

Market efficiency on the Indian equity derivatives market

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1 Introduction

India has experienced considerable success with the transformation of the market design on the equity market. These changes were driven by a focus on *systemic integrity* and *transactions costs*. The new market design on the equity market appears to have enjoyed considerable success in addressing these concerns.

It is hence important to shift attention from these basic issues to the underlying purpose of financial markets: allocative efficiency. The role that financial markets play in the economy is to deliver appropriate risk/return tradeoffs across a large number of financial instruments and portfolios. If

¹Email ajayshah@mayin.org and URL <http://www.igidr.ac.in/~ajayshah> on the web. The opinions expressed in this paper are those of the author and not those of the Ministry of Finance or IGIDR. I am grateful to Infotech Financials Pvt. Ltd. for the use of their '*Chanakya*' software, to Indian Quotation Systems for making data available from the NSE derivatives market, and to NSE for the use of the 'NSE Release A' CDs of data for the NSE spot market. This paper greatly benefited from discussions with Jayanth Varma, Jaimini Bhagwati, Ashish Chauhan, and with Susan Thomas and others at the Computational Finance Laboratory at IGIDR.

the financial sector effectively discharges this role, we should obtain market efficiency, i.e. supernormal rates of return should not be available.

India has achieved unique success in obtaining liquidity and turnover on the equity derivatives market. This paper examines market efficiency on the equity derivatives market.

High levels of market efficiency on the derivatives market critically require a large number of teams of professional arbitrageurs. These teams require a combination of capital, skills, and sophisticated IT systems. Every new derivatives market faces the question about how these firms will come about, and perform their function of obtaining market efficiency in the financial ecosystem.

If the broad regularity of a derivatives market is one with poor standards of market efficiency, then an arbitrageur who enters into an arbitrage position has to realistically plan on holding till expiration. In other words, pervasive failures of market efficiency imply that opportunities for early unwind are unlikely to arise. Under these circumstances, arbitrage becomes capital intensive. The firms best suited to commence with arbitrage in such a setting, such as banks, may often be hamstrung by policy constraints.

In addition to specialised arbitrage firms, such as hedge funds, existing finance companies (such as banks, mutual funds, FIIs or securities firms) can setup professional arbitrage groups. The impediments that can hold back such forms of organisation include (a) small market size, (b) lack of skills amongst decision makers and (c) policy or operational impediments.

In practice, there is a close interplay between these three factors. Many operational impediments are mere fixed costs. However, in a small market, these fixed costs can contaminate the viability of establishment of professional arbitrage groups. The public goods of research and knowledge about the opportunities in arbitrage, and the instrumentalities for exploiting them, can help in improving decision making.

In this paper, we implement a sophisticated measurement of the returns to three specific arbitrage strategies (Section 3). The software program *Chanakya*, which is produced by the software firm Infotech Financials, is used to measure the highest available rate of return on utilising funds or securities, across thousands of potential arbitrage positions. This measurement is done using sound assumptions governing transactions costs. An intra-day time-stamped series of these rates of return is obtained. This al-

allows us to make time-series graphs of the rates of return available from maximal usage of capital in arbitrage.

In Section 4, we enumerate an exhaustive set of constraints which could constrain economic agents from exploiting arbitrage opportunities. These are classified into regulatory constraints, implementation hurdles external to the finance company, and internal difficulties faced by the finance company itself.

This enumeration was used for conducting a survey amongst experienced market practitioners in March 2002 (Section 5), who were asked about impediments limiting their arbitrage activities. The survey results help us focus on the few, most-important impediments out of the exhaustive list in Section 4.

Section 6 shows results for measurement of the incidence of arbitrage opportunities in one week in September 2002. It documents substantial violations of market efficiency. There were extremely high rates of return in reverse cash and carry strategies, there were substantial delays between an arbitrage opportunity surfacing and its being exploited, and option pricing often violated elementary sense.

Some of the impediments to arbitrage were addressed in recent changes announced at SEBI and NSE. These are summarised in Section 7. Finally, Section 8 concludes the paper, and summarises the impediments that limit market efficiency of the equity derivatives market as of early 2003.

2 Understanding violations of no-arbitrage

In an ideal neoclassical world, there would be a large mass of highly well informed and well motivated traders, equipped with sophisticated IT systems, who would rapidly eliminate arbitrage opportunities as they surface.

In the real world, there have been many constraints in achieving such a state of market efficiency (Brenner et al. 1990, Figlewski 1984, Peters 1985). The international experience suggests that when new derivatives markets are launched, it takes some time before high levels of efficiency are established.

When an arbitrage position is adopted, extremely high returns can be obtained using early unwind, if efficiency asserts itself rapidly. If the market suffers from pervasive levels of inefficiency, then opportunities for early

unwind might not quickly surface. In the worst case (from the viewpoint of the arbitrageur), the arbitrageur may end up holding his position till expiration, which yields the lowest returns.

This suggests a paradoxical contrast between two scenarios. In an ideal neoclassical world, arbitrage would be a highly competitive business, where it is difficult to obtain an arbitrage position. However, if a given trader did manage to lock into an arbitrage position, the rates of return obtained therein would be extremely high owing to a quick early unwind. In contrast, we could have a world with pervasive mispricings, where a trader has little hope of early unwind. In this case, arbitrage would be capital intensive, and require holding till expiration. Some of the entities best equipped for such slow and capital intensive work (e.g. banks or mutual funds) often have the weakest skills and regulatory framework for enabling this.

Professional teams focusing on arbitrage, either as stand-alone arbitrage companies or as arbitrage groups inside finance companies, are a key source of efficiency. However, this requires finance companies in the country, such as banks or mutual funds or securities firms, to organise themselves and allocate capital for arbitrage. In each new derivatives market, this encounters constraints of the knowledge and decision making in these finance companies. At the extreme, there are concerns that the behaviour of professional arbitrageurs who operate in an agency capacity (as opposed to individuals engaging in arbitrage with their own money) might be ineffective in producing efficiency (Shleifer & Vishny 1997).

Regulatory and operational impediments play an important role here. Many operational impediments can be overcome at a cost. It often appears that the costs involved are small when compared with the enormous returns that can be obtained in arbitrage. However, these costs could be disproportionately important if they succeed in deterring finance companies from establishing professional arbitrage operations. The returns on arbitrage are based on a combination of (a) the capital deployed in arbitrage and (b) the rates of return available in arbitrage. If the capital deployed is “too small” in a small fledgling market, then relatively modest fixed costs can block entry into arbitrage, thus perpetuating the small size of the market.

This suggests that in a young derivatives market, it is extremely important to focus on removing regulatory and operational impediments to

arbitrage, so as to quickly get a large number of economic agents who focus upon arbitrage, and to rapidly reach high levels of efficiency.

3 Measuring violations of no-arbitrage

The market efficiency of the equity derivatives market is measured by the extent to which it is not possible to obtain riskless profits on this market. If all futures and all options are priced soundly, there should not exist any trading strategy that earns riskless, supernormal rates of return.

Market efficiency is a dynamic process. In real-world markets, mispricings will inevitably surface when news breaks, or when shocks to the order flow impact on some but not all securities which are bound by arbitrage relationships. For example, if the first speculative orders reflecting breaking news are placed on the futures market (as opposed to the spot market), then this will momentarily yield a mispricing between the spot and the futures prices. Some time later, arbitrage transactions would take place, and restore rational pricing relationships.

Hence, the important question is not one about whether mispricings *ever* exist. The null of market efficiency should not be rejected if even one isolated violation of no-arbitrage is found. The key question is whether mispricings are “rapidly” picked off by arbitrageurs, or whether mispricings persist for extended periods of time. In other words, we do not expect prices found on the derivatives market to satisfy no-arbitrage at every instant in time; the key question is whether prices found on the market are “often” wrong.

3.1 Trading strategies of interest

In this paper, we focus on a small subset of riskless trading strategies:

Cash and carry arbitrage for futures The simplest strategies consist of one-shot arbitrage on the futures market. We buy on the spot and sell on a future date, thus deploying money and getting a locked-in rate of return. Conversely, we sell securities today, and buy them back on a future date. These strategies can be interpreted as “stock repos”, since they are bundles of spot and forward transactions.

Put-call parity arbitrage Put-call parity asserts that

$$S + P - C = Xe^{-rT}$$

This leads to arbitrage strategies that involve deploying money by purchasing the left hand side of the relationship, when it is lower than Xe^{-rT} . That is, the arbitrageur would buy the spot, buy the put and sell the call. Conversely, when the left hand side of the relationship is higher, the arbitrageur would like to take the opposite position.

Early exercise of american call options American options can be exercised ahead of maturity. This opens up many interesting arbitrage strategies. Specifically, when a call option price drops below its intrinsic value, it is efficient to buy the option and immediately exercise it. This is meaningful in the last 30 minutes, when trades executed on the spot market would (on average) yield an execution price that is close to the official closing price.

All these strategies can be conducted for the individual stock derivatives, or for the index derivatives.

It should be emphasised that these three strategies are extremely simple, one-shot arbitrage strategies. They are the simplest possible conditions for market efficiency, which are necessary but not sufficient to assert that sound pricing prevails.

For example, the implied volatility at a given option strike could be wrong, but the put and call prices could be internally consistent (i.e. satisfy put-call parity). In this case, it would be possible to earn riskless supernormal profits using dynamic arbitrage strategies, but the above three strategies might not yield riskless supernormal profits. However in this situation, market efficiency would still be violated.

3.2 Notion of market efficiency at a market-wide level

In 2002, there were 30 underlyings (Nifty and 29 individual stocks) on the market. There are 1506 derivative securities based on these 30 underlyings. There is a very large number of combinations of securities that could be involved in applying these 3 arbitrage strategies. Specifically, for every option strike, for every expiration, there is a possibility of put-call parity. For every option, there is a possibility of early exercise. For every futures

product, there is a possibility of cash and carry (or reverse cash and carry) arbitrage.

In order to make statements about the market efficiency of the market as a whole, we need to measure the *highest* rates of return available, across all these combinations, and judge whether or not it is consistent with the GOI zero coupon yield curve. If the rates of return available on the market are “too high” when compared with the GOI zero coupon yield curve, then we may conclude that market efficiency is being violated.

This computation is done by the program ‘*Chanakya*’, which is produced by the software firm Infotech Financials.² *Chanakya* is a real-time decision support system. At each instant in time, *Chanakya* applies the above three arbitrage strategies to all combinations of securities that exist on the market, and computes out the best opportunities for deploying money and the best opportunities for deploying securities. It also shows the returns available (if any) from early exercise of american calls.

Chanakya displays these best opportunities for deploying funds, or securities, or early exercise of options, in real-time. Figure 5.1 shows an example of the display in *Chanakya* of returns on deploying funds or securities. Figure 5.2 shows an example of the display in *Chanakya* of returns in early exercise.³

The results of this paper were obtained by instrumenting *Chanakya* to produce a dataset of time-stamped rates of return at every instant in time.

3.3 Measurement of transactions costs

The measurement of market efficiency is fraught with questions of accurately measuring transactions costs. Ideally, it is possible for the exchange to reveal data for the limit order book at every instant in trading time. This would make it possible to accurately estimate the market impact cost of ev-

²<http://www.infofin.com>

³Software like *Chanakya* highlights the strength of the electronic limit order book market as a foundation for deploying analytically sophisticated IT systems. If NSE disseminated the limit order book in realtime, then the arbitrage as calculated by *Chanakya* would be completely accurate in the measurement of transactions costs on both spot and derivatives markets. This would eliminate all guesswork in arbitrage. This is in sharp contrast with manual markets, such as the OTC market for currency and fixed income derivatives, where trading is innately manual, and such sophisticated IT systems cannot be constructed.

Figure 5.1 Example: Returns on deploying securities or funds

This figure shows an example of a screen from *Chanakya*, where (at one instant in time), the best opportunities for deploying funds and the best opportunities for deploying securities are displayed.

We see that the best return on deploying funds is a cash and carry arbitrage for L&T stock futures (October expiration), where a return of 3.33% annualised is available. The second-best return available is on the L&T stock futures (September expiration), where 2.25% annualised is available. Turning to securities, the best return available is reverse cash and carry on BPCL August expiration futures, where 48.31% annualised is available, and the second best return is by exploiting put-call parity on the $X = 300$ August options on BPCL, where 43.48% is available.

The screenshot shows the Chanakya (1.1-Beta) DEMO software interface. It features a menu bar with 'The Market', 'Analytics', 'Settings', 'Help', and 'Exit'. Below the menu bar, there are two main sections: 'Deploying Money' and 'Deploying Securities', each containing a table of contracts and their corresponding returns.

Deploying Money	
Contract	Returns
FUTSTK L&T OCT	3.33
FUTSTK L&T SEP	2.25
FUTIDX NIFTY OCT	1.78
FUTSTK VSNL SEP	1.14
FUTSTK TISCO SEP	0.83
FUTSTK SATYAMCOMP SEP	0.24
FUTIDX NIFTY SEP	0.16
FUTSTK TELCO SEP	0.14

Deploying Securities	
Contract	Returns
FUTSTK BPCL AUG	48.31
OPTSTK BPCL AUG 300	43.48
OPTSTK BPCL AUG 280	33.00
FUTSTK BPCL SEP	22.81
FUTSTK HINDLEVER AUG	14.86
OPTSTK HINDLEVER AUG 100	13.83
OPTSTK HINDLEVER AUG 190	11.05
FUTSTK ITC AUG	9.38
FUTSTK RELIANCE SEP	6.96
FUTIDX NIFTY OCT	4.27

Figure 5.2 Example: Returns on early exercise of american options

This figure shows an example of a screen from *Chanakya*, where (at one instant in time), the best opportunities for early exercise of american options are shown.

We see that there is a profit of Rs.5979.55 available by purchasing a $X = 190$ put on Hindustan Lever, which expires on 29 August 2002, and immediately exercising it.

Contract	Profit
OPTSTK HINDLEVER 100 PUT 29 AUG 2002	5979.55
OPTSTK MTNL 120 CALL 29 AUG 2002	6000.88
OPTSTK INFOSYSTCH 3000 PUT 29 AUG 2002	288.76

ery transaction involved in a given trading strategy. NSE does not reveal this information.⁴

Hence, our computation of returns on arbitrage was based on certain simplifying assumptions, as follows:

- Derivatives purchases are assumed to take place at the ask, and sales are assumed to take place at the bid.

NSE terminals observe the MBP but Indian Quotation Systems does not.⁵ Hence, it was not possible to make calculations for transactions larger than one contract, which is typically around Rs.200,000.

- Spot market transactions are assumed to suffer an impact cost which is the average of the impact cost seen in the previous *month* (using the NSE Release A CDs).⁶ The execution price is estimated by applying this imputed impact cost upon a benchmark price which is $(\text{bid} + \text{ask})/2$ as observed in real-time.

⁴NSE has impediments against capturing information that is being transmitted to offices of NSE brokerage firms. Hence, the data used in simulations with *Chanakya* in this paper was sourced from Indian Quotation Systems.

⁵The “market by price” (MBP) display shows the quantities available on both buy and sell sides, for the five best prices on the market. The MBP is sent by NSE to the trading software at broking firms. However, there are constraints in connecting it up to analytical software. This can be thought of as a restricted version of real-time dissemination of the limit order book.

⁶The data available with Indian Quotation Systems shows the bid and the offer price on the spot market for every security. However, the typical transaction for one contract of the derivatives involves a number of shares which is larger than that available at the bid or the ask. Hence, it is not meaningful to use bid and offer prices from the spot market in estimating the impact cost that is suffered on the spot market. NSE does not disseminate databases which can be used for more accurate computations.

- Brokerage fees are assumed to be 0.25% on the spot market and 0.1% on the derivatives market. In addition, it is assumed that the depository participant imposes a tariff of 0.02%, subject to a minimum of Rs.20, when spot market settlement takes place.
- It is assumed that short positions on options, and all futures positions, incur an initial margin of 20%. This is in keeping with the existing risk containment system, which penalises riskless positions that span across the equity spot and derivatives markets.

These assumptions constitute a realistic portrayal of the actual transactions costs faced in arbitrage in 2002. It is important to note that the last traded price (LTP), which is a source of many errors in the measurement of rates of return in arbitrage, is never used in these calculations. The rates of return computed for arbitrage strategies, after taking into account all these costs, hence are likely to constitute accurate measures of the rates of return accessible to arbitrageurs in the real world.

As an example of these procedures at work, Figure 5.3 shows the experience of rates of return available in deploying funds, on one day (20 September 2002), and Figure 5.4 shows the experience of rates of return available in deploying securities, on this same date. Both graphs attempt to show rates of return on five distinct arbitrage opportunities, as long as these rates of return are positive.

4 Enumerating potential constraints

It is useful to first attempt a comprehensive enumeration of the hurdles which might *potentially* exist. At this point, we do not seek to ascribe factors at work; all that is attempted is to emerge with a comprehensive list of constraints which could possibly be at work on the Indian equity market.

Regulatory constraints

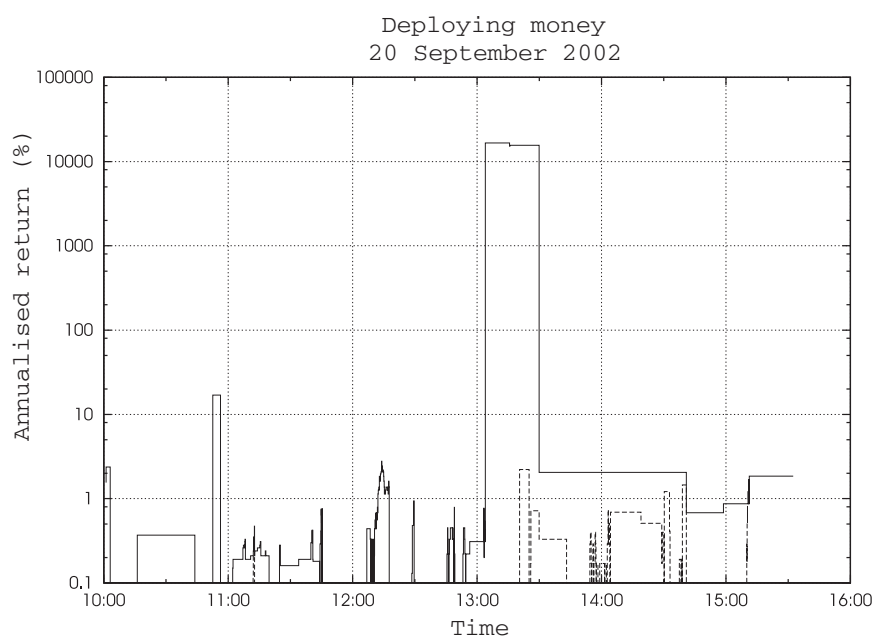
1. Limitations upon mutual funds caused by SEBI regulations of mutual funds.
2. Regulatory restrictions upon proprietary trading by brokerage firms.
3. Regulations that make it difficult for brokers to do arbitrage transactions on behalf of investors.

Figure 5.3 An example: Returns on deploying money for one day

This figure shows the results of measuring the highest rates of return available in deploying money on one day. The best five arbitrage opportunities which yield returns above 0.1% annualised are displayed, subject to a limit of five opportunities.

We see that shortly before 11 AM, an opportunity offering roughly 20% annualised came up, and was quickly taken away. Shortly after 1 PM, an opportunity offering around 11000% came up. It was slightly reduced shortly after, but it only went away at around 1:30 PM.

It should be emphasised that the specific identity of the best-available arbitrage fluctuates from instant to instant. For our purposes, we only care about the highest available rate of return, in order to judge whether riskless supernormal rates of return are available on this market or not.



4. RBI regulations which hinder arbitrage by banks.
5. RBI regulations which hinder loans by banks to arbitrageurs.
6. Concerns that regulators might (ex-post) frown upon arbitrage in some future crisis situation
7. Difficulties in obtaining approvals at the board level.
8. Difficulties in obtaining approvals from trustees.
9. Difficulties in obtaining approval of top management.
10. Exchange rules which require paper-based order placement and paper-based contract notes, which are inconsistent with index arbitrage.

Implementation hurdles

1. Borrowing shares at a plausible price is infeasible.
2. Exchange regulations inhibit program trading.
3. Margining principles over-margin arbitrage positions even though they are really riskless.
4. Deficiencies of the trading system on the spot market, which imply that index program trades take a long time.
5. Hurdles placed by the exchange against building software which interfaces to the exchange.
6. Staleness of MBP information, so that the actual impact cost proves to be different from that perceived before the trade took place.
7. Misleading index information produced owing to index calculation using LTP.
8. Difficulties in implementing trades the government bond market.
9. Magnitude of charges to the depository.

Internal difficulties

1. Inadequacies of human capital.
2. Unprepared back office.
3. Contractual terms with brokers and custodian firms penalise the large number of small value transactions.

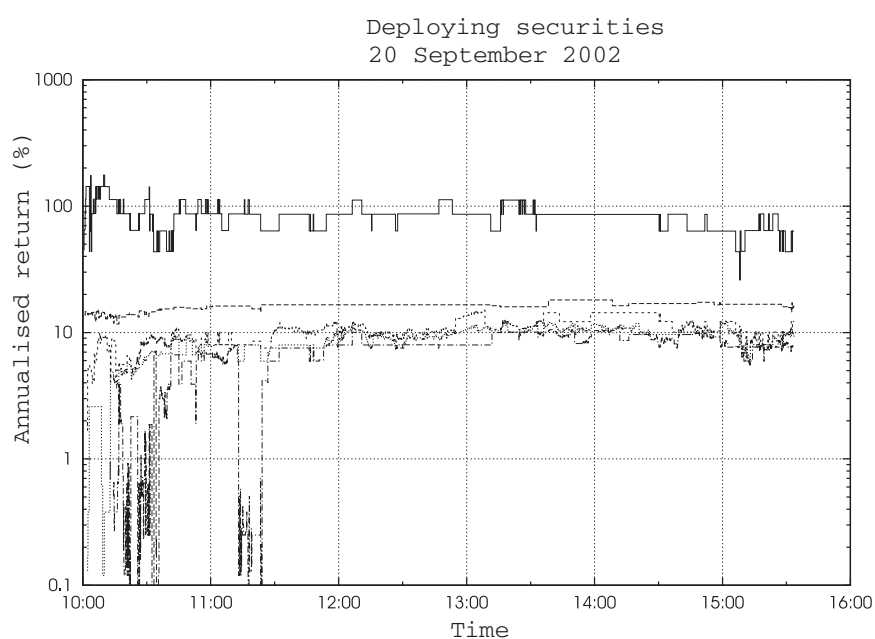
4. Charges for brokerage and custodian services make arbitrage by institutions uncompetitive, when compared with the cost structure faced by retail investors.
5. Lack of real-time feeds and analytics required to participate in arbitrage.

Figure 5.4 An example: Returns on deploying securities for one day

This figure shows the results of measuring the highest rates of return available in deploying securities on one day. The best five arbitrage opportunities which yield returns above 0.1% annualised are displayed, subject to a limit of five opportunities.

We see very high rates of return prevailing through almost all the day, with the best opportunity hovering between 90% to 200% annualised.

It should be emphasised that the specific identity of the best-available arbitrage fluctuates from instant to instant. For our purposes, we only care about the highest available rate of return, in order to judge whether riskless supernormal rates of return are available on this market or not.



On the issue of hurdles faced by professional arbitrage firms, it may be pointed out that this paper is the first time that systematic calculations about the rates of return available in equity derivatives arbitrage in India

have become available. The data and feed constraints faced in doing these elementary calculations are fairly onerous impediments – they were overcome in this paper by putting together *Chanakya* from Infotech Financials with imperfect intra-day NSE derivatives data from Indian Quotation Systems, coupled with imperfect NSE spot market impact cost data for the previous month from the NSE Release A CDs.

When an investor contemplates entering into arbitrage on the equity derivatives market, the first step would be to undertake back-testing of the rates of return available under various strategies. NSE does not presently release databases into the public domain that are required to support such analysis.

5 Results of a survey

Casual empiricism, based on observing the *Chanakya* screens for many days, suggested that large rates of return were available on equity derivatives arbitrage in early 2002.

In order to assess the relative significance of these alternative explanations for the poor market efficiency of the equity derivatives market, a small survey was conducted where the above explanations were given to respected practitioners and experts. Each was asked to grade the importance of each candidate explanation on a scale from 1 (unimportant) to 10 (extremely important).

The survey was based on individuals and entities who were already actively participating in the equity derivatives market, as of March 2002. To some extent, this generates a certain bias, since the better prepared firms are likely to have embarked upon transactions. In this sense, these responses understate the hurdles faced by economic agents who were not already trading on the market as of March 2002. Further, by polling the more knowledgeable individuals, these survey results understate the problems of lack of knowledge in the financial industry.

Table 5.1 shows survey responses on the subject of regulatory constraints. The survey seems to focus upon explanations 1, 4, 5, 6, 8 and 10 as being relevant.

Table 5.2 shows survey responses on the subject of implementation constraints. All the issues mentioned in the survey seem to be important ones.

Table 5.1 Regulatory constraints

Explanation	Mean response
1. Limitations upon mutual funds caused by SEBI regulations of mutual funds.	7.23
2. Regulatory restrictions upon proprietary trading by brokerage firms.	1.86
3. Regulations that make it difficult for brokers to do arbitrage transactions on behalf of investors.	5.00
4. RBI regulations which hinder arbitrage by banks.	8.77
5. RBI regulations which hinder loans by banks to arbitrageurs.	7.92
6. Concerns that regulators might (ex-post) frown upon arbitrage in some future crisis situation	5.07
7. Difficulties in obtaining approvals at the board level.	4.08
8. Difficulties in obtaining approvals from trustees.	5.23
9. Difficulties in obtaining approval of top management.	4.08
10. Exchange rules which require paper-based order placement and paper-based contract notes, which are inconsistent with index arbitrage.	6.08

Table 5.2 Implementation constraints

Explanation	Mean response
11. Borrowing shares at a plausible price is infeasible.	7.62
12. Exchange regulations inhibit program trading.	6.08
13. Margining principles over-margin arbitrage positions even though they are really riskless.	7.62
14. Deficiencies of the trading system on the spot market, which imply that index program trades take a long time.	5.61
15. Hurdles placed by the exchange against building software which interfaces to the exchange.	5.98
16. Staleness of MBP information, so that the actual impact cost proves to be different from that perceived before the trade took place.	6.69
17. Misleading index information produced owing to index calculation using LTP.	5.15
18. Difficulties in implementing trades on the government bond market.	6.92
19. Magnitude of charges to the depository.	6.38

There is substantial controversy about the difficulties in borrowing shares, and their impact upon market efficiency. A professional arbitrageur, who holds very little capital, would definitely benefit from access to borrowed shares. This is, currently, a constraint in India.

At the same time, it is hard to understand how a mutual fund can own shares of BPCL, and continue to earn a negative cost of carry (i.e. depository charges), but not utilise these shares in the arbitrage shown in Figure 5.1, where a return of 48.31% annualised was available. Such inaction can be interpreted as being inconsistent with the fiduciary obligations of mutual funds. Similarly, when BPCL was trading at a low price on the futures market, if any mutual fund was buying shares of BPCL on the spot market at the same time, this was inconsistent with the goal of obtaining good returns.

This suggests that as long as institutional investors learn about derivatives and modify their operational procedures to reflect the existence of the derivatives market, supernormal returns on reverse cash and carry strategies can be eliminated. A fluent ability to borrow shares is a sufficient but not necessary condition for obtaining efficiency in this respect.

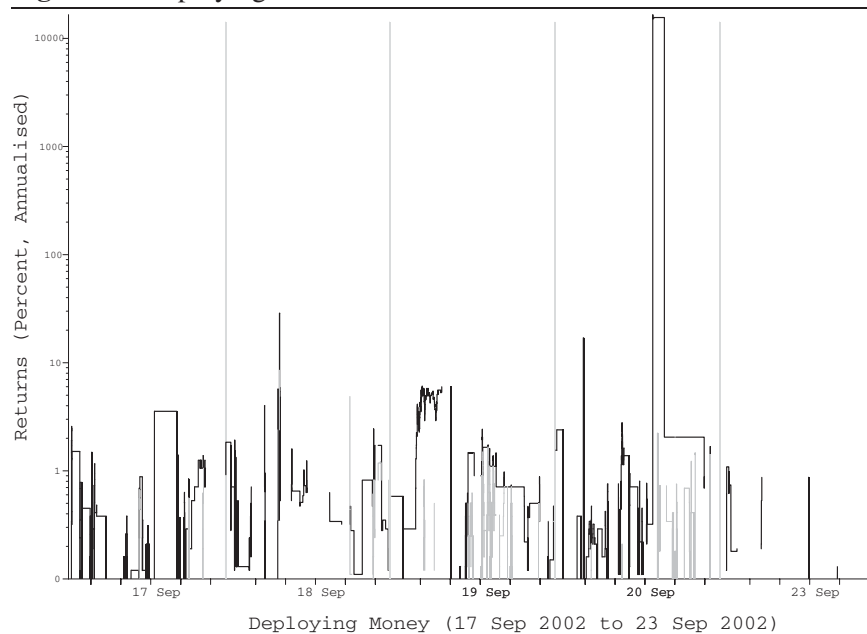
Table 5.3 shows survey responses on internal constraints. Explanations 21 and 24 seem to be the important ones.

Table 5.3 Internal constraints

Explanation	Mean response
20. Inadequacies of human capital.	5.00
21. Unprepared back office.	5.23
22. Contractual terms with brokers and custodian firms penalise the large number of small value transactions.	4.69
23. Charges for brokerage and custodian services make arbitrage by institutions uncompetitive, when compared with the cost structure faced by retail investors.	3.84
24. Lack of real-time feeds and analytics required to participate in arbitrage.	5.23

6 Empirical results measuring returns in arbitrage

Figures 5.5, 5.6 and 5.7 show results with the two best arbitrage opportunities available, through these three channels, over one trading week.

Figure 5.5 Deploying funds - 17/9/2002 to 23/9/2002

In Figure 5.5, we see a striking episode on 20 September, where returns of around 10,000% annualised became available. It took a full 30 minutes for some trader in the country to exploit this opportunity. This suggests poor levels of market efficiency.

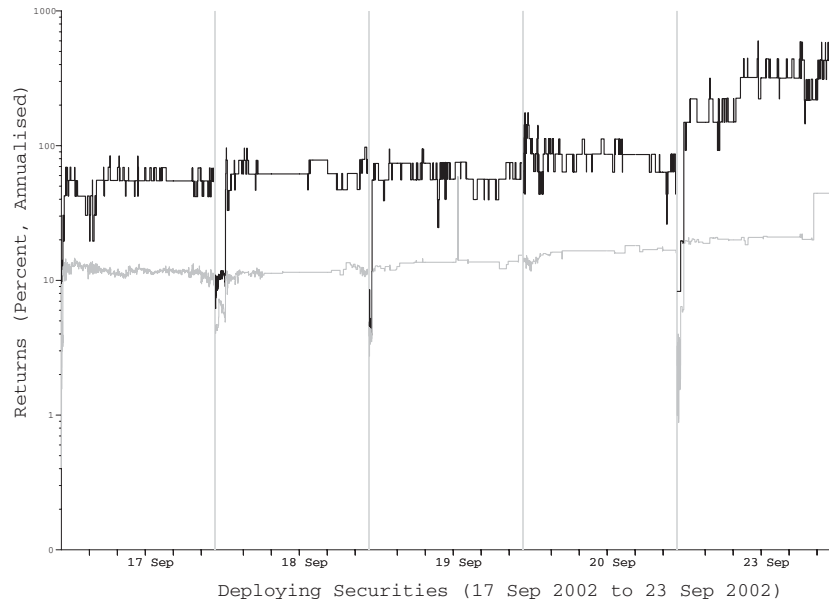
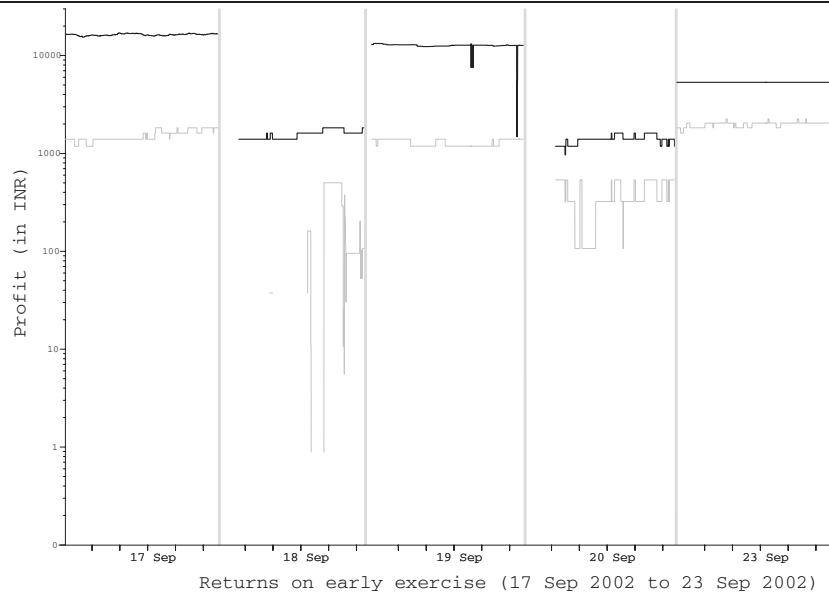
Broadly speaking, the rates of return available in utilising money seem to be low, when compared with the rates of return available in utilising securities (Figure 5.6). It appears that returns of 60% to 125% annualised were available on reverse cash and carry arbitrage (and similar strategies).

Figure 5.7 shows substantial violations of rational option pricing.

These three figures suggest that as of late September 2002, the equity derivatives market had remarkably poor levels of market efficiency.

7 Developments in 2002

Through 2002, the equity derivatives market grew enormously, and steadily attracted a larger number of participants. In addition, many elements of the constraints faced by arbitrageurs were addressed.

Figure 5.6 Deploying securities - 17/9/2002 to 23/9/2002**Figure 5.7** Early exercise - 17/9/2002 to 23/9/2002

In 2002, SEBI's *Advisory Committee on Derivatives*, chaired by Jayanth Varma, addressed many regulatory problems faced by mutual funds. Specifically, SEBI paved the way for arbitrage transactions by mutual funds. SEBI also emphasised that it was the fiduciary obligation of mutual funds to buy at the lowest price and sell at the highest price. This may have encouraged mutual funds to compare prices between spot and derivatives markets when implementing transactions.

In 2002, SEBI paved the way for foreign institutional investors (FIIs) to commence participation in the derivatives market. Significant transactions by FIIs appear to have commenced from October 2002 onwards. It appears that some FIIs have focused on arbitrage strategies.

Explanation 13 (lack of cross-margining) was also addressed by the SEBI *Advisory Committee on Derivatives*. However, in terms of implementation, cross-margining has not yet been implemented.

Explanation 19 was addressed by a shift to per-transaction tariffs at the depository, and a drop in the per-transaction tariff.

In terms of securities infrastructure, in January 2002, NSE greatly improved their software support for program trading, so that Nifty program trades could be done in under five seconds (as compared with 200 seconds which used to be taken previously). This addresses Explanation 14. In January 2003, NSE began the process of removing impediments that prevented members from *reading* realtime feeds. This partially addresses Explanation 15. However, as of May 2003, the NSE broadcast has many blemishes and is not yet ready for serious use. Many hurdles continue to impede the creation of end-to-end integrated IT systems, which would put orders back into NSE remain.

8 Conclusion

At an abstract level, policy concerns on securities markets from 1992 till 2001 were focused on basic issues in market design. As a consequence of that focus, the equity market now has sound foundations of market design: with electronic trading, novation at the clearing corporation, dematerialised settlement, rolling settlement, sound governance principles in the largest exchange, and equity derivatives.

Hence, it may now be appropriate to shift the focus of financial sector policy away from these basics, to the fundamental function of the financial sector, which is about sound information processing and the quest for market efficiency. The violations of no-arbitrage on the equity market could serve as a valuable litmus test about the policy and securities infrastructure constraints holding back market efficiency, the quality of human capital, and the IT systems that are in place in the financial sector.

Market efficiency on the equity derivatives market appears to be improving, but there are substantial violations of no-arbitrage. The important constraints affecting this seem to be:

Policy constraints

- RBI regulations which hinder arbitrage by banks.
- RBI regulations which hinder loans by banks to arbitrageurs.
- Concerns that regulators might (ex-post) frown upon arbitrage in some future crisis situation.
- The lack of a stock lending mechanism.

Securities infrastructure

- Exchange rules which require paper-based order placement and paper-based contract notes, which are inconsistent with index arbitrage.
- Exchange regulations which inhibit program trading.
- Hurdles placed by the exchange against building software which interfaces to the exchange.
- Low quality MBP, and lack of limit order book in realtime.
- Misleading index information produced owing to index calculation using LTP.

This may help suggest directions for policy makers and exchanges in moving towards a more efficient equity derivatives market.

Transparency has always been a major issue in evaluating the functioning of an exchange. So far, the issues faced in transparency on the equity spot market were of a certain simple nature. The integrated equity spot and derivatives market makes new demands in terms of transparency. This new environment makes demands on the exchange in terms of revealing

the limit order book in realtime, revealing documents required for building sophisticated IT systems, and releasing high quality intra-day historical databases for research. Arbitrage will also place new demands upon the technological capacity of NSE in coping with the peak load of program trades, and in improving index computations.

SEBI has made substantial progress on improving upon the earlier policy regime, with the new report of the *Advisory Committee on Derivatives*. The full implementation of this report, which has yet to take place, would overcome constraints like cross-margining. A comparable policy effort at RBI would assist greater participation by banks, which would benefit both banks and the derivatives market.

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Commodity Derivatives

