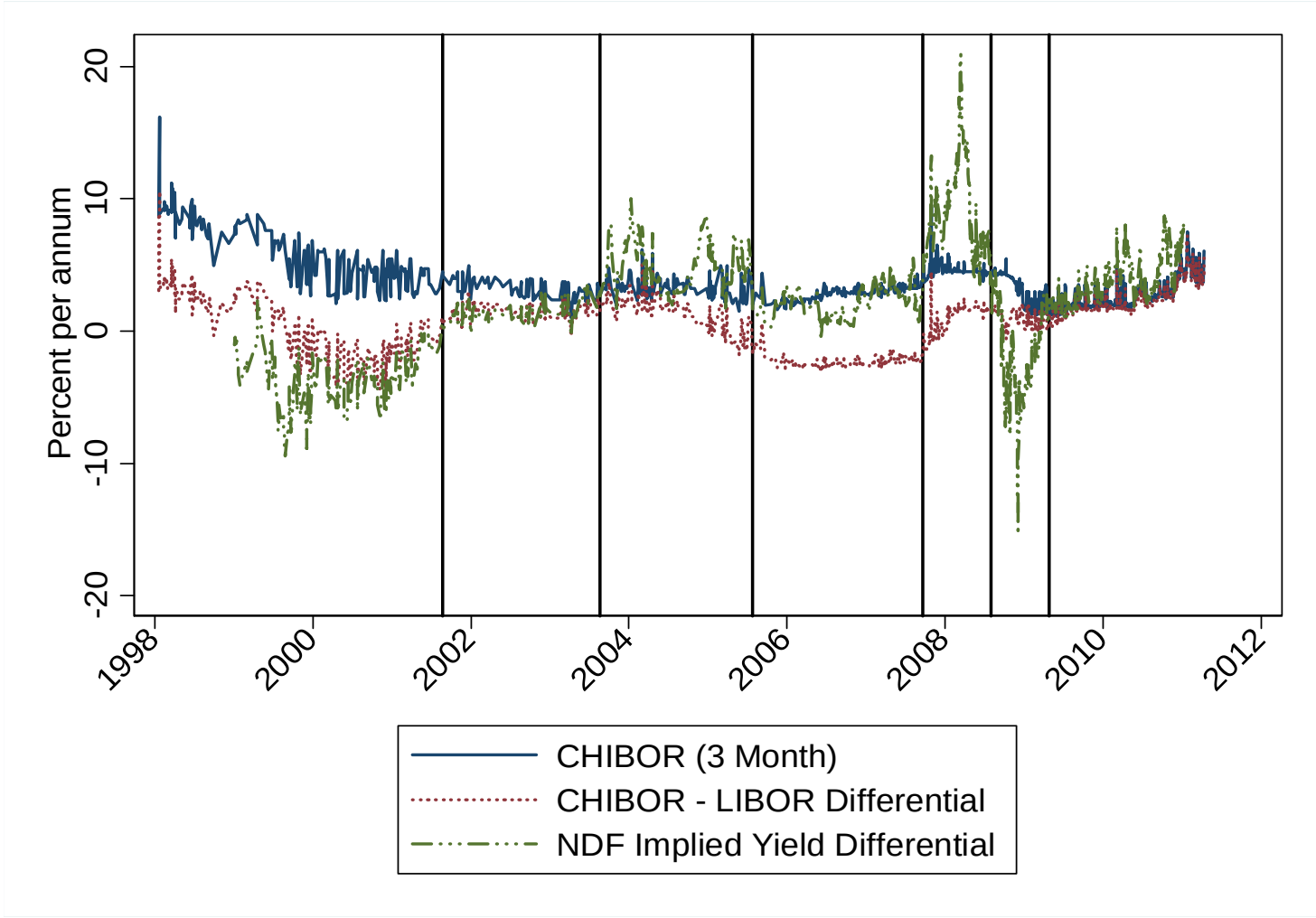


Figure 5: China: SETAR Estimation Results: CIP Deviations and Estimated Boundaries
(Blue indicates observations within the no-arbitrage zone; Red indicates observations outside the no-arbitrage zone)