Index Fund Implementation in India

Ph.D. Thesis

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Statement

I hereby state that this thesis for the Ph.D. degree on ``Index Fund implementation in India'' is my original work and that it has not previously formed the basis for the award of any degree, diploma, associateship and fellowship or any other similar title to the best of my knowledge and information.

Kshama Fernandes

Certificate

As required under the Goa University ordinance, we certify that the thesis entitled ``Index Fund implementation in India'' submitted by Kshama Fernandes for the award of degree of doctoral philosophy in Management is a record of research done by the candidate during the period of the study under our guidance, and that it has not previously formed the basis for the award of any degree, diploma, associateship and fellowship or any other similar title to the best of our knowledge and information.

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Abstract

Approaches to portfolio management can be divided into two broad categories - active and passive. While active strategies have always been popular with investors, in recent years passive investment strategies have gained attention, especially among mutual fund managers and pension funds. A fund following a passive strategy attempts to reproduce as closely as possible the performance of a theoretical index representing the market, and hence is called an index fund.

Index tracking strategy is a fairly well established strategy in the developed markets. It scores on account of the cost advantage it provides by way of reduced expense ratios and transactions costs. Monitoring the performance of an index fund boils down to simply observing its tracking error. Tracking error summarises the extent to which the index fund is able to accurately track the underlying index.

The first chapter of this thesis is a literature survey of index funds in the world, with no particular emphasis on the Indian market. It discusses the relevance and benefits of indexing as an equity investment strategy as a whole.

While the index fund industry in India is relatively young, the index fund market has been growing steadily since the launch of the first index fund in 1999. In the second chapter, we seek to measure and understand the tracking error of index funds in India to find out if indexing as a strategy can be implemented under Indian conditions. The consistency and level of tracking errors obtained by some well–run index funds suggests that it is possible to attain low levels of tracking error under Indian conditions. At the same time, there do seem to be periods where certain index funds appear to depart from the discipline of indexation.

In an index fund world, every basis point of tracking error counts. While indexing may seem a simple strategy to adopt, replicating index performance may not be as easy as

it seems. The third chapter of the thesis seeks answers on how to improve index fund implementation in India. The central theme is to understand the use of the index futures market for index fund implementation. We study *two* causes of tracking error, namely buffer cash held and dividend delays. Our findings show that the tracking error caused by these two factors can be significantly reduced by the use of index futures. This could help index funds in India to attain low tracking errors in line with those obtained by the best run funds across the world.

Chapter four ties together the findings of the two empirical studies and concludes the thesis.

Chapter 1

Index funds – a literature survey

1.1 The idea of index funds

In the decade of the 1960s and 1970s, many studies indicated that actively managed funds – which seek to obtain excess returns by actively forecasting returns on individual stocks – do not actually obtain statistically significant excess returns. This was consistent with the hypothesis of 'market efficiency', which suggested that obtaining excess returns should be difficult in a competitive market.

This research suggested a superior investment strategy: the index fund. This would be a portfolio which passively replicated the returns of the index. The most useful kind of market index is one where the weight attached to a stock is proportional to its market capitalisation. Index funds are easy to construct for this kind of index, since the index fund does not need to trade in response to price fluctuations. Trading is only required in response to issuance of shares, mergers, etc.

Indexing is a fairly well established strategy in the developed markets. It scores on account of the cost advantage it provides by way of reduced expense ratios and transactions costs. The burgeoning growth in index funds and index related investments seems to indicate that indexing works as a *long-term strategy*. Literature based on US markets widely confirms the inability of active mutual funds to outperform passive benchmarks such as the S&P 500 or the Wilshire 5000. Table 1.1 gives percentage of stock mutual funds that failed to match the broad Wilshire 5000 stock index, an index made up of essentially all the stocks in the S&P 500 and a large number of smaller firms (Malkiel 1999).

Year	Percent of mutual funds
1972	82
1973	71
1974	38
1975	77
1976	64
1977	42
1978	47
1979	44
1980	57
1981	42
1982	28
1983	65
1984	68
1985	78
1986	62
1987	58
1988	67
1989	73
1990	43
1991	57
1992	55
1993	46
1994	63
1995	78
1996	62
1997	79
1998	71

Source: Malkiel (1999)

Table 1.1: Percent of stock mutual funds that failed to match the Wilshire 5000 stock index

The first index fund dates back to 1972. According to a survey of index-based managers conducted by *Pensions and Investments* (February 23, 1998), indexed assets totalled over $1 trillion by the end of 1997. A 1998 report commissioned by Barclays Global Investors concluded that indexing had saved institutional investors worldwide as much as $105 billion since inception of the first index fund in 1973. By end of 2000, indexed assets totalled over $1.5 trillion. Today Index funds are arguably one of the most successful ideas that have flowed from academic economics into the real world.

In an ideal world, where trading is frictionless and dividends are obtained by shareholders on the exact ex-dividend date, the index fund would exactly replicate the returns on the index (inclusive of dividends). A variety of events necessitate trading by the index fund: issuance of shares by a company (which raises the weight of the company in the index), addition or deletion of companies from the index, reinvestment of dividends, etc. In the real world, trading imposes transactions costs upon the index fund, and dividends are not obtained exactly on the ex–date.

When a security trades at an "ideal" price of $\bar{p}$, purchasers end up paying a slightly higher price p_b. The percentage degradation faced here, $100(\frac{p_b}{\bar{p}} - 1)$, is called "market impact cost".

Index maintainers make their calculations assuming that all trading is done at zero market impact cost; index funds always suffer impact cost and thus generate inferior returns. Suppose we have a time–series of returns on an index (inclusive of dividends) of r_t, and the index fund experiences a time–series of returns of r'_t. Then the annualised standard deviation of $r_t - r'_t$ is termed "tracking error".

Tracking error summarises the extent to which the index fund is able to accurately track the index. Index fund managers seek to minimise tracking error. From the viewpoint of an investor, an index fund which experiences a large tracking error is a source of risk since it might not replicate the returns on the index in the future.

1.2 The rationale for index funds

Traditional fund management has been based on the premise that the fund manager adds value through his continuous efforts at improving risk–adjusted returns by forecasting returns. Index funds are counter–intuitive in that they make no such effort. The index fund manager makes no attempt at returns forecasting; his only goal is to replicate index returns. Why might index funds be more attractive? The arguments can be summarised under two basic issues:

- *Market efficiency* If markets are fairly efficient, then it would prove difficult for active managers to obtain excess returns, after considering the higher fees and costs that they have to run up.

- *Agency problems* The principal–agent problem between investors and money managers presents special difficulties owing to the unobservability of the fund managers ability and effort.

	(Percent of assets)			
	Large-Cap stocks		M/S-Cap stocks	
	Active	Index	Active	Index
Expense ratio	1.16	0.20	1.43	0.25
Total transaction costs	0.57	0.02	1.47	0.15

Source: Table 3-7 from Good & Hermansen (1998).

Table 1.2: Costs and expenses of equity mutual funds in the US(1996)

The relative ease with which the principal can monitor the fund management activities of the agent, in the context of index funds, is one factor which underlies the growth of index funds.

1.2.1 Does active management yield excess returns?

Active management is an attempt to obtain excess returns. In doing this, active managers have to expend resources on the enterprise of fund management, and have to incur transactions costs in trading.

Index funds feature lower expenses by avoiding the expenditures into information collection and information processing that is required in returns forecasting. Table 1.2 shows some US evidence about the expenses of index funds as compared with actively managed funds, where index funds hold an advantage of around one percent per year through lower expenses.

As a broad regularity, index funds tend to engage in smaller trading volumes as compared with actively managed funds, which also helps enhance returns through lower costs of transacting. Table 1.2 shows some US evidence about the transactions costs incurred by index funds as compared with actively managed funds, where index funds hold an advantage of between 0.55 to 1.32 percentage points per year through lower transactions costs.

We may note here that the large-cap stocks on the US stock market are amongst the largest companies in the world. The situation in many developing countries may be closer to the evidence shown for the medium-cap and small-cap universes of the US stocks market.

In the fund industry, index funds are a highly contestable area owing to product

Product	Average returns, 1976–97
Returns on S&P 500	15.2%
Returns on S&P 500 index fund	14.8%
Return on General Equity Funds	14.1%
Source: Figure 5 in Bogle (1998).	

Table 1.3: A performance comparison: Evidence from the US over 1976–97

Category of funds	Benchmark index	Period	Fraction of funds which underperformed
General equity	Wilshire 5000	1986–95	65%
International equity	MSCI-EAFE	1986–95	73%
Emerging market	MSCI-Emerging Markets	1993–95	88%
Bond	Lehman Brothers Bond	1986–95	77%
Source: Lipper Analytical Services			

Table 1.4: Mutual funds which were outperformed by their respective indexes

standardisation. If an active manager (e.g. Warren Buffet) is highly successful, and supports high fees, it is not clear how a competitor can offer a comparable competing product. In contrast, if one index fund on a given index commands high fees, it is easy for entrants to offer sharply comparable products and hence lead to a reduction in fees.

Low fees and expenses are not an end in themselves. The higher fees and expenses of actively managed funds might be justified if markets were inefficient enough so that excess returns were obtained, in excess of these fees and expenses. For example, the justification often cited for paying higher management fees and transactions costs in small-cap, illiquid asset classes is that the prospective returns are seen as being higher. Hence, the most important issue in evaluating index funds is the ultimate returns delivered to the investor, net of fees and expenses.

The historical experience with index funds as opposed to active managers is summarised in Table 1.3 and Table 1.4. Table 1.3 shows that the index fund in the US lagged behind index returns by 40 basis points; however actively managed funds lagged behind index returns by a larger margin of 110 basis points. In Table 1.4, we see that in four major asset classes, the majority of actively managed funds proved to lag behind their benchmark indexes. This includes two categories outside the US: the classes of "international equity" and "emerging markets" investments.[1]

1.2.2 Agency problems

We can obtain important insights into the appeal of index funds by focusing on the principal-agent relationship between the investor and the fund manager. How is the investor to choose among competing fund managers? How is the agent to monitor the fund manager, and ensure that the actions of the fund manager are in his best interest?

Fund management is a complex process, in which agency problems could surface at many levels. There are many decisions where the fund manager could choose to act in ways which are not in the best interest of the investor (Shah 1999*b*). Some examples are offered here:

- The fund manager could choose to buy stocks in which he has a personal interest. Sometimes, fund managers allow the assets of the fund to be used in manipulative efforts, for which they may receive private benefits.
- The fund manager could "front-run" against the fund; buying stocks on his personal account immediately before doing so on behalf of the fund.
- The fund manager could choose trading mechanisms which yield superior private rents instead of choosing the trading mechanism which yields the lowest transactions costs.
- The fund manager has choices about custodial and administrative services which might not be made in a cost-minimising fashion.

It is difficult for an investor, or for a trustee, to closely monitor the fund manager and ensure that these decisions are being made in his best interest. Hence, the prominent device through which control can be exercised is by monitoring performance. The investor would select fund managers who have exhibited the highest returns in the past, and fire fund managers who fail to perform.

A naive comparison of returns across alternative funds is an inefficient way to measure fund manager ability when there are differences in the levels of risk adopted by different funds. The inherent randomness of market returns suggests that a casual comparison of returns should give way to a formal statistical test in comparing fund managers. This leads us to the enterprise of scientific performance evaluation efforts.

[1]The concept of an "emerging market index" appears to have many difficulties as of yet (Masters 1998). In this article, we restrict our attention index funds in one country.

1.3 Index funds as an investment strategy: empirical evidence

Index funds are arguably one of the most successful ideas that have flowed from academic economics into the real world. Index fund performance, net of index fund charges could be a more optimal investment strategy than active management. Overwhelming majority of performance evaluation studies over the last couple of decades have confirmed the inability of active mutual funds to outperform market indexes ((Treynor & Mazuy 1966), (Jensen 1968), (Elton et al. 1996), (Malkiel 1995), (Gruber 1996)). Clearly, if active management incurs significantly higher transaction costs in executing a strategy, then the higher expense ratios charged by these funds will translate into lower after–expenses returns to investors (Keim & Madhavan 1998). Besides, the higher turnover exhibited by active funds has a potentially greater effect on future capital gains tax liabilities, which further diminish after–expense and after–tax performance.

"The Losers Game", by Charles Ellis, one of the earliest academic articles that discussed the futility of active management was written in 1975 (Ellis 1975). Ellis noted that at that time, institutional traders had gone from placing 30% of trades to placing 70% of trades. His theory can be demonstrated by the following example. Take the case of a manager who wants to beat the market by 20%. What should be his gross return at a turnover of 30%, long term return on stocks of 9%, average commission cost of 3% of the principal and management & custody fees of 20 basis points? We can arrive at his required gross return by using the following formula and solving for X:

$$(X \times 0.09) - (0.30 \times (0.03 + 0.03)) - (0.002) = (1.20 \times 0.09)$$

It turns out that he must earn a gross return of 42% to beat the market by 20%. In markets which are reasonably efficient, reshuffling portfolios to achieve superior performance would prove to be useless. In fact, such portfolio turnover would adversely affect performance because of transactions costs and taxes. Indexing on the other hand scores on various fronts. We shall discuss each of these in light of the empirical evidence available.

1.3.1 Asset allocation

"Asset allocation" is the manner in which an investor allocates investable money among asset classes in his portfolio. These asset classes can include stocks, bonds and/or cash. Asset allocation is recognised as an important determinant of variance in investment performance.

A number of studies have sought to understand specific factors that contribute to overall fund performance. Fama (1972)'s approach based on the Capital Asset Pricing Model splits the overall return into risk-free rate, systematic risk premium, premium for unsystematic risk and returns due to superior fund management capabilities. Multifactor models have included more explanatory parameters, some of which are economy specific while others are firm-specific (Ross 1976). Henriksson & Merton (1981) established that perfect market timing ability was equivalent to owning a call option that pays at expiration the return to the best performing asset class. Grinblatt & Titman (1984) generated insights about the applicability of commonly used measures of portfolio performance by decomposing the measured abnormal returns into three components: selectivity, timing and the mismeasurement of the average beta of the portfolio.

A study of the performance of 91 large pension plans over a ten year period by Brinson et al. (1986) sought to find an answer to the question "Why did some pension plans perform better and some worse?" The study found that the three factors that accounted for the variation in investment returns among the pension plans were stock picking, market timing and asset allocation. The study concluded that asset allocation is the overwhelmingly most important determinant of variance of investment returns. An update of the same study in 1991 reaffirmed the conclusions. As shown in Table 1.5, asset allocation accounted for 93.6 percent of the variance, whereas stock picking and market timing only for 4.2 percent and 1.7 percent of the variance respectively. Two major implications of this study were:

- Stock picking and market timing are essentially irrelevant to a portfolio's investment performance.
- Once an investor has implemented the asset allocation policy, the long term risk and return characteristics are largely determined.

Given the importance of the asset allocation policy in determining the variance of portfolio returns, index funds provide a reliable way to implement these policies. The reliability comes from the fact that an index fund invests solely in the investments that comprise a

Factors	Percent of variance in portfolio performance accounted for
Asset allocation policy	93.6
Stock picking	4.2
Market timing	1.7
Other	0.5
Source: Brinson et al. (1986)	

Table 1.5: Factors that determine variance in investment returns

particular asset class. This enables it to efficiently capture the investment performance of that entire asset class. For instance, assume that one of the goals of an investor's asset allocation policy is to obtain the performance of the large company stocks in the S&P 500. By simply buying into an S&P 500 index fund, he is assured of capturing the long term performance of the asset class of large company stocks. In their quest for market–beating performance, actively managed mutual funds often experience "asset class drift" . This makes them an unreliable option for implementing asset allocation policies.

1.3.2 Risk control

Active managers encouraged to manage only return and tracking error are motivated toward higher total risk rather than lower total risk (Wilcox 2000). Investing in an index fund however, is about owning securities that meet specific objective criteria. Index funds limit risk by way of superior diversification and restrictions on incremental risk taking.

A diversified portfolio of index funds reduces risk at two levels. First, proper diversification of risk within each asset class is ensured when an index fund manager holds all the investments or a representative sample of those that comprise the asset class invested in by the fund. Second, proper diversification among all the portfolio's asset classes can be ensured by including index funds that suitably offset each others performance under different market conditions.

A well–managed index fund provides a high degree of protection against incremental risk taking because its composition is publicly known and predictable. If an index manager strays away from securities that represent the relevant index, the resulting discrepancy immediately stands out. On the other hand, the manager of an actively managed mutual does not encounter such tight restrictions. As a consequence these managers

Fund	Turnover(%)
Vanguard Index 500	4
American:Investment Co. of America	21
American:Washington Mutual	23
American:Income Fund of America	26
Vanguard Windsor	32
Fidelity Growth & Income	67
Fidelity Puritan	76
20th Century Ultra	87
Fidelity Magellan	155
Fidelity Contrafund	223
Source: Evans (1999)	

Table 1.6: Turnover rate of ten large mutual funds ranked by size(1996)

often take substantial departures from previous practice and in the process revise the risk characteristics of their funds. It is not uncommon to find a large–capitalisation equity fund manager shift to buying more volatile small–capitalisation issues. Often fund managers move from a broadly diversified portfolio to concentrate heavily on one or two favoured sectors/industries. Conversely, unusual buildup of cash and bonds in an equity portfolio to protect against a fall in stock prices can result in lost opportunities if the market begins a strong uptrend. Shareholders often fail to recognise the evolving risk until it is too late.

1.3.3 Turnover

An index fund holds on to its securities year after year, and trades only in response to changes in the index. Most active mutual funds however turn their portfolio every one or two years. Add to this the management fees and it becomes even more difficult to overperform a buy-and-hold strategy. At present turnover levels for mutual funds, transactions costs may be expected to subtract between 0.5 to 1.0 percent annually from gross portfolio returns. Gruber (1996) finds that the average mutual fund underperforms passive market indexes by about 65 basis points per year from 1985 to 1994. Carhart (1997) finds that net returns are negatively correlated with expense levels, which are generally much higher for actively managed funds. Table 1.6 gives the turnover rates for ten large US mutual funds, ranked by their size in 1996. If we take the twenty largest funds, instead of the top ten, the average turnover of this group climbs to 97 percent (Evans 1999).

Table 1.7 gives illustrative costs in basis points of buying and selling portfolios of various

Portfolio Universe	Number of stocks	Size of trade(millions) $100	$300	$500
Salomon Smith Barney large-cap/growth	50	36	53	64
Salomon Smith Barney large-cap/value	50	26	37	44
Salomon Smith Barney small-cap/growth	50	131	196	246
Salomon Smith Barney small-cap/value	50	113	183	239
S&P large-cap/growth	162	27	38	45
S&P large-cap/value	338	27	34	44
S&P small-cap/growth	234	136	187	226
S&P small-cap/value	366	132	189	234

Note: Costs estimated using Salomon Smith Barney's impact-cost model

Table 1.7: Model turnover costs(in basis points)

sizes for various universes of stocks (Sorensen et al. 1998). Such high activity results in high trading costs. Trading involves explicit costs such as brokerage commissions paid on both the buying and selling side of the transaction. Much more difficult to measure are the implicit trading costs – the bid–ask spreads, price impacts, and opportunity costs.

Transactions costs related with trading have a significant impact on fund performance. Carhart (1997) documents that persistence in mutual fund performance does not reflect superior stock-picking skill. It is the persistent differences in mutual fund expenses and transactions costs that explain almost all of the predictability in mutual fund returns.

Example: Active portfolio versus passive portfolio

Consider an active portfolio with an expected return of 10.5 percent, portfolio turnover of 80 percent(which is actually on the lower side), management fees of 0.50 percent and trading costs of 0.75 percent of value. For the active manager, the total(two–way) turnover represented by purchases and sales is 2 × 80 percent = 160 percent. So the total costs are 0.75 percent × 160 percent = 1.20 percent of portfolio value. The net expected return of this portfolio is 10.5 percent - 1.20 percent - 0.50 percent = 8.80 percent.

Now consider a passive portfolio with a lower expected return, 9.5 percent, but turnover of only 4 percent, management fees of of 0.10 percent, and trading costs of 0.25 percent. The total turnover for this portfolio is 8 percent, which implies transaction costs of only 0.25 percent × 8 percent = 0.02 percent of portfolio value. The net expected return is 9.5 percent - 0.02 percent - 0.10 percent = 9.38 percent, which is higher than the net expected return from the active portfolio.

Composition	Active	Passive
Expenses included in expense ratio		
Investment Advisor	52	8
Distributor for 12b1 fees	22	2
Transfer Agent	12	5
Other (Custodial, legal, audit, etc.)	8	13
Reported expense ratio	95	28
Other expenses		
Brokerage fees paid by fund	12	3
Annualised front–loaded sales paid by shareholder	43	1
Total expenses as percentage of assets	150	32
Source: Table 4 from James et al. (1999)		

Table 1.8: Composition of mutual fund expenses, 1997

1.3.4 Management fees

The average general-equity mutual fund has an expense ratio of about 1.33 percentage points per annum as against passively managed funds which are available to individuals with an annual expense ratio of only 0.20 percentage points per annum. Table 1.2 shows a comparison between the expenses and transactions costs incurred by actively managed funds, as compared with index funds, using data for the United States in 1996. We see that index funds have a total cost advantage of 1.5 percentage points for large-cap stocks and 2.5 percentage points for medium-cap or small-cap stocks.

James et al. (1999) point out that typically *expense ratio* includes fees paid by the fund to the investment advisor, to distributors of funds and, in smaller amounts to lawyers, auditors, transfer agents and others. This figure is subtracted from gross return to obtain the net return which is passed on to the investor. However this net return figure often gives a misleading picture of the real return as expenses such as front–loaded and back–loaded sales commissions which are directly paid by the investor to the brokers or other distributors are not included in this expense ratio. Brokerage fees paid for securities transactions are also excluded from the expense ratio and are simply netted out of the fund's reported gross returns. Table 1.8 gives a clearer picture of the real costs which includes the expense ratio plus brokerage costs plus loaded sales commissions. As can be seen, in 1997 the fund expense profile was 1.5 percent of the assets, compared to the reported expense ratio of 0.95 percent.

Total return	Number of funds beaten	Percentage of funds beaten
Pre–tax	56	79
After capital gains taxes	61	86
After capital gains taxes and dividend taxes	62	87
After all taxes including deferred taxes	58	82
After all taxes, commission loads and fees	69	97

Source: Jeffrey & Arnott (1993)

Table 1.9: Actively managed mutual funds beaten by the Vanguard Index 500 fund

1.3.5 Tax advantage

Because the stock market has a long-run uptrend, portfolio turnover involves the realization of capital gains. For taxable investors, this can make an enormous difference in net returns. Table 1.9 gives the numbers and percentages of 71 large actively managed mutual funds beaten by the Vanguard Index Fund over the period 1982–1991 (Jeffrey & Arnott 1993). Earlier realization of capital gains can substantially reduce net returns. Dickson & Shoven (1995) took a sample of 62 mutual funds and examined the pre–tax and post–tax returns over a thirty–year period. They made the following observations:

- Pre–tax, one dollar invested in 1962 would have grown to $21.89 in 1992. After paying taxes on dividends and capital gains distributions, however, that same dollar invested in mutual funds would have grown to only $9.87.
- Investors in high–tax brackets actually got only 45 percent of the returns published by mutual funds.
- For these high–tax investors, Vanguard's Index 500 fund would have outperformed 92 percent of the funds in the study, if all realized capital gains could have been deferred(ten-year period ending 12/31/92).
- Even for investors in intermediate tax brackets, there were substantial changes in pre–tax and post–tax fund rankings.

Table 1.10 gives details of the study by Dickson & Shoven (1995). Index funds have an outright tax advantage over actively managed funds. By not trading from security to security, they minimise taxes by deferring or avoiding capital gains.

	$1.00 invested in 1963 grew into this amount by 1992
Pre–tax value(investing tax–deferred money so 100% of distributions are reinvested)	
S&P 500 index	$22.13
Median mutual fund(31 funds grew in value more than this and 31 funds grew less)	$21.89
After–tax value(reinvesting only money that's left after paying taxes on distributions)	
High–tax bracket(45% of the median fund's value of $21.89)	$9.87
Medium–tax bracket(59% of the median fund's value of $21.89)	$12.52
Low–tax bracket(75% of the median fund's value of $21.89)	$16.45
Liquidation value(selling out completely and paying all taxes)	
High–tax bracket(42% of the median fund's value of $21.89)	$9.17
Medium–tax bracket(55% of the median fund's value of $21.89)	$12.06
Low–tax bracket(73% of the median fund's value of $21.89)	$15.95

Source: Dickson & Shoven (1995)

Table 1.10: Pre–tax and post–tax value of mutual funds over 30–year peroid

1.3.6 Lack of *size disadvantage*

Fund size affects active mutual fund performance (Indro et al. 1999). Growth in the size of net assets initially provides cost advantages because growth increases net returns. This happens because the brokerage commissions on the execution of large volume trades for large funds are lower. In addition, the costs of access to data, research services, and support, as well as administrative and overhead expenses, do not rise in direct proportion to fund size.

However, brokerage commissions are only the tip of the transaction costs iceberg (Wagner & Edwards 1993). With uncontrolled growth in fund size come cost disadvantages that reduce net returns.

- Transaction costs increase because the purchase and sale of large blocks of stock exacerbate the liquidity and informational asymmetry problem for market makers and increase the bid–ask spread. Loeb (1983) found that bid–ask spread increases dramatically with block size. On average, a change in block size from $1 million to $2.5 million increases bid–ask spread by 170 basis points for medium–cap stocks and 70 basis points for large–cap stocks. Moreover, whereas small block trades can be executed anonymously, large block trades are typically negotiated with intermediaries. A fund manager known to trade on information will incur higher transaction costs to execute a large block trade than a manager known to follow a passive investment strategy.

- The sheer size of a large fund makes it an obvious target for attention. Outsiders carefully examine the fund manager's stock selections for clues and insights into the manager's information and stock selection and/or market timing strategy. As a consequence, the fund manager's ability to trade without signalling his or her intentions is greatly curtailed.

- A large influx of capital causes administrative stress. The organisation has to hire new people to accommodate growth, and the portfolio management process may suffer. Problems of coordination intensify as the number of portfolio managers grows, and the complexity of overseeing a large fund increases as the universe of stocks expands.

- Growth in fund size may often cause a manager to boost returns by deviating from the fund's stated investment objective. With increasing size, a fund manager is likely to engage in strategies or invest in assets that would normally not have been chosen because of policy constraint (Herring 1996).

As an actively managed fund grows in size, it gets harder and harder to manage the portfolio. Table 1.11 shows the three year rolling performance of "Around the World Fund" Megellan Fund versus the S&P 500 from 1981 to 1997 as the fund grew from an average asset size of $0.9 Billion to $52 Billion (Malkiel 1999). In the early years of the fund, when its assets were less than a billion dollars, performance was particularly outstanding. The excess performance during the remainder of the 1980s and into the 1990s while impressive was substantially lower than in the earlier periods. Toward the end of 1997, the Magellan Fund was more than 650 basis points behind the S&P 500. The record of one of the most successful mutual fund illustrates the tendency of superior performance to disappear as the size of the fund increases.

Index funds do not suffer from disadvantages due to increase in fund size. They simply hold on to a market portfolio no matter how large it may get. To the extent the fund grows and new purchases need to be made, these can be done gradually over time through efficient means. Index funds can for instance, take on immediate exposure by buying index futures so as not to miss on market movement while getting invested. The underlying index portfolio can then be gradually acquired by buying smaller baskets.

Year	Average assets (in Billions)	Percentage points gains/losses of fund versus the S&P 500
1981	0.9	30.00
1982	0.9	27.80
1983	0.9	21.40
1984	6.0	11.50
1985	6.0	6.90
1986	6.0	3.40
1987	6.0	3.30
1988	6.0	2.00
1989	20.0	1.30
1990	20.0	2.30
1991	20.0	3.40
1992	20.0	2.10
1993	20.0	7.80
1994	52.0	3.10
1995	52.0	3.40
1996	52.0	-5.20
1997	52.0	-6.60

Source: Malkiel (1999)

Table 1.11: "Around the World Fund" versus S&P 500

1.3.7 Performance monitoring

Subscribers to active funds assume that decisions taken by fund managers are in the best interests of the investors. Whether or not this happens in reality is unobservable as far as active fund manages are concerned. Front–running the index, buying stocks in which the fund manager has a personal interest and non–optimal decisions regarding the choice of trading mechanisms, custodial and other services are some of the agency problems faced by index funds (Shah 1999*a*). Monitoring performance across time becomes difficult due to the poor signal–to–noise ratio whereby genuine ability in fund management tends to get drowned in the noise of market fluctuations.

Monitoring the performance of index fund managers on the other hand simply involves looking at the tracking error of the fund. Deciding which index fund to buy into simply becomes a matter of finding out if the chosen index fund has lived up to its promised tracking error.

1.4 THE MECHANICS OF INDEX FUNDS

The stereotypical view of index funds is that their management is a trivial task. Yet, in practice, there are significant challenges in the creation and operations of an index fund.

Unlike active managers, who make no promises about future returns, index funds promise to replicate the returns of a publicly observable index. If the index rises by 20%, and if the index fund reports 19% returns, then the investor is entitled to be suspicious about how a hundred basis points of returns were lost. Index fund management is a challenge because of this level of scrutiny and accountability.

1.4.1 Choice and construction of index

In many countries, 'widely prevalent' stock market indexes exist. In this case, the modern development of the financial sector, in the direction of index funds or index derivatives, almost automatically proceeds using these widely prevalent indexes. These market indexes often present a host of awkward difficulties in modern applications.

These market indexes were created years ago, in an environment with limited information access, poor computation, and a much more limited knowledge of financial economics. All three factors are much altered today. Modern electronic stock exchanges, which use anonymous trading with computerised order matching, offer a wealth of information about market liquidity. The revolution in computational power at ever–lower prices has made it possible to embed complex computational procedures into day to day index management. Finally, research into index funds and index derivatives through the decade of the 1980s and 1990s has shed new light upon the issues in index construction.

The difficulties with many traditional stock market indexes may be summarised as follows:

1. When some stocks in the index are inadequately liquid, this contaminates the information represented by the index, and makes it harder to use the index for financial products such as index funds or index futures.

   An illiquid stock contaminates the information content of the index via 'stale prices', where the computation of the index at time t_2 is forced to use information about a trade on an illiquid stock at t_1, $t_1 < t_2$.

   Illiquid stocks make it difficult to trade the entire index as a portfolio, and significantly hamper the viability of index funds and index derivatives. For example, it is fairly

Index	Market Cap. (Rs. Trillion)	Impact Cost (%) at trans. size (Rs. Mln)		
		5	10	20
BSE-30	1.96	0.35	0.46	0.67
Barings India Index	1.59	0.29	0.36	0.50
IFC India Index	2.62	0.53	0.65	0.89
MSCI India Index	2.67	0.53	0.64	0.87
NSE-50	2.21	0.29	0.36	0.49

Table 1.12: Impact cost in portfolio trades for alternative stock market indexes in India

inconvenient to undertake program trades for all 500 components of the S&P 500 index, and approximation of the index using 150-300 stocks is a common procedure. Similarly, stock market indexes for developing countries created by agencies such as IFC are often highly impractical when it comes to using them for index funds or index futures.

2. The procedures for 'managing' the stock market index often leave much to be desired. The composition of an index should evolve over the years, reflecting changes in the economy, and the procedures through which this takes place should be immune to special interests. Many traditional index maintainers have proved to be weak on this count. For example, in many countries, index maintainers do not even produce a variant of the market index inclusive of dividends.

Every stock market index is a tradeoff between diversification and liquidity. Small market indexes tend to be illiquid and under-diversified; large market indexes tend to be well-diversified and illiquid. Yet, there are sharply diminishing returns to diversification. Most randomly chosen portfolios in a country prove to be extremely highly correlated with each other, as long as they are highly diversified. Hence, as long as adequate diversification is obtained, the identity of specific stocks in the index is not too important as far as the risk/return character of the index is concerned.

Hence, Shah & Thomas (1998) suggest that choosing highly liquid stocks, to form a well-diversified index, could be a useful strategy. There are two aspects to market liquidity: *market impact cost* (the degradation in price faced when placing a market order) and *market resilience* (the time taken for the market to revert to its original state after an order is placed). Measuring and characterising market resilience is, as yet, a unsolved research problem. However, on electronic exchanges, market impact cost can be accurately measured. Shah & Thomas (1998) use this in their method for index construction. Table 1.12, which is from their paper, summarises the market impact cost in doing program

Index	Basket size ($ million)	Commission (%)	Market impact cost (%)	Total (%)
US: S&P 500	5	0.057	0.150	0.207
US: S&P 500 futures	100	0.005	0.012	0.017
US: S&P Midcap	5	0.100	0.300	0.400
US: Russell 2000	5	0.150	0.655	0.805
India: NSE-50	5	0.200	0.250	0.450
India: Nifty Junior	2	0.200	0.800	1.000

Source: US data from Exhibit 3 of Chiang (1998) and page 756 of Mason et al. (1995); Indian data from author's experiences (1999).

Table 1.13: Trading costs on spot market for some market indexes

trades on alternative indexes in India. The NSE-50 index, where low market impact cost in doing index program trades is explicitly a goal, proves to have substantially lower market impact cost as compared with alternative indexes.

Stock market indexes which use methods such as these would be well suited for the implementation of index funds and index derivatives. The reduced market impact cost when doing program trades on the index lead to reduced tracking error in for index funds.

Table 1.13 gives an international perspective on the transactions costs faced in doing program trades on a given index. In each case, it is assumed that a series of trades are done through one trading day, in order to buy the desired 'basket size'. In the US, the spot market supports transactions of around \$5 million with a total cost of 0.21%. When the index futures market is used, the size of the basket rises to \$100 million and the cost drops to one–twelfth of this. The costs faced in obtaining baskets of less liquid stock market indexes, such as the S&P Midcap or the Russell 2000, are much higher. In a developing country, India, the main stock market index (NSE-50) supports much smaller basket sizes: around \$5 million can be obtained in a day at a market impact cost of 0.25%. The next tier of less liquid stocks in India, the Nifty Junior index, faces a higher market impact cost of 0.8% for obtaining \$2 million in a day.

1.4.2 Methods of implementing index funds

At first glance, implementing an index fund appears straightforward : the index fund is supposed to buy stocks with the correct weights, and trade in response to changes in the index set or when any of the index stocks issue new capital. In practice, implementing index funds proves to be a significant challenge, especially when the underlying stock market index has been poorly designed. Liesching & Manchanda (1990) is a survey of these techniques.

The simplest method through which index funds are implemented is "full replication", where the portfolio held by the index fund is the same as the index. Such an index fund will replicate the returns of the index, subject to the caveat of transactions costs in trading. In a full replication approach, the portfolio manager typically sets a tolerance or bias on the individual stocks in the portfolio(Olma 1998). For example, a portfolio manager might choose to manage an S&P 500 portfolio in such a way that no individual stock's weight deviates from its weight in the index by more than p basis points, where p represents the bias. As contributions are made or dividends reinvested, the portfolio manager would seek to minimise the sum of squared biases, as that will generally produce the best tracking portfolio. Most index funds in India follow the strategy of full replication.

Sampling is an effective way to manage a portfolio when the liquidity of the stocks in an index precludes full replication. For example, in the case of the very large indexes such as the Wilshire 5000 in the US, it may be possible to purchase most if not all of the stocks in the index in their proper capitalisation weights. However, it is inadvisable to do so because the transactions cost in such a trade will almost certainly lead to underperformance versus the index.

Sampling provides a way to establish a portfolio position without actually owning all of the stocks in a given index. In the case of indexes such as the Wilshire 5000, managing the portfolio so that the larger stocks are fully replicated and the smaller stocks are sampled will produce a lower tracking error than if all the stocks are purchased and maintained in perfect capitalisation weights. Generally speaking, the greater the number of securities in the sampled portfolio, the lower the tracking error.

In the sampling approach, all stocks in the index are characterised according to a number of parameters(size, dividend yield, industry, etc.), and the portfolio manager divides the universe of securities into cells based on these parameters. For example, the universe may have a cell containing all technology stocks that have a market capitalisation between a particular range and that have yields less than $x\%$. Cells might contain financial and healthcare stocks in the same size and yield categories. The cell structure of the universe should be sufficiently fine to ensure that all stocks within the cell are reasonably good substitutes for each other. The portfolio manager assembles the portfolio by "sampling" stocks within each cell to create a portfolio that has fewer stocks than the entire universe, but with characteristics similar to the universe. The weight of each cell in the portfolio should be similar to the cell's weight in the index.

Many countries have market indexes with design flaws, and one of the commonest problems is that of a market index which contains stocks which are highly illiquid. Sometimes, a market index for a sector innately suffers from high transactions costs in trading when the entire sector is only made up of illiquid stocks. When some or all index components are inadequately liquid, index funds which use full replication can suffer from a large tracking error owing to the large transactions costs faced in trading the entire index. One path for the implementation of an index fund, in this situation, consists of holding a portfolio p' which is different from the index portfolio p where: (a) the transactions costs associated with implementing p' are much lower than those faced with the true index p, and (b) the correlation between p and p' is high. In general, the portfolio p' should be chosen by explicitly solving a mathematical programming problem to minimise the tracking error.[2] If the liquidity of index components is sufficiently 'unbalanced', where some components are disproportionately more liquid than others, such an index fund might obtain a lower tracking error as compared with a fund which uses full replication.[3]

Optimisation requires a risk or factor model describing all the stocks in the index specified along a number of dimensions(e.g., size, beta, yield, economic sector). This is similar to the sampling approach, but the risk model takes into account the covariance between the factors. Consequently, whereas sampling simply requires sufficient data to assign attributes to stocks, optimisation requires a history of these attributes to establish the risk/return relationships between them.

Although optimisation is a very useful portfolio management tool widely used by both index and quantitative managers, it is important to understand its principal limitation. Optimised portfolios are created based on the assumption that the risk model is a perfect representation of the real world. The risk model, however is subject to a variety of imperfections. First, no matter how good the risk model is, it is not perfectly specified.

[2]Liu et al. (1998) offer an exposition of this procedure. Blin (1997) is an example of applying factor models to solving this problem, of finding a ten–stock portfolio which is maximally correlated with India's NSE-50 index. Harrison (1991) is an example of applying this to obtaining an index fund in New Zealand.

[3]There is relatively little research on tracking error. Part of the problem here is that accurate measurement of transactions costs, with the market mechanisms prevalent in the US, is difficult. For example, Larsen & Resnick (1998) discuss tracking error obtained through optimisation, but assume that there are no transactions costs.

That is, the risk model does not perfectly capture all the risks associated with each stock in the model. Even if it did, risks in the real world are subject to change, and the model is based on historical data which may not accurately reflect the future. Finally, even if the model could accurately reflect changing risks in real time, the portfolio would have to be rebalanced continually to capture those changing risks.

In a frictionless world, constructing index funds is a simple task. However, in the real world, index fund implementation involves transactions costs that are associated with portfolio implementation, re-balancing and capital flows. either due to additions or deletions of constituents or due to corporate restructuring. The index assumes that the theoretical portfolio's new weights to each security can be achieved automatically. However, for the index fund, realigning the portfolio to mimic the underlying benchmarks involves physical trading in stocks and the transactions costs incurred thereby.

Index funds can also be implemented using the index futures market. Suppose an index futures product requires placing $\$x$ of collateral to support a position of \$100. Then it is possible to replicate the returns on an index portfolio worth \$100 by adopting a long position on the index futures market for \$100, and investing the residual cash $100 - x$ in riskless government securities Mason et al. (1995). Hill & Naviwala (1999) show synthetic index returns are generated using index futures, and study their performance and tracking risk characteristics relative to the underlying index. Miller & Meckel (1999) focus on the use of derivatives contracts to index a portfolio and generate enhanced returns in the process. In most markets, where the rates of return embedded in index futures prices are slightly in excess of the riskless rate of return, the 'synthetic index fund' can systematically earn slightly higher returns than the index. Table 1.14 explains three ways of generating index returns.

1.4.3 Evaluating the alternative implementation strategies

Full replication is feasible when the liquidity of the stocks that make up the index supports low–cost program trades on the complete index. The methods for index construction in Shah & Thomas (1998) are oriented towards index funds implemented through full replication. Full replication requires the least sophistication in terms of analytical and computational abilities in the fund industry.

When stock market indexes suffer from illiquid index components, optimisation–strategies

Buy stocks in an index	Buy futures and cash–equivalents	Swap cash–equivalents for index returns
+ Dividends	+ Interest income	+ Interest income
+ Ending value of the index(capital gains or losses	+ Ending value of the index(capital gains or losses	Total return on the index(gains plus dividends)
+ Return on stock lending	- Futures premium	- Fixed or floating–rate payment
Source: Exhibit 1 of Hill & Naviwala (1999)		

Table 1.14: Equity exposure through stock index futures and equity index swaps

can be useful; however, they require considerable sophistication in terms of quantitative finance.

When liquid index futures markets are available, synthetic index funds are often an excellent option. In mature markets, the transactions costs faced when trading the index using the index futures market can be as low as one–tenth to one–twentieth of the transactions costs faced when trading shares on the spot market. Holding a position on index futures involves lower custodial and administrative costs, especially in markets with primitive settlement systems where physical share certificates are still in use. On the flip side, the index futures implementation will forgo revenues from stocklending which the full replication fund enjoys.

Implementation through index futures is particularly attractive when the market index suffers from disproportionately illiquid index components: the index futures market offers a single, liquid, tradeable product. The user of the futures market would be relatively shielded from the illiquid index components.

The weaknesses of this implementation strategy are two–fold:

- The first problem is that index futures contracts expire, and the index fund would need to re-establish this position on the next available contract, a process called "rollover". If an index fund has assets of $100 billion, it would need to execute trades worth either $100 billion or $200 billion on the index futures market every few months. This is in sharp contrast with an index fund which is implemented using full replication: a fund with assets of $100 billion would typically undertake trading volume of one to five billion dollars in a year.

Large index funds would suffer considerable transactions costs when doing this rollover, for even the highly liquid index futures markets are not adequately liquid to support such large transactions. Hence, the largest of index funds have often been limited to full replication strategies.

There is an element of active management in the rollover process. If a rollover can be timed carefully for an instant in time when the near contract is expensive and a far contract is cheap, then the rollover can actually yield excess returns. However, this gives us an element of active management, and is inconsistent with the goals of index funds.

- Further, at the level of the economy, the index futures implementation has a basic weakness since index futures are in "net zero supply": for each buyer of a futures, there has to be an equal and opposite seller. If we think of 50% of the GDP of a country being invested in index funds using index futures, it will prove to be hard to find sellers who would be at the opposite end of the trades (Rubinstein 1989). If index futures markets are used by index funds on this scale, we could observe breakdowns in the market efficiency of the index futures market and enhanced tracking error for these index funds.

In the real–world, all three implementation strategies have a useful role to play, depending upon the situation. Ideally, if index construction is done optimally in a country, then full replication can be the mainstream implementation strategy used by the bulk of indexed assets. Index futures are often attractive for individual index fund products, but considerations of the economy as a whole relegate implementation strategies using index futures to the margin, in efficiently coping with incremental assets moving in or out of index funds. Optimisation–based strategies could be useful for extending the universe of indexation beyond the most liquid assets, or when faced with badly designed market indexes.

1.5 The enabling market infrastructure for index funds

The conventional analysis of index funds is generally based on treating the stock market index and the equity market as a given, and analysing the usefulness and implementation of index funds. For example, in the US, the S&P 500 as an index, and trading based on the 'specialist' on the New York Stock Exchange as a market design, have existed for many decades.

From a policy perspective, it is useful to view the question from a different perspective: What is a market infrastructure which can best enable index funds? What aspects of the design of the financial system can be modified in a way which helps the implementation and usefulness of index funds?

1.5.1 Index

The most basic foundation of indexation is the stock market index. The treatment of index construction, in Section 1.4.1, suggests that there are significant gains to redesigning market indexes using modern knowledge of financial economics, especially in countries with modern market infrastructure in the form of electronic order-matching.

Unfortunately, market indexes which have existed for decades are hard to displace from the public imagination. Even in a highly educated country such as the US, the poorly designed 'Dow Jones' index plays an important role. Yet, in many developing countries, where existing market indexes are not too well established, there are opportunities for successfully introducing a new index.

1.5.2 Electronic trading

Implementing index funds obviously relies on an exchange where orders are executed. Prior to modern technology, a variety of market mechanisms have developed to address this problem: these include the 'specialist' of the New York Stock Exchange, the 'dealers' of NASDAQ, the floor with 'open outcry' at the futures exchanges in Chicago, etc.

From the early 1970s onwards (Black 1971), an important new idea has come to the centre stage of market design, this is the idea of using a computer to match orders in a market where economic agents *anonymously* post prices and quantities that they desire. This has also been termed the 'open electronic limit order book' market. It has significant theoretical appeal (Glosten 1994), and is the dominant form of market organisation that has been employed by exchanges worldwide in the decade of the 1990s. After a decade of debate and resistance, many traditional exchanges have moved from a market design that was labour-intensive to the electronic exchange (e.g. the London Stock Exchange (LSE) in 1997, and the London International Financial Futures Exchange (LIFFE) in 1998).

In labour-intensive markets, a 'program trade' is difficult to execute, since human response are slow and unpredictable. If an index containing 100 stocks has to be purchased, it would require interacting with 100 (or more) humans. This is a complex and expensive affair.

Even today, on the NYSE, executing program trades for the S&P 500 takes around two minutes; the index trader is exposed to the risk of market fluctuations within this time interval. In contrast, electronic exchanges make it convenient and efficient to place program trades. It is possible for an electronic exchange to execute 100 orders in a very short time, thus reducing the tracking error that results from purchases that are spread over different index levels.

The open electronic limit order book market is particularly valuable for index funds since it is transparent about prices and liquidity. An entire program trade can be priced before it is placed.[4] This is in sharp contrast with a traditional market such as the New York Stock Exchange, where every program trade results in an unpredictable execution.

While the implementation of equity index funds, worldwide, has been greatly enabled by the spread of electronic exchanges in the decade of 1990s, most bond markets continue to use primitive market institutions. This is a significant hurdle to the growth of bond index funds.

1.5.3 Call auctions

The "call auction" is a uniform price double auction where buyers and sellers compete in offering buy and sell prices for a stated interval of time (Economides & Schwartz 1995). It is a trading procedure which aggregates the order flow over a period of time to produce greater liquidity, and allows all buyers and sellers to obtain a single price (there is no 'market impact cost' in the electronic call auction).

Three examples of the use of the call auction can be cited:

1. The NYSE 'opening price' is obtained using (manual) call auctions on each of the underlying stocks. This makes it convenient for program trading to take place at the NYSE open. Market orders which are placed in the call auctions are guaranteed to obtain the exact opening index level. For this reason, the S&P 500 futures settlement price is derived from the NYSE opening price of the *next day* after trading on the futures market has stopped.

2. The Arizona Stock Exchange (`http://www.azx.com`) is a stock exchange which exclusively relies on electronic call auctions.

[4]For example, at `http://www.utisel.com/livefeed`, the market impact cost for doing index trades in India is displayed in realtime. It is calculated off the limit order book, which is publicly visible on India's National Stock Exchange (NSE), an electronic exchange.

3. In India, for a while, the National Stock Exchange (NSE) used electronic call auctions at the start and end of the day. This ensured that the opening and closing levels of the index could be attained by index traders at zero impact cost.

To the extent that index funds are able to execute program trades at zero impact cost using call auctions, it reduces the tracking error faced by them.

1.5.4 Index futures

Index futures reduce the transactions costs of doing large index trades. As seen in Table 1.13, execution of basket trades for twenty times the basket size in the US takes place at one–twelfth the cost. This clearly suggests that index futures have a major role to play in implementing index funds. To the extent that a country has a functioning index futures market, it would assist index funds in obtaining lower tracking error.

1.6 Negative externalities of indexation

The worldwide growth of index funds in recent decades has raised concerns about the externalities that this rise of indexation could impose upon the economy. There are primarily four concerns which have been expressed : (a) distorted cost of capital for index stocks, (b) inferior corporate governance, (c) diminished market efficiency, and (d) enhanced concentration in the fund industry.

1.6.1 Distorted prices of index stocks

Many observers have expressed concerns about index funds 'blindly' buying index stocks. If $100 billion are in index funds on a given index, and if a stock enters the index with a weightage of 0.5%, then index funds would be forced to buy $500 million of this stock. Conversely, index funds would be forced to sell shares of companies that are dropped from the index.

Could these activities significantly distort share prices? Do they result in elevated valuations, and hence an unusually low cost of capital, for index stocks? Does the growth of index funds thus contaminate the resource allocation produced by the stock market?

	(% change in stock price)	
	Addition	Deletion
From announcement date to effective date	+3.8	-12.7
From effective date to ten days after	-2.3	+6.2

Table 1.15: Abnormal price fluctuations owing to inclusion/exclusion in the S&P 500 index

While these concerns may appear intuitively sound, they should be interpreted in the context of the actions of the rest of the market. If index funds purchased $500 million of a given stock, and if the price of the stock rose above a 'fair valuation', then many informed speculators would choose to sell that stock. If markets were efficient, we would see a reshuffling in the ownership pattern of the company, with many shares going from informed speculators into index funds; however in the ideal efficient market, the impact on prices should be 0.

Malkiel & Radisich (2001) examine the claim that indexing results in inflating prices of index securities and is hence self–fulfilling. They find that indexing does not influence security prices. They conclude that the success of indexing results from the general efficiency of stock markets, and that the gap between the performance of index funds and active managers can be fully explained by the extra management costs and transactions costs involved in active management.

The event of addition or deletion of stocks from the S&P 500 index, with large index funds in the background, has given researchers many opportunities to study these effects, starting from the early work of Shleifer (1986) and Harris & Gurel (1986). The evidence, from Lynch & Mendenhall (1997), is summarised in Table 1.15. When Standard & Poors announces that a stock is added in the index, a future date where this announcement takes effect, called the "effective date" is announced in advance. Index funds who seek to do full replication would be forced to buy the stock by this date. From the announcement to this "effective date", an abnormal price movement of +3.8% is observed; however 2.3% of this is lost in the following ten days. Hence, the long–term price of inclusion in the S&P 500 is +1.5%. While this is a clear violation of market efficiency, it appears fairly benign in terms of not constituting a large distortion of stock prices or the cost of capital.

The evidence is less benign in the case of stocks which are dropped from the index: the selling by index funds generates a temporary drop of 12.7%, of which 6.2% is regained in the following ten days. The permanent drop in price amounts to 6.5%.

Hence, there *is* evidence that in a world with large indexed assets, the prices and hence cost of capital of stocks is distorted depending on inclusion or exclusion from the index. However, these effects do not appear to be very large.

1.6.2 Inferior corporate governance

Some observers have criticised index funds on the grounds that index fund managers do not take interest in resolving the agency conflicts between shareholders and managers. Index funds are viewed as free–riders on the corporate governance problem that other agents in the other economy are expending resources upon.

This free–rider problem is present with any investor who chooses to not take interest in corporate governance issues. The very logic of the limited liability company is that it gives shareholders the right, and not the obligation, to vote.

We can view failures of corporate governance as a violation of market efficiency. If a firm is producing inferior cashflows owing to improper incentives for managers, then there is an opportunity for an active portfolio manager to seize control of the company, modify the activities of the company so as to attain higher cashflows, and benefit from these activities to the extent that the share price of the company goes up. The existence of these situations, and the importance of speculators who engage in such activities, is undeniable.

1.6.3 Diminished market efficiency

Index funds are criticised for not engaging in stock speculation, in making forecasts about future returns, buying 'undervalued' stocks and vice versa. If, in principle, the entire economy shifted to index funds, then market efficiency would undoubtedly deteriorate drastically. This is somewhat related to the previous issue; if the entire economy shifted to index funds, agency problems would be exacerbated.

It is useful to view index funds as the product of an equilibrium. In a world where numerous economic agents compete for speculative profits, a state approaching market efficiency is obtained. Index funds are useful in this state. The appeal of index funds is closely related

World		U.S.	
Manager	Assets ($ billion)	Manager	Assets ($ billion)
Barclays Global	557	Barclays Global	407
State Street Global	258	State Street Global	207
Bankers Trust	192	Bankers Trust	156
Vanguard	126		

Source: Pension & Investments, Aug. 24 1998 and Feb. 22 1999.

Table 1.16: The largest indexers

to the extent to which competition between speculators makes it difficult to obtain excess returns from active management.

If, in a country, there were "too few" speculators and "too many" index investors, then the rates of return in active management would significantly exceed those obtained through indexation. As of yet, we have probably not encountered this situation in any country.

1.6.4 Concentration in the fund industry

Earlier, in Section 1.2.2, we commented on the role of signals such as pedigree, size and years of experience as proxies for fund management ability, in a world where it is difficult to identify genuine ability. This serves to reduce the contestability of the money management industry.

While this problem is an important motivation for index funds, insofar as index funds lend themselves to easier monitoring of the actions of fund managers, the pressures towards concentration of the fund industry are even more acute with index funds. The basic problem faced here is that index fund management is a fixed cost activity. Once computer systems are setup for managing a small index fund, the same systems scale up to much larger assets. The costs of sales and distribution costs also prove to be lower, per unit of assets, for larger funds.

This phenomenon has led to remarkably low fees for large investors: in the US market, fees of 0.01% per year are known to be prevalent for assets of $1 billion. However, this phenomenon serves to throw up entry barriers against a new firm that seeks to manage index funds. Hence we see a pronounced concentration in the index fund industry, with four–firm concentration ratios in excess of 80% (see Table 1.16. Each basis point of fees on a billion dollars of assets is a revenue of $10 million. The major indexers seen here probably earn significant monopoly rents.

This is one negative consequence of the rise of index funds. Active management, in contrast, does not suffer from increasing returns to scale to this extent; indeed, many active managers view the management of large assets as being an important handicap which makes it difficult for them to obtain excess returns.

1.7 Issues related to performance evaluation of mutual funds

Mutual fund performance evaluation as yet suffers from many conceptual difficulties (Roll 1977). Evaluating return on a fund, whether index or non–index is not as simple as it may seem. There does not seem to be a consensus in the industry as to what "return" actually stands for. For promotional purposes, mutual fund sponsors use return numbers which suit them most. For instance, it has been pointed out in much of financial media that 2000 was a very successful year for active management. Table 1.17 gives the returns for different asset classes, together with the percentage of mutual funds that had higher returns than that index in 2000. As mentioned in the same, 72 percent of all funds had higher returns than the S&P 500 in the year 2000. However, note that most active funds tend towards smaller stocks than those held by the S&P 500. Small stocks did better than large cap stocks in 2000. Therefore the average performance of active funds appears better than that of S&P 500. Compare the returns of active funds to the S&P 600 index of small cap stocks. This shows that only 17 percent of the fund universe managed higher returns. A better comparison than the S&P 500 or the S&P 600 might be an index that represents the total market, like the Wilshire 5000 or the Russell 3000. Table 1.18 gives the percentage of funds that beat these indexes over 5, 10 and 15 years. The picture is obviously quite different from that in Table 1.17. Measuring and comparing fund performance is no easy task. In order to avoid a comparison between *apples* and *oranges*, the following nuances need to be borne in mind.

- Performance differs across asset classes, as different asset classes carry different amounts of risk. What really needs to be evaluated is the risk–adjusted return.
- Gross return figures are often significantly different from net returns figures as they often do not reflect various substractors such as *sales charges*.
- Returns should be measured across comparable time periods.

Index	Asset class	Index return in 2000(%)	Percent of funds beating index
S&P 500	US large cap	-9.10	72.22
S&P Midcap 400	US mid cap	17.50	7.66
S&P Smallcap 600	US small cap	11.79	16.86
Wiesenberger data through 12/31/2000			

Table 1.17: Percentage of mutual funds which had higher returns than index(2000)

Index	Funds beating index 5 years: 1996–2000	Funds beating index 10 years: 1991–2000	Funds beating index 15 years: 1986–2000
Wilshire 5000	15.89%	16.26%	17.23%
Russell 3000	13.74%	14.09%	14.53%

Table 1.18: Percentage of mutual funds which outperformed total market indexes

- The effect of survivorship bias can be substantial, often resulting in overstatement of fund returns.[5]

Even after taking the above into consideration, the statistical efficiency of existing performance evaluation procedures for actively managed funds is limited owing to the poor signal-to-noise ratio whereby genuine ability in fund management tends to get drowned in the noise of market fluctuations. At page 735 of Bodie et al. (1989), we see an example of a fund manager who has substantial skill – he adds returns of 0.2 percentage points per month (i.e., is in excess of 2.4 percentage points per year). It turns out that if the standard procedure of measuring the 'alpha' of the fund manager were employed using monthly returns, we would need to observe the results of his fund management for 32 years before we can reject the null hypothesis of no ability ($\alpha = 0$) at a 95% level of significance. This makes it difficult for investors to identify and adequately monitor fund managers. We may note here that this signal-to-noise ratio would be at its worst in developing countries, where stock market returns tend to be more volatile.

This poor signal-to-noise ratio becomes a particularly contentious issue when anyone other than an individual makes decisions about the choice of a fund manager for the individual. Consider a situation where a pension fund committee selects an active fund manager:

[5]Malkiel (1995) points out that for a fifteen–year period, the average return on surviving diversified equity funds was 18.7 percent. However, when all funds were counted, including non–survivors, the figure fell to 14.5 percent. In one of the most comprehensive study on mutual funds covering the period 1962–1993, Carhart (1997) found that by 1993, one–third of all funds in his sample had disappeared. In 1996, 242 of the 4,555 stock funds tracked by *Lipper Analytical Services* were merged or liquidated.

- This poor signal-to-noise ratio reduces the ability of the committee to identify the manager with the best ability. When ability is relatively hard to measure, there is a greater role for political lobbying in determining the choice of the manager. Alternatively, signals such as pedigree, size or years of experience are often used as proxies for ability: this reduces the contestability of the market for money management services.
- Once a manager is chosen, suppose the returns prove to be below the index at a future date. The pension fund committee would then be relatively vulnerable to accusations of having chosen the wrong fund manager. This factor also generates a bias towards hiring fund managers who fare well on signals such as pedigree, size or years of experience, which helps the committee to produce a plausible defence for their actions in the future, if the need arises.

These problems are an important motivation for the growth of index funds, particularly in situations like pension investment. Comparing alternative index fund managers is relatively straightforward – it essentially reduces to comparing the tracking error that they have produced. It also makes it easier for individuals to obtain accountability from an institution such as a pension committee: poor asset returns should be directly linked up to poor returns on the index (Shah & Fernandes 1999).

1.8 Evaluating index fund performance: tracking error

Index funds aim to deliver the returns and the risk of the underlying benchmark index. Therefore evaluating an index fund's performance boils down to observing how closely a fund tracks the underlying index. This is measured in terms of 'tracking error'. A well–managed index fund is one which exhibits low tracking error. The job of an index fund manager is therefore to minimise the tracking error.

Theoretically, managing an index portfolio is a straight forward activity, often termed a "no–brainer", requiring investment in all constituent index securities in the exact proportion as the underlying benchmark (called a "full replication" strategy). In reality, however, fund managers adopting an indexing approach often face problems in replicating the benchmark index returns. Chiang (1998) talks about the difficulty faced by managers in matching index returns. Factors driving tracking error are transactions costs, fund cash flows, uninvested/buffer cash, treatment of dividends by the index, corporate activity, index composition changes and volatility of the benchmark. The liquidity of the underlying index securities also has implications for transaction costs(in terms of impact costs) and in turn the tracking error incurred by funds (Keim 1999).

1.8.1 Index as a 'paper' portfolio

The index represents a mathematical calculation derived from a portfolio of securities that are not subject to the same market frictions as those faced by index mutual funds(Perold 1988). In reality however, index funds incur transactions costs that are associated with portfolio implementation, rebalancing and capital flows. When the composition of the underlying index changes, either due to additions or deletions of constituents or due to corporate restructuring, the index assumes that the theoretical portfolio's new weights to each security can be achieved automatically. However, for the index fund, realigning the portfolio to mimic the underlying benchmarks involves physical trading in stock and the transactions costs incurred thereby. These transactions costs, exiting for a real fund and non–existent for a benchmark or "paper" index, is one of the main reasons why it is so difficult to match the performance of an index.

1.8.2 Fund cashflows

Open–ended index mutual funds engage in flow–induced trading as a result of ongoing subscriptions and redemptions. Upon subscriptions, they are required to rapidly invest the cash flow across index securities, and upon redemptions, to sell securities to generate cash. Index funds often maintain buffer–cash to meet redemptions. This makes the *beta* of the fund less than that of the index and contributes to tracking error.

The size and timing of cashflows also has an impact on tracking error. Liquidity of index stocks has implications for transactions costs, both implicit and explicit. Full–replication index funds could be required to have part of their assets in less illiquid securities. When faced with large subscriptions or redemptions, the fund is forced to trade on the market under unideal liquidity conditions, resulting in higher transactions costs and in turn higher tracking error.

1.8.3 Corporate restructuring and dividends

Typically there is a timing delay between when the index incorporates the dividend(at the ex–dividend date and the actual receipt of the dividend by the index fund(after the ex–dividend date). Most indexes assume that accrued dividends are reinvested the day the stock goes ex–dividend. Actual receipt of dividends could take as long as several weeks. This timing delay invariably results in tracking error.

Similarly, when index securities are subject to corporate restructuring such as mergers, acquisitions or takeover by another company outside the index, there may be a timing delay between the date the company is removed from the index and the date the index fund receives the cash settlement. In addition, front–running by risk arbitraguers who acquire securities ahead of their inclusion in the index may also have an undesirable impact(Beneish & Whaley 1996).

1.8.4 Benchmark volatility

If the index fund is perfectly aligned with the index, the volatility of the underlying index will not result in tracking error. Since the index fund owns exactly the same portfolio as the index, however volatile the index movements are, the fund will perfectly track them. If however, the index fund portfolio does not perfectly mirror the index, the volatility of the underlying index will result in tracking error. The magnitude of the tracking error will be related to the volatility of the securities that make up the index.

Index volatility is of greater concern to funds that track the index by using optimisation techniques. They hold a portfolio that is different from the index portfolio in the hope of minimising transactions costs associated with trading illiquid stocks. The portfolio is chosen such that it has a high correlation with the index. Under situations of normal index volatility, such an optimised portfolio will track the index closely. However during periods of high index volatility caused by index securities not held by the optimised portfolio, the fund will fail to track the index, resulting in tracking error.

1.9 Index funds in developing countries

In the context of a developing country, the four central questions concerning index funds are:

- Are index funds relevant in developing countries, given the prevalence of inferior market efficiency?

- Are the benefits of index funds inaccessible in developing countries owing to the greater tracking error that is faced owing to illiquid stock markets?
- What implementation strategies should be adopted for index funds in developing countries?
- What can developing countries do in order to better benefit from the supply of risk capital through index funds?

1.9.1 Are index funds relevant?

Many observers believe there are greater opportunities for returns forecasting in developing countries as compared with the degree of market efficiency found in OECD countries. At a basic level, there are three aspects, where developing countries differ from OECD countries, which could lead to inferior market efficiency:

Information access Inferior disclosure laws, and an ill–developed information business, imply that information access in developing countries is inferior.

Human capital Inferior human capital may imply there are fewer economic agents who can arbitrage away mistakes in observed prices.

Transactions costs Market mechanisms in developing countries often impose high transactions costs, so that what appears to be a breakdown of market efficiency at a statistical level is actually not a profit opportunity. To the extent that inefficiencies are not exploitable, net of transactions costs, market efficiency *holds*, in an economic sense. The efficient markets hypothesis is only a statement about the absence of arbitrage opportunities in an economy populated by rational, profit-maximising agents. To quote Jensen (1978), "an efficient market is defined with respect to an information set $\mathcal{F}_t$ if it is impossible to earn economic profits by trading on the basis of $\mathcal{F}_t$."

If these three factors are at work in producing inferior market efficiency in developing countries, it does not necessarily imply that active management is a superior course. If information access is poor, then active managers would similarly suffer from the lack of information. The skills in the financial sector of a country are equally applied in active management as they are in individuals engaging in stock speculation seeking profits. It is not clear that active managers would somehow be able to tap into superior human capital. Finally, if market inefficiencies exist owing to high transactions costs, these inefficiencies are not profit opportunities for active managers.

Section 1.2.2 showed an important motivation for indexation: the agency problems between investors and fund managers. These problems are present to a greater extent in developing countries, where institutional development is inferior, and law enforcement in the financial sector is highly limited. Hence, index funds are particularly valuable in developing countries where the institution of the corporation, and the mechanisms for overcoming principal–agent problems between investors and fund managers, are ill–developed. This is particularly true in situations where a pension committee has to make decisions on behalf of workers; in developing countries, the risk of a poor decision by the pension committee owing to ethics lapses is acute.

If the above arguments are sound, then the empirical evidence should favour index funds in developing countries. The evidence in Table 1.4 suggests that 73% of equity funds that invest outside the US underperform a benchmark index, and 88% of funds which invest in 'emerging markets' underperform the index. These fractions are not particularly different from those seen with index funds in OECD countries. Table 1.19 gives a list of the Exchange Traded Funds in Asia. There are a large number of index funds launched in four markets – Japan, Singapore, Hong Kong and India.

1.9.2 Are index funds feasible?

Some observers have expressed concerns that the inferior stock market liquidity, and the weaknesses of stock market indexes, in developing countries will lead to significant tracking error in index funds.

The evidence in Table 1.13 suggests that program trading on some stock market indexes in developing countries is feasible; though the basket size which can be obtained in a day is obviously much smaller than that seen in the US. Index funds in developing countries are likely to be formed of much smaller assets than those seen in the US, hence this is not a key constraint. There is some empirical evidence which suggests that some index funds in developing countries have attained fairly low tracking errors.[6]

[6] Nayak (1997) documents an experience of the first index fund running out of India, on the NSE-50 index, where the tracking error has proved to be fairly small.

Market where listed/ Index tracked	Name of fund	Sponsor
Hong Kong/Hang Seng	Tracker Fund of Hong Kong	State Street
Hong Kong/MSCI Korea	iShares MSCI South Korea Index Fund	Barclays
Hong Kong/MSCI Taiwan	iShares MSCI Taiwan Index Fund	Barclays
Singapore/Dow Jones	Diamonds	Barclays
Singapore/SP 500	SPDRs	Barclays
Singapore/SP 500	iShares S&P 500 Index Fund	Barclays
Singapore/MSCI Singapore	iShares MSCI Singapore(Free) Index Fund	Barclays
Singapore/Dow Jones tech sector	iShares DJ US Tech. Sector Index Fund	Barclays
Japan/TOPIX	Daiwa Exchange Traded Fund-TOPIX	Daiwa
Japan/TOPIX	TOPIX Exchange Traded Fund	Nomura
Japan/Nikkei 225	Nikko Exchange Traded Index Fund 225	Nikko
Japan/TOPIX	i Shares TOPIX	Barclays
Japan/SP Topix 150	i Shares SP/TOPIX 150	Barclays
Japan/Nikkei 225	i Shares Nikkei 225	Barclays
Japan/Nikkei 225	Daiwa ETF-Nikkei 225	Daiwa
Japan/Nikkei 225	Nikkei 225 Exchange Traded Fund	Nomura
Hong Kong/MSCI China	iShares MSCI China Tracker	Barclays
India/SP CNX Nifty	Nifty Benchmark Exchange Traded Scheme	Benchmark
Japan/TOPIX	Nikko Exchange Traded Index Fund TOPIX	Nikko
Japan/TOPIX Core 30	Daiwa ETF Topix Core30	Daiwa
Japan/TOPIX Elec.Appliances	Daiwa ETF TOPIX Electric Appliances	Daiwa
Japan/TOPIX Trans Equipt	Daiwa ETF TOPIX Transportation Equipment	Daiwa
Japan/TOPIX Banks	Daiwa ETF TOPIX Banks	Daiwa
Japan/TOPIX Core 30	TOPIX Core 30 Exchange Traded Fund	Nomura
Japan/TOPIX Elec Appliances	TOPIX Electric Appliances ETF	Nomura
Japan/TOPIX Transport Equip	TOPIX Transportation Equipment ETF	Nomura
Japan/TOPIX Banks	TOPIX Banks Exchange Traded Fund	Nomura
Singapore/Straits Times street	TRACKS Straits Times Index	State Street

Table 1.19: The spread of ETFs in Asia

1.9.3 How should index funds be implemented?

Developing countries are characterised by significant concerns about stock market liquidity, low skills in modern financial economics, and ill developed derivatives markets.

The concerns about stock market liquidity would emphasise caution in terms of being able to execute program trades on the index basket. In developing countries, it is not safe to make assumptions about reliably trading even the stocks in the largest quartile. For example, the IFC India index, which is not conscious about market impact cost in program trades, suffers from a market impact cost which is 82% worse than that of the NSE-50 index, when doing program trades of Rs.20 million.

The weakness in skills in modern financial economics suggests that optimisation–based procedures may be hard to implement. Even if skills and software were to be transplanted from external sources, the factor models that are required for these optimisation-based procedures are typically based on the research literature going over decades. Such knowledge is typically not available in the literature in a developing country.

The weakness in index derivatives suggests that index derivatives would not play an important role in implementing index funds.

Hence, the simplest situation is one where an index fund is implemented using full replication, and the index is free of stocks which are disproportionately illiquid. The methods of Shah & Thomas (1998), described in Section 1.4.1, are designed to produce an index which suits these needs.

For countries which already have index derivatives, index funds which use full replication can greatly benefit, on the margin, from using a liquid index futures market. Index options can be used to construct a variety of guaranteed return products (Mariathasan 1997).

In each country, a research program on models of asset pricing would create the knowledge and understanding of factor models which would lead to optimisation–based procedures in the future.

1.9.4 What can policy makers do to enable index funds?

The primary role that policy makers can play, in enabling index funds, is in terms of building the institutional infrastructure which helps index funds. This runs over the issues of index construction, electronic trading, program trading, call auctions, and index futures that are discussed in Section 1.5. From the viewpoint of pension reforms, to the extent that equity investment by pension funds is channelled through index funds, it would generate greater development of human capital in this area, and generate a constituency for the reforms which would lead to this market infrastructure.

1.10 USE OF INDEX FUNDS FOR HARNESSING EQUITY PREMIUM

The basic motivation for equity investment is based on the 'equity premium', the excess expected returns that is offered by the equity market (Siegel 1998). On seventy–year horizons, for which stock market indexes are observed in OECD countries, the real rate of return on the equity index is around five to six percentage points in excess of the real rate of return on fixed income investments. The existence of the equity premium is consistent with economic theory -- where investors who bear the risk of non-diversifiable fluctuations should be compensated with a premium in the form of higher expected returns – however the size of the premium seems to be difficult to explain (Mehra & Prescott 1985).

The equity premium provides a powerful justification for investment into equities by entities such as pension funds which have a long–term horizon. Over a thirty–year horizon, investing at 1% in real terms (a typical fixed–income asset) yields a return of 35% while investing at 6% in real terms (a typical stock market index) yields a return of 474%.

Can an actively managed fund result in the core equity premium (the returns to the index) and an additional "active management premium"? The empirical evidence (Table 1.3 and 1.4) seems to suggest that we cannot reject the null hypothesis that the "active management premium" is zero.

The empirical evidence about the equity premium is entirely based on the growth of stock market indexes observed over past decades. Hence, investment in the equity index is a direct method of translating this evidence into an investment strategy. The viability of index funds, and their ability to operate at fairly low levels of tracking error, suggests that this is indeed a feasible investment strategy.

1.11 Conclusion

In conclusion, index funds are an important investment strategy for investors who seek to harness the equity premium. The case for index funds has often been phrased in terms of market efficiency, and the observed inability of active managers to outperform the index over long periods of time. In addition, the agency conflicts between investors and fund managers are also an important motivation for index funds, which benefit from simple and unambiguous accountability.

The equity premium gives us a powerful motivation for equity investment by pension funds. In this context, index funds make it possible to sidestep the complexities of forming contracts and monitoring institutions to govern fund managers.

In developing countries which seek to use index funds in pension investment, there are avenues through which policy makers can improve the viability of index funds. The issues faced here are primarily those of market mechanisms used on the equity market, and the construction of the market index. In many countries, there are significant avenues for improvement in these areas, which will benefit market efficiency at large, and the viability of index funds in particular.

Chapter 2

Evaluation of index funds in India

2.1 Introduction

In the decade of the 1960s and 1970s, many studies indicated that actively managed funds which seek to obtain excess returns by actively forecasting returns on individual stocks, do not actually obtain statistically significant excess returns. This was consistent with the hypothesis of 'market efficiency', which suggested that obtaining excess returns should be difficult in a competitive market.

This research suggested a superior investment strategy: the index fund. This would be a portfolio which passively replicated the returns of the index. The most useful kind of market index is one where the weight attached to a stock is proportional to its market capitalisation. Index funds are easy to construct for this kind of index, since the index fund does not need to trade in response to price fluctuations. Trading is only required in response to issuance of shares, mergers, etc.

Index funds are central to the modern approach to fund management. Since the first index fund launched in 1972, investors all over the world have discovered that there are substantial benefits from utilising index funds as an alternative to actively managed funds. In many countries, assets with index funds amount to 30% to 40% of the total equity assets managed by professional fund managers.

In this study however, we do not address the question of *whether* index funds outperform actively managed funds in India; nor do we address the question of whether the agency conflicts between the investor and fund manager are better addressed by index funds.

Our focus is on questions of *implementation*. Assuming that an investor *is* interested in utilising an index fund, the hurdle faced is that of *tracking error*, i.e. the annualised standard deviation of the error between index fund returns and index returns. It is argued that in developing countries, where the equity market is illiquid, the tracking error of index funds can be fairly large, thus diminishing the benefits from indexation. In this study we make a systematic effort to measure and understand tracking error of index funds in India.

We argue that correct index fund tracking error calculations require great care in data handling, and show how small mistakes in data handling can generate huge tracking errors. One problem faced is that of missing data – days where index values were available, but fund NAV values were not. Using a simulation, we show that a modest incidence of missing data can lead to an economically significant upward bias in the apparent tracking error. We offer an alternative heuristic for measuring tracking error which is unbiased in the face of such missing data.

Tracking error is typically measured as the standard deviation of difference between index returns and fund returns. The goal of an index fund is to minimise the tracking error. International evidence suggests that index funds incur a tracking error in the range of 4 basis points to about 120 basis points. We compute tracking error for the four longest existing index funds in India. Over comparable time–periods, we observe tracking error in the range of 68 basis points to 1097 basis points. In the Indian experience, we find that the Templeton Franklin funds have consistently shown low tracking error since inception. IDBI Index I-Nit Fund appears to have learned how to do index fund management and improved substantially. The UTI Nifty Index Fund exhibits unacceptably large tracking errors through out.

We go on to seek some insights into the sources of tracking error. Open-ended funds in India need to maintain buffer cash to meet redemptions. To the extent that a fund maintains buffer cash, it has $\beta \neq 1$. This inevitably induces tracking error. In addition, a fund could also incur tracking error due to active management. These constitute two competing hypotheses about the sources of tracking error.

We seek to obtain insights into this question using the single market model. We hypothesise that if the fund holds a fixed fraction of cash and does perfect indexation with the remainder, we would observe the following observable effects: (a) a highly stable beta which is less than one, (b) alpha of roughly 0 and (c) an error variance of roughly 0. We find that in the case of the UTI, where tracking error is clearly present, the buffer cash hypothesis does not serve to explain the bulk of tracking error.

We also explore the relationship between index volatility and index fund tracking error. When the index is more volatile, we expect index fund tracking error to be larger for two reasons: (a) Greater imprecision in achieving trades at the NSE closing price, (b) Liquidity is inferior when volatility is higher. In addition, if active management is present, then portfolio volatility is likely to be higher when index volatility is higher. We find that there is, indeed, a positive correlation between Nifty volatility and index fund tracking error. There is a remarkable homogeneity in the volatility - tracking error relationship, across different funds.

In summary, our study shows that while some funds have shown periods of very high tracking error, given the magnitude and consistency of tracking error obtained by the better performing funds, indexing as a strategy does seem implementable in India. To enable performance measurement, there is need for high quality data dissemination both by the funds and by the index provider. There is also a need for performance measurement using the methods of this paper, and their communication to customers of index funds.

The remainder of this paper is organised as follows. Section 2 is a survey of literature on index fund performance. Section 3 outlines the motivation and goals of the study. Section 4 describes the data sources employed and the methodology that is used in this paper. Section 5 documents the findings of the study. Finally, Section 6 concludes.

2.2 Issues

Index funds are arguably one of the most successful ideas that have flowed from academic economics into the real world. Indexing is based on the premise that if markets are fairly efficient, then it would prove difficult for active managers to obtain excess returns, after considering the higher fees and costs that they have to run up. Hence, instead of actively engaging in stock picking, index funds simply try to replicate the returns on a chosen market index and aim to deliver the returns and the risk of that index. Evaluating an index fund's performance boils down to observing how closely a fund tracks the underlying index. This is measured in terms of 'tracking error'. A well-managed index fund is one which exhibits low tracking error. The job of an index fund manager is therefore to minimise the tracking error.

In principle, managing an index portfolio requires investment in all constituent index securities in the exact proportion as the underlying benchmark. This is called a "full replication" approach. In practice, fund managers often face problems in replicating the benchmark index returns. Chiang (1998) describes the difficulties faced by managers in matching index returns. The index represents a mathematical calculation derived from a portfolio of securities that are not subject to the same market frictions as those faced by index mutual funds (Perold 1988).

Index funds incur transactions costs that are associated with portfolio implementation, re-balancing and capital flows. When the composition of the underlying index changes, either due to additions or deletions of constituents or due to corporate restructuring, the index assumes that the theoretical portfolio's new weights to each security can be achieved automatically. However, for the index fund, realigning the portfolio to mimic the underlying benchmarks involves physical trading in stock and the transactions costs incurred thereby.

Hence, factors driving tracking error include transactions costs, fund cash flows, uninvested/buffer cash, treatment of dividends by the index, corporate actions, and index composition changes. The liquidity of the underlying index securities also has implications for transaction costs (in terms of impact cost) and in turn the tracking error incurred by funds (Keim 1999).

As a result of ongoing subscriptions and redemptions, open–ended index mutual funds engage in flow–induced trading. Upon subscriptions, they are required to rapidly invest the cash flow across index securities, and upon redemptions, to sell securities to generate cash. Index funds often maintain buffer–cash to meet redemptions. This gives $\beta < 1$ and innately yields tracking error.

The size and timing of cashflows also has an impact on tracking error. Liquidity of index stocks has implications for transactions costs, both implicit and explicit. Full–replication index funds could be required to have part of their assets in illiquid index securities. When faced with large subscriptions or redemptions, the fund is forced to trade on the market under non–ideal liquidity conditions, resulting in high transactions costs and tracking error.

Typically there is a timing delay between when the index incorporates the dividend(at the ex–dividend date) and the actual receipt of the dividend by the index fund(after the ex–dividend date). Most indexes assume that accrued dividends are reinvested the day the stock goes ex–dividend. Actual receipt of dividends could take as long as several weeks.

When index securities are subject to corporate restructuring such as mergers, acquisitions or takeover by another company outside the index, there may be a timing delay between the date the company is removed from the index and the date the index fund receives the cash settlement. In addition, front-running by risk arbitraguers who acquire securities ahead of their inclusion in the index may also have an undesirable impact (Beneish & Whaley 1996).

If the index fund is perfectly aligned with the index, the volatility of the underlying index will not result in tracking error. Since the index fund owns exactly the same portfolio as the index, however volatile the index movements are, the fund will perfectly track them. If however, the index fund portfolio does not perfectly mirror the index, volatility of the underlying index will result in tracking error.

Index volatility is of much greater concern to funds that track the index by using optimisation techniques (Rudd 1980, Jansen & van Dijk 2002). They hold a portfolio that is different from the index portfolio in the hope of minimising transactions costs associated with trading illiquid stocks. The portfolio is chosen such that it has a high correlation with the index. Under situations of normal index volatility, such an optimised portfolio will track the index closely. However during periods of high index volatility caused by index securities not held by the optimised portfolio, the fund will fail to track the index, resulting in elevated tracking error.

An ideal index fund exactly replicates index returns. Indexing achieves the investor's goal of removing discretionary powers from the fund manager. Investors would expect the index fund return to under-perform the underlying index to the extent of the management fee. In reality, index funds under-perform beyond fees charged. For reasons cited above, tracking error will be inherent in index fund performance. This can give 'cover' to discretion in fund management.

A large number of performance evaluation studies have been undertaken for actively managed funds (Elton et al. 1993, Malkiel 1995, Gruber 1996, Elton et al. 1996, Daniel et al. 1997, Carhart 1997). However, despite the significant growth in the value of assets being indexed across the world, empirical research evaluating the performance of index funds is scarce. Frino & Gallagher (1999) examine the performance of passive equity fund managers in Australia. Frino & Gallagher (2001) evaluate the extent of S&P index fund tracking error and compare active fund and index fund performance. In this paper, we examine the tracking error experienced by index funds in India.

2.3 Motivation and goals of the study

The index fund industry in India is still young. Relatively little is known about the extent of tracking error experienced by index funds. Individual funds do report tracking error. However a systematic effort to measure and compare tracking error, using a consistent methodology, has not been undertaken. The short history with index funds in India implies that relatively little data is available. Yet, it is important to utilise this limited evidence in order to understand the limitations of indexing in India.

Index funds have attracted considerable attention in India. Most major fund houses have already launched index funds while many others are on way to launching. Our work is of direct usefulness to these fund houses. From the perspective of investors, our work helps in assessing the extent to which index funds deliver on their promise of exactly tracking the index. As of today, there is a lack of clarity on the extent to which index funds in India are able to accurately track the index. Our work helps produce some stylised empirical facts on this question.

Index funds may increasingly play a major role in public policy formulation. For example, the Dave Committee has recommended that equity investments by pension funds should exclusively be done using index funds. Similar arguments can, in principle, be made in the insurance sector also. While this recommendation is entirely defensible using conceptual arguments, we need to verify the extent to which accurate tracking is attainable under Indian conditions. The study helps to shed light on this, and thus advance these policy debates.

This paper is concerned with measuring and understanding the tracking error of index funds in India. We seek to address the following questions:

- Q1 What are the difficulties faced in measuring tracking error and how can they be overcome?
- Q2 What is the overall experience with tracking error of the competing index fund products in India today? Which are the index funds with the best fidelity?
- Q3 Can we decipher the source of tracking error? Is tracking error due to buffer cash maintained or due to active management at the fund?
- Q4 What can we say about the determinants of tracking error?

Fund	NAV data available from
Nifty-based	
IDBI Index I-Nit'99	July 1999
UTI Nifty Index Fund	Feb 2000
Templeton Franklin India Index Fund	Aug 2000
Templeton Franklin India Tax Fund	Mar 2001
Pioneer ITI Index Fund (NSE Nifty)	Aug 2001
FT India Index fund	Aug 2001
Benchmark ETF	Jan 2002
SBI Magnum Index Fund	Jan 2002
IL&FS Index Fund	Feb 2002
Prudential ICICI Index Fund	Feb 2002
HDFC Index Fund Nifty Plan	Jul 2002
Birla Index Fund	Sep 2002
LIC Index Fund Nifty Plan	Dec 2002
Tata Index Fund Nifty Plan(A)	Mar 2003
Tata Index Fund Nifty Plan(B)	Mar 2003
Sensex-based	
UTI Index Equity Fund	May 1997
Pioneer ITI Index Fund (BSE Sensex)	Aug 2001
FT India India Index Fund(BSE Sensex)	Aug 2001
ILFS Index Fund(BSE Sensex)	Feb 2002
LICMF Index Fund Sensex Advantage Plan	Dec 2002
LICMF Index Fund Sensex Plan	Dec 2002
Prudential ICICI ETF	Jan 2003
Tata Index Fund Sensex Plan(A)	Mar 2003
Tata Index Fund Sensex Plan(B)	Mar 2003

Table 2.1: Information availability about index funds in India

2.4 Data and Methodology

In India we have a fairly short time-series of index fund returns. The first index fund was launched in June 1999. Table 2.1 gives a list of existing index funds. Of these, we restrict ourselves to funds which have daily NAV data at least for a period of two years. This leaves us with four funds, IDBI Index I-Nit'99 Fund, UTI Nifty Index Fund, Templeton Franklin India Index Fund and Templeton Franklin India Tax Fund. The daily NAV data has been obtained from the funds and from CMIE[1]. We did not have access to data such as buffer cash maintained by funds, fund subscriptions/redemptions and impact cost for various basket sizes.

[1]Centre for Monitoring Indian Economy.

Foreign Index Funds	Net Assets (Million US$)	Tracking error(%)
Morgan Stanley S&P 500 Index-A	1991.90	0.041
Scudder S&P 500 Index Fd-AA	879.86	0.071
Vanguard 500 Index Fund-Inv	86298.83	0.078
Dreyfus Basic S&P 500 Stock I	1122.79	0.092
Merrill Lynch S&P 500 Index-D	1745.08	0.096
Fidelity Spartan 500 Index	7102.61	0.126
E*Trade S&P 500 Index Fund	85.30	0.153
Invesco S&P 500 Index Fund-Inv	278.19	0.157
Nationwide S&P 500 Index-A	498.89	0.177
Barclays S&P 500 Stock Fund	1420.52	1.126

Source: Bloomberg

Table 2.2: Some international evidence on tracking error

2.4.1 Tracking error

Roll (1992), Pope & Yadav (1994), and Larsen & Resnick (1998) identify a number of ways in which tracking error can be measured. M.Rudolf et al. (1999) investigate models for minimising the tracking error between the returns of a portfolio and a benchmark. We measure tracking error as the standard deviation of returns differences between the market portfolio and the index fund. Suppose we have daily time series r_{Mt}, r_{pt}, $e_p = r_{Mt} - r_{pt}$. We focus on tracking error as $\sqrt{250}\sigma_{e_p}$.

It is conventional to think of tracking error on an annualised basis. Suppose TE=0.5. Then the 95% confidence interval for index fund returns over one year will be $\pm 1\%$ compared with returns on the index. We measure the overall tracking error for the entire life of the fund. To enable comparison across funds, we compute the tracking error for the last two years ending 31/3/2003, a period for which we have NAV data for all funds under study. To capture the time dynamics of changes in tracking error, we calculate the rolling tracking error using a 250–day moving window.

Most index funds promise to maintain a particular level of tracking error. Table 2.2 gives some evidence of the magnitude of tracking errors incurred by index funds in the US. This suggests that the values for TE could be in the range of about 4 basis point to 120 basis points.

Fund	Span of data	Days with NAV missing	Percent
IDBI Index I-Nit'99 Index Fund	919	16	1.45%
UTI Nifty Index Fund	753	11	1.46%
Templeton Franklin India Index Fund	659	2	0.30%
Templeton Franklin India Tax Fund	518	3	0.60%

Table 2.3: Problems with Indian data

2.4.2 Difficulties in measurement

Achieving low tracking error is not easy. Suppose e is a one–day error. Further suppose $E(e) = 0$. Then the variance of the error is:

$$\begin{aligned} \text{Var}(e) &= E(e^2) - [E(e)]^2 \\ &= E(e^2) \\ &= \frac{\text{SSE}}{T} \\ \text{so} \quad \text{SSE} &= T\sigma_e^2 \end{aligned}$$

Suppose a fund wants to maintain an annualised tracking error of 0.5. This means its daily tracking error, σ_e, can at most be 0.0316. This implies that the SSE should be equal to 0.25. This is the 'budget' for one–year of SSE for a fund that promises a tracking error of 0.5. Now suppose we get *one day* with $r_M = 2\%$ and $r_p = 2.5\%$, i.e. $e = 0.5$ and $e^2 = 0.25$, this uses up the full year's 'budget' for SSE. Hence index funds need to be very careful in terms of consistently tracking the index.

This sensitivity also highlights the importance of sound data management. Small problems in measurement make it impossible to obtain low tracking error values like 0.5. To correctly measure index fund performance, we need high quality data.

Ideally, index fund NAVs should be available for every day that the index trades. One problem with Indian data is that of missing NAVs values. Table 2.3 shows the number of days of missing NAVs for the four funds under study. We use Table 2.4 to try to understand the impact of missing data on tracking error. If we define $r_{M,3} = M_3/M_2$ and $r_{p,3} = N_2/N_1$,

Date	Index level	Fund NAV
t_1	M_1	N_1
t_2	M_2	missing
t_3	M_3	N_2
t_4	M_4	N_3

Table 2.4: Snapshot of a returns series with missing data

this will give a huge error $e_{p,3} = r_{M,3} - r_{p,3}$. This will throw off the TE calculation, as argued above.

We propose an alternative heuristic. Faced with the data in Table 2.4, we drop points t_1, t_2 and t_3. The only data-point that is used is returns from $3 \rightarrow 4$. While this appears to waste data, it avoids the bias in tracking error estimates caused by the erroneous e value.

While such an approach appears logically sound, there is a need to evaluate the economic significance of a small incidence of missing data. We conduct a Monte Carlo simulation to measure the impact of missing data on tracking error calculations. We simulate a million points of data from an imaginary index with the daily standard deviation of returns, σ_M, equal to 1.4. We focus on an index fund with a true daily tracking error σ_e, and a probability of missing data of λ.

We measure tracking error of the simulated index fund by two methods of handling missing data – one, by using the standard practice of ignoring days with missing NAVs, and two, by using the alternative heuristic suggested by us above. We calculate the exaggeration in tracking error obtained by ignoring days with missing NAVs.

We find that fairly modest rates of missing data (e.g. 0.4% or 1 point per year) suffice to bias annualised TE from 1% to 1.74%. Figure 2.1 shows the exaggeration observed in tracking error due to incorrect handling of missing data.

Our finding reinforces the need for high quality data. With a growing number of index funds now available to investors, measurement of tracking error becomes an important issue. Index maintainers and index funds need to ensure an identical set of dates on which r_M and r_p is reported. If this is not the case, $r_{M,t} = M_t/M_{t-1}$ should not be compared against $r_{p,t} = N_t/N_{t-2}$. In this paper, we use the 'alternative heuristic' shown above.

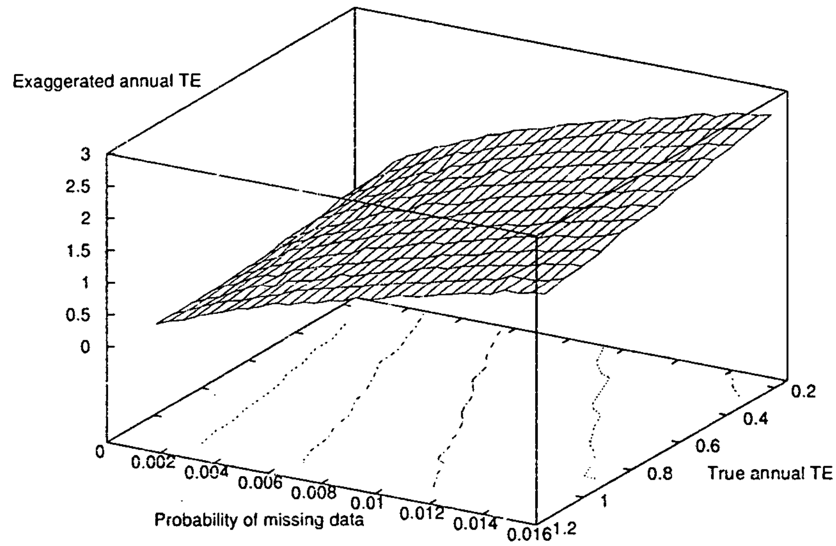

Figure 2.1: Exaggeration in tracking error due to incorrect handling of missing data

2.4.3 Buffer cash as a source of tracking error

Many index funds hold some amount of 'buffer cash', in order to cope with redemptions. This is clearly one source of tracking error.

Suppose a fund holds a λ fraction in cash which earns zero return. With the remaining $(1 - \lambda)$, the fund does perfect indexation. Further, suppose the return on the market is normally distributed with mean zero and standard deviation σ_M^2. Then:

$$\begin{aligned} r_M &\sim N(0, \sigma_M^2) \\ e_j &= r_M - (1-\lambda) r_M \\ &= \lambda r_M \\ \text{so} \quad \sigma_{e_j} &= \lambda \sigma_M \end{aligned}$$

If for example, $\sigma_M = 1.4$ and $\lambda = 0.01$, this suggests that $\sigma_{e_j} = 0.014$. In spite of perfectly indexing $(1 - \lambda)$, the fund would invariably incur an annualised tracking error of 0.22%, purely because of the 1% buffer cash held by it.

Broadly speaking, investors should be relatively benign towards index funds that hold buffer cash, and suffer tracking error as a consequence. In contrast, investors should be concerned when funds engage in active management. Both paths involve tracking error, and we need to find ways of distinguishing the two.

2.4.4 Regression framework

The market model of Sharpe (1964) captures the relationship between return on a security and the return on the market index for the same period. We use this to model the returns on an index fund. The return on the index portfolio is regressed against the return on the benchmark/index portfolio. The α provides an estimate of the excess return/value added by the index fund and the β gives an estimate of the sensitivity of index fund returns to returns on the market index.

$$r_{pt} = \alpha + \beta r_{Mt} + \epsilon_{pt} \tag{2.1}$$

where:

r_{pt} – return on index portfolio for a given period

r_{Mt} – return on market index for the same period

α – intercept term, represents excess return over market, should *approx* zero.

β – slope of the regression, represents systematic risk, should ideally be close to one.

Suppose the fund holds a fixed fraction λ of cash and does perfect indexing with the remainder. If this be the case, in the regression Equation 2.1, we will observe the following three effects:

1. A highly stable $\beta = 1 - \lambda$,
2. We should not get $\beta > 1$.
3. $\mathrm{Var}(\epsilon) \approx 0$.
4. $\alpha \approx 0$.

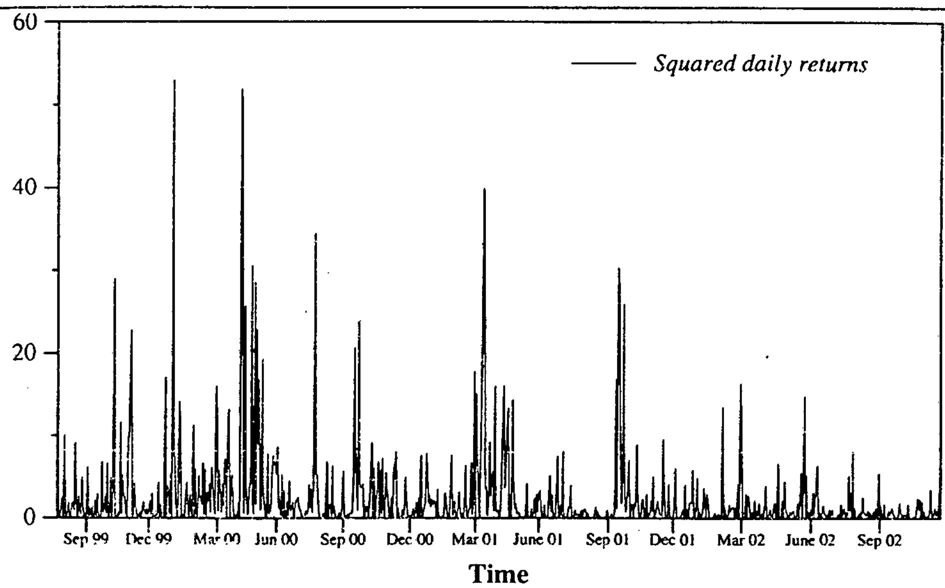

Figure 2.2: Time series of daily squared returns on Nifty

5. $R^2 \approx 1$.

We engage in rolling estimation of β, var(ϵ) and α to look for these phenomena.

2.4.5 Index volatility and tracking error

Research on the time-series variation of the bid/offer spread suggests that when expected volatility is high, economic agents demand a larger bid/offer spread. In addition, high volatility can yield tracking error through the imprecision introduced into index program trades, which are executed over a finite window of time. We would hence like to learn more about the relationship between tracking error and index volatility.

Towards this goal, we first need estimates of index volatility. The returns in many financial markets are not well modelled by an independent and identically distributed process. Figure 2.2 shows the time series of daily squared returns on Nifty. This shows time-varying volatility, and volatility clustering. A variety of tests strongly reject unconditional normality of Nifty returns. We model the time–varying volatility of Nifty returns by using an AR(1) - GARCH(1,1) model (see Appendix). We find that the AR(1) - GARCH(1,1) model mostly removes non–normality in the series.

$$r_t = \alpha_0 + \alpha_1 r_{t-1} + \epsilon_t \quad (2.2)$$

$$H_t = \gamma_0 + \gamma_1 \epsilon_{t-1}^2 + \gamma_2 H_{t-1} \quad (2.3)$$

where $\epsilon_t \sim N(0, H_t)$. Equation 2.2 models the autoregressive conditional mean and Equation 2.3 models the conditional variance of the Nifty returns series. Using this model we get a daily H_t time–series for Nifty variance. We try to explain tracking error in terms of Nifty volatility measured as the square root of conditional variance, H_t. This is done using the regression:

$$\sigma_{et} = \alpha_i + \beta_i log(\sigma_{bt}) + \epsilon_t \quad (2.4)$$

We use estimates of σ_e, the tracking error, over one week of fund returns at a time. These weekly estimates of index fund tracking error are regressed against σ_{bt}, weekly estimates of Nifty volatility.

2.5 Findings

2.5.1 Replicating index returns

Table 2.5 gives the tracking error for the funds under study from inception till 31/03/2003. The Templeton Franklin India Tax Fund has the lowest tracking error, and achieves values which compare well with those seen in developed markets. UTI Nifty Index Fund shows the highest tracking error. Table 2.6 gives the tracking error across a comparable time period for two years ending 31/03/2003. IDBI Index I-Nit'99 and the two Templeton Franklin Index Funds show acceptable levels of tracking error, whereas the UTI Nifty Index Funds shows a further deterioration in performance in recent times.

We do a quick comparison of the time–variation in Nifty volatility and the index fund volatility, both measured as rolling standard deviation of returns. Figure 2.3 shows the rolling volatility of Nifty and the four index funds across comparable time periods. The volatility of UTI Index Fund significantly deviates from that of the underlying Nifty,

Product	From	Tracking error
IDBI Index I-Nit'99 Fund	26/07/1999	2.09
UTI Nifty Index Fund	27/03/2000	9.97
Templeton Franklin India Index Fund	04/08/2000	0.81
Templeton Franklin India Tax Fund	26/02/2001	0.79

Table 2.5: Tracking error incurred by index funds since inception

Product	Tracking error
IDBI Index I-Nit'99 Fund	0.68
UTI Nifty Index Fund	10.97
Templeton Franklin India Index Fund	0.74
Templeton Franklin India Tax Fund	0.79

Table 2.6: Tracking error incurred by index funds over the last two years

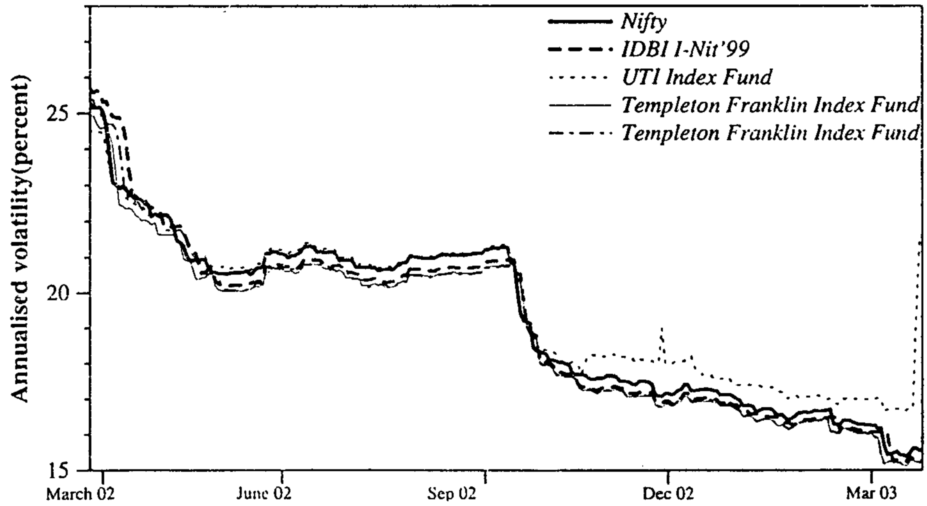

Figure 2.3: Rolling volatility of Nifty and Nifty–based index funds

suggesting that the two portfolios could be different. Figure 2.4 to 2.7 show the time-variation in tracking error. IDBI Index I-Nit'99 Fund showed high tracking error during the initial year and a half, after which it has been consistent and low. The tracking error for UTI Nifty Index Fund has been highly inconsistent. Both the Templeton Franklin funds show consistently low tracking errors since inception.

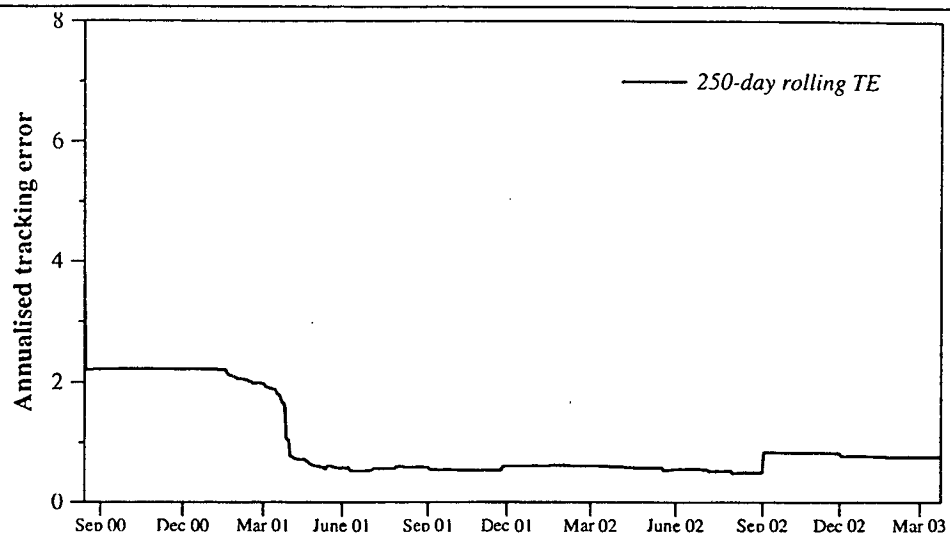

Figure 2.4: Rolling tracking error of IDBI Index I–Nit'99 Fund since inception

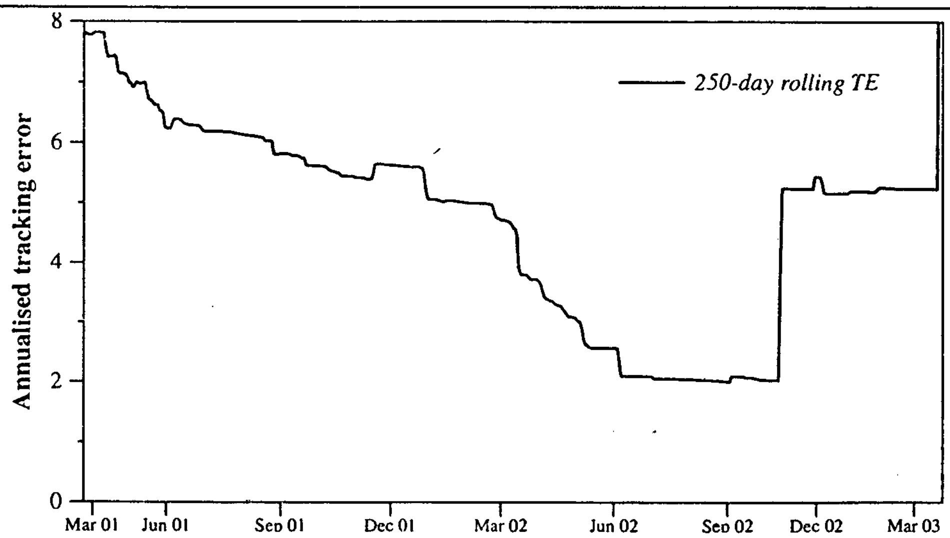

Figure 2.5: Rolling tracking error of UTI Nifty Index Fund since inception

2.5.2 Tracking error and buffer cash

We regress return on the index portfolio, r_{ip}, on return on the market, r_{Mi}, and estimate the α, β and variance of ϵ for the single market model. Table 2.7 gives these parameters since inception. Both the Templeton Franklin funds show a highly stable beta. The R^2 of the regression is almost one, suggesting that most of the tracking error incurred by these funds could be explained by the buffer cash held. The beta of UTI Nifty Index Fund has

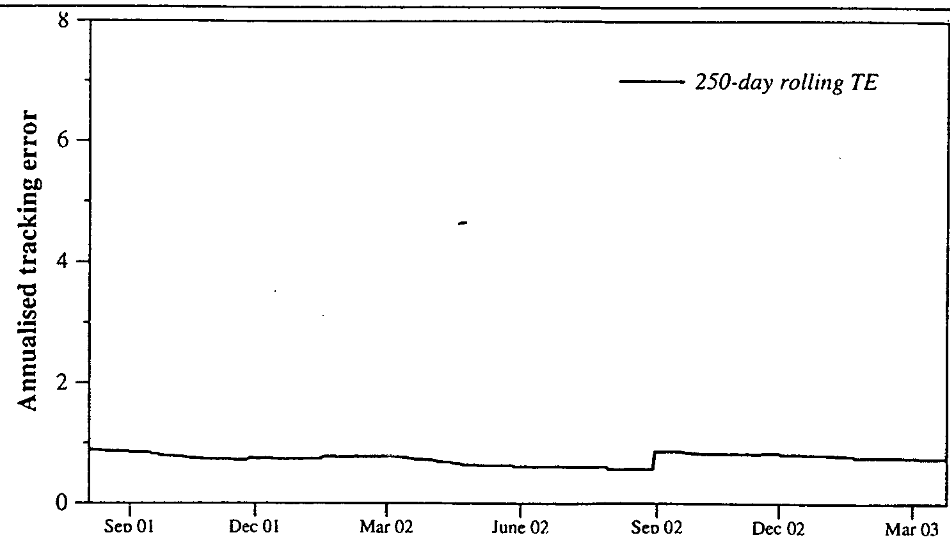

Figure 2.6: Rolling tracking error of Templeton Franklin India Index Fund since inception

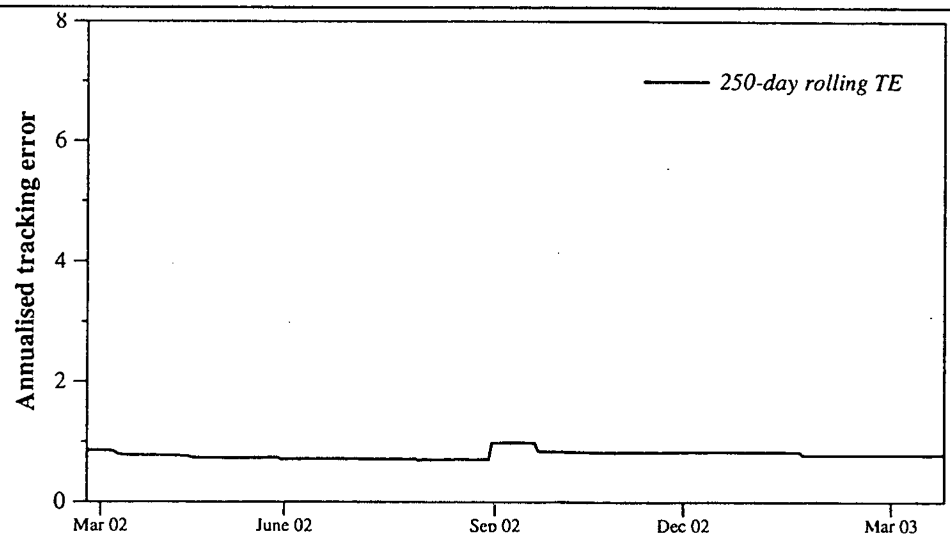

Figure 2.7: Rolling tracking error: Templeton Franklin India Tax Fund

been highly unstable, and in recent times has hovered around 1.

To discern if the fund incurs tracking error due to buffer cash held or due to active management, we engage in rolling estimation of β, ϵ and α. Figure 2.8 to Figure 2.11 give estimations of rolling beta. Figure 2.12 to Figure 2.15 give estimations of rolling variance of errors and alpha. The two Templeton Franklin funds and the IDBI index fund exhibit the following:

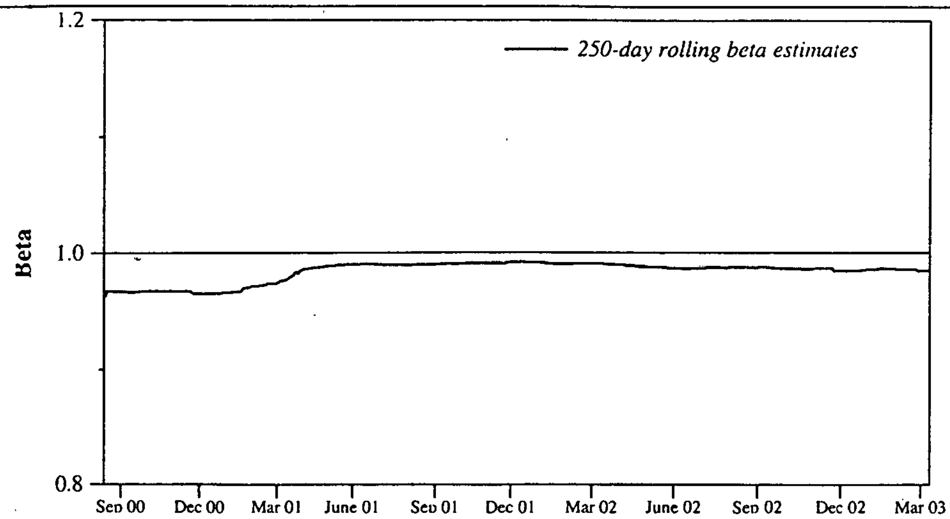

Figure 2.8: Rolling β : IDBI Index I-Nit'99 Fund

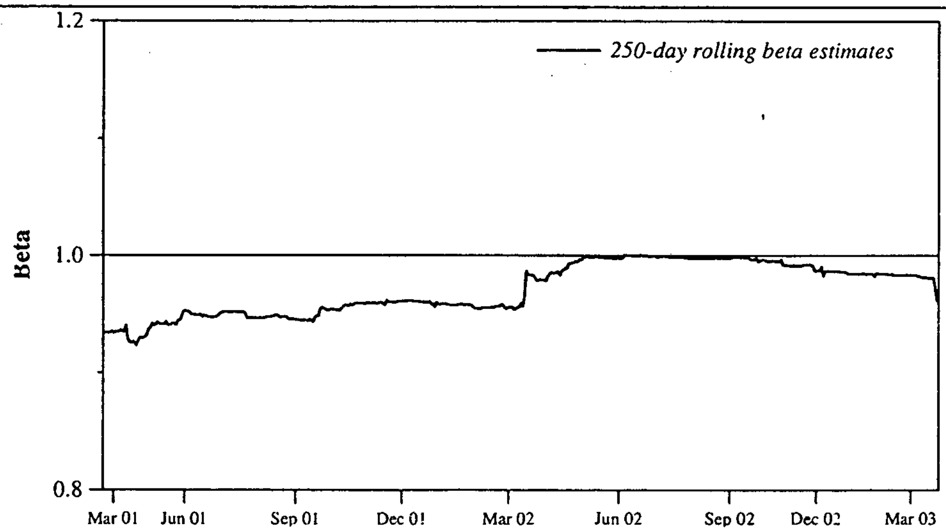

Figure 2.9: Rolling β : UTI Nifty Index Fund

1. A highly stable β.

2. $\dot{V}ar(\epsilon) \approx 0$.

3. $\alpha \approx 0$.

4. $R^2 \approx 1$.

The UTI fund however exhibits almost the opposite:

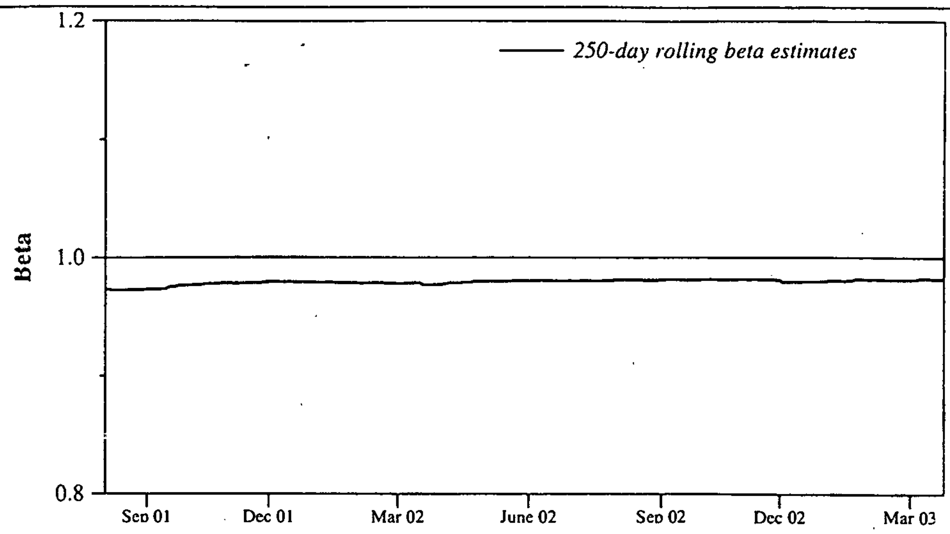

Figure 2.10: Rolling β : Templeton Franklin India Index Fund

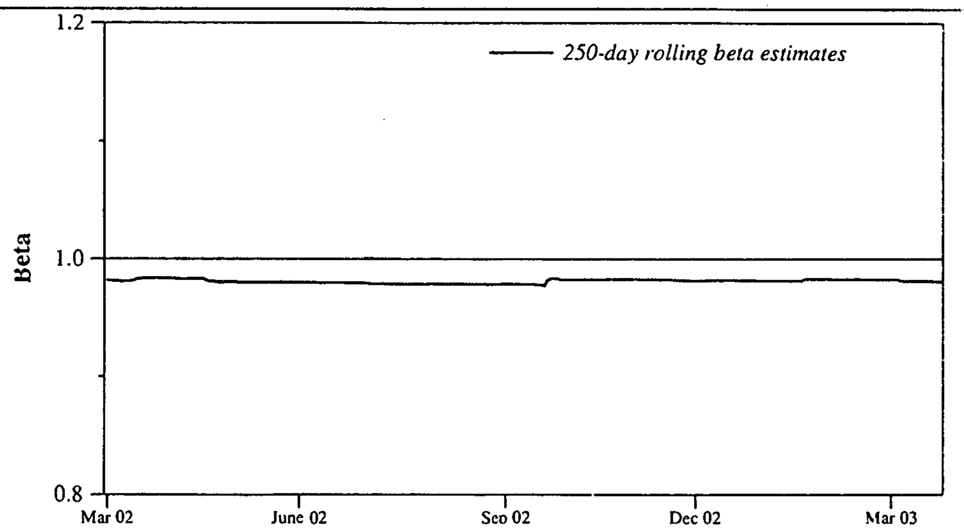

Figure 2.11: Rolling β : Templeton Franklin India Tax Fund

1. A highly unstable β.
2. A highly unstable $Var(\epsilon)$ that is different from 0.
3. $\alpha \approx 0$ and sometimes positive.
4. R^2 equal to 0.8423.

This may suggest that the tracking error obtained by UTI Nifty index fund is not due to buffer cash held, but probably due to active management.

Product	Alpha	Beta	$Var(\epsilon)$	R^2
IDBI Index I-Nit'99 Fund	-0.0031	0.9774	0.0162	0.9932
UTI Nifty Index Fund	-0.0069	0.9506	0.3929	0.8423
Templeton Franklin India Index Fund	-0.0034	0.9766	0.0014	0.9992
Templeton Franklin India Tax fund	-0.0029	0.9817	0.0020	0.9988

Table 2.7: Single market model regression results

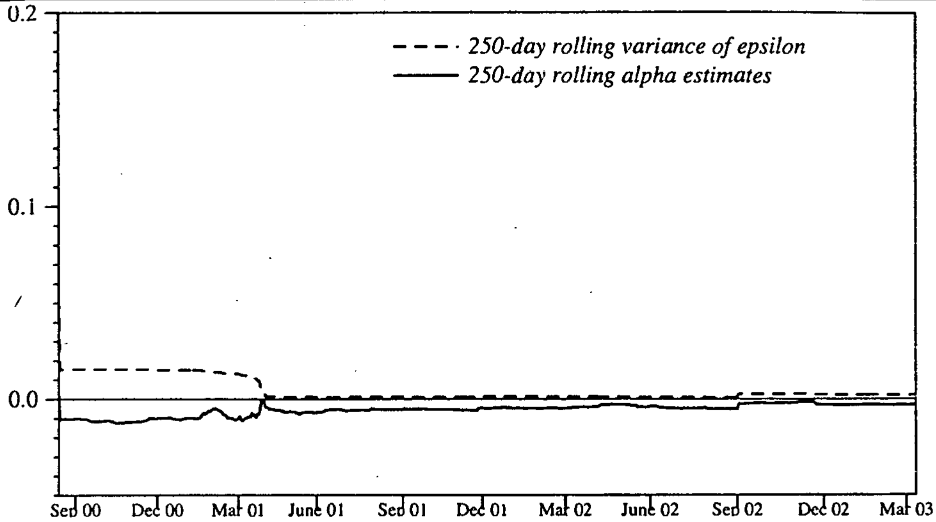

Figure 2.12: Rolling $Var(\epsilon)$ and α : IDBI Index I-Nit'99 Fund

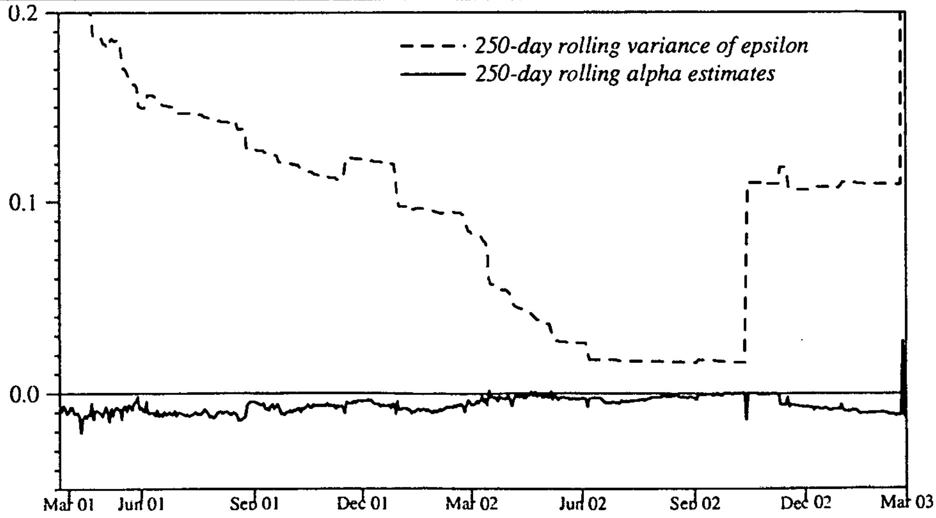

Figure 2.13: Rolling $Var(\epsilon)$ and α : UTI Nifty Index Fund

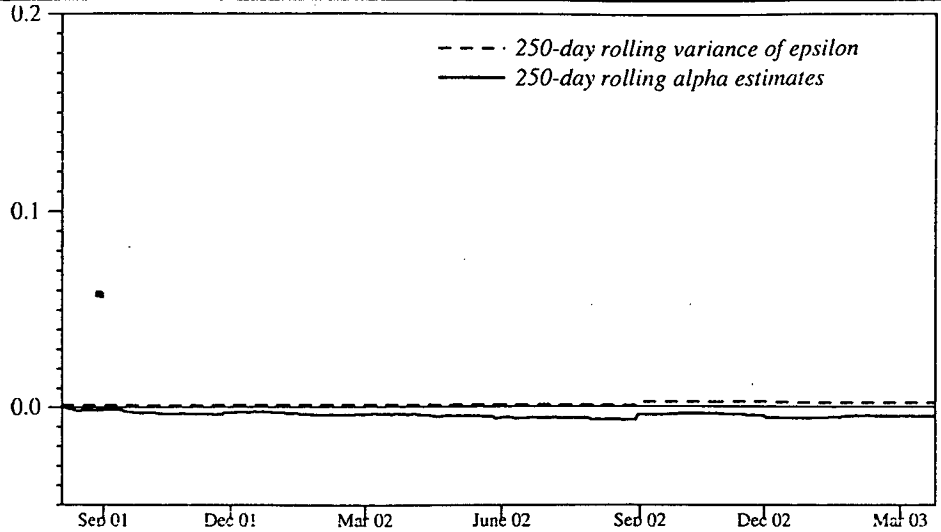

Figure 2.14: Rolling $Var(\epsilon)$ and α : Templeton Franklin India Index Fund

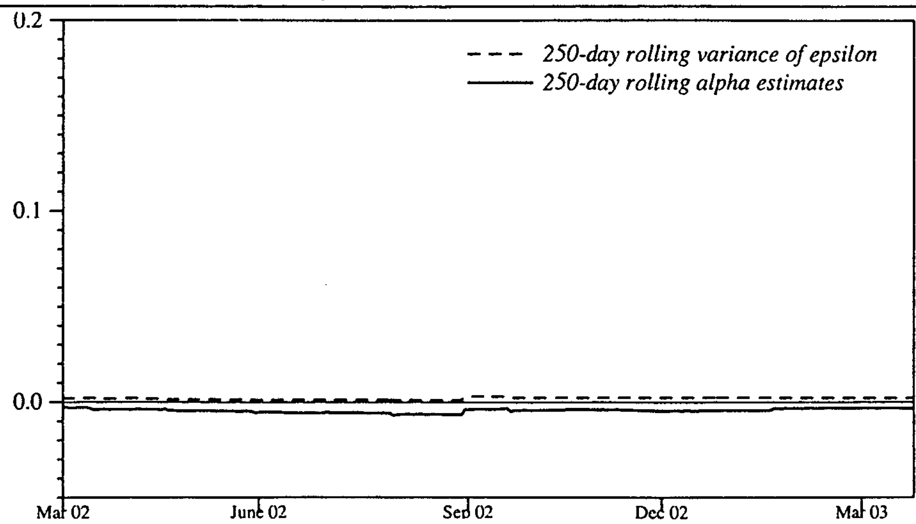

Figure 2.15: Rolling $Var(\epsilon)$ and α : Templeton Franklin India Tax Fund

2.5.3 Nifty volatility and tracking error

We model time–varying volatility of Nifty using the AR(1) – GARCH(1,1) model. Table 2.8 gives the model parameters for daily returns. Figure 2.16 shows the variance estimates obtained from the model. We try to explain tracking error in terms of Nifty volatility. Table 2.9 shows the regression results for the four funds. We conclude that Nifty volatility is positively correlated with index fund tracking error. Its impact upon various highly

Parameter	Coefficient	t
Mean equation		
Intercept	0.0378784	0.77
AR(1)	0.0689488	1.76
Volatility equation		
Intercept	0.1242849	5.60
ARCH(1)	0.1401796	7.30
GARCH(1)	0.8120375	41.50

Table 2.8: AR(1)- GARCH(1,1) model estimates for daily returns

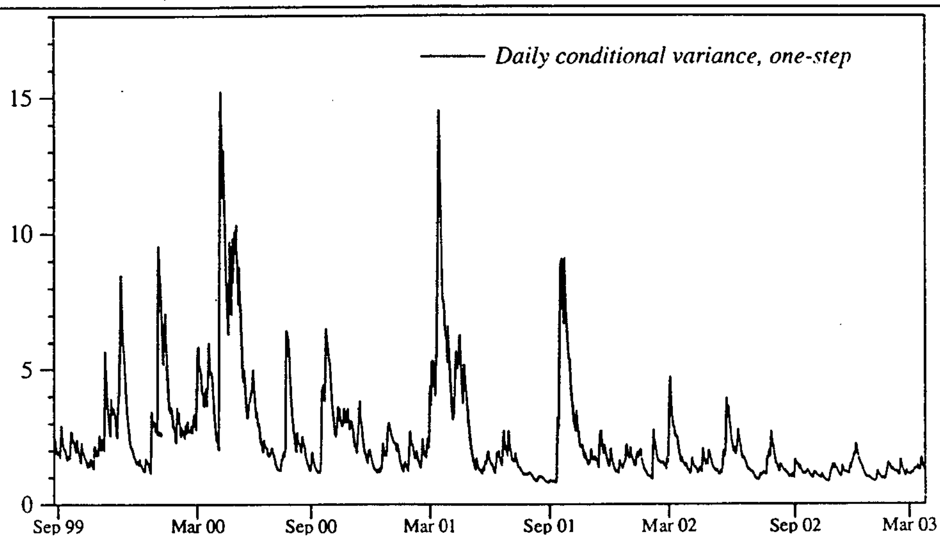

Figure 2.16: Variance estimates from AR(1)-GARCH(1,1) model

Fund	Intercept	Coefficient	R^2
IDBI Index I-Nit'99 Fund	0.5630496	1.977154	0.4182
UTI Nifty Index Fund	0.6979911	1.727080	0.2919
Templeton Franklin India Index Fund	0.6064298	1.729016	0.4321
Templeton Franklin India Tax Fund	0.6086619	1.691724	0.4386

Table 2.9: Regression estimates

heterogeneous funds seems to be remarkably alike.

2.6 CONCLUSION

In this study, we look at the performance of index funds in India. Index management requires supreme care in data management – by fund managers in terms of providing daily NAVs, dividend and expenses related data, and by index providers in terms of providing a neat time–series of daily index values and impact cost data for various basket sizes. It should be possible for an external observer to simulate an ideal index fund, assume zero transactions costs, and replicate the index. Our study shows that incorrect handling of data can result in significantly exaggerated values of tracking error. We suggest an alternative heuristic to handle the missing data problem encountered by us.

Using a comparable period of performance, we find that the tracking error for index funds in India ranges between 0.68% and 10.97%. The Templeton Franklin funds seem to be the best of the lot, consistently maintaining low tracking errors. The IDBI Index I-Nit'99 Fund showed high tracking error during the first half of its life, but has reduced since. The UTI Nifty Index Fund has fared very poorly on replicating index performance, exhibiting significantly high tracking error. Our rolling tracking error calculations to study the time–dynamics of tracking error suggest a *learning effect* over time.

We study buffer cash as a source of tracking error. Funds that hold buffer cash invariably run up tracking error. In the guise of holding buffer cash, funds could indulge in active management. We try to decipher this behaviour across funds by studying the single market model parameters for these funds. Except in the case of UTI Nifty Index Fund, we observe a highly stable beta, and alpha and variance of errors approximately equal to zero.

We model the time–varying volatility of Nifty returns using the AR(1)–GARCH(1,1) model and try to explain tracking error in terms of index volatility. We conclude that Nifty volatility is positively correlated with index fund tracking error.

While some funds show unacceptably high tracking error, the consistency in performance of the better run funds suggests that it is possible to attain fairly low levels of tracking error under Indian conditions.

Chapter 3

Improving index fund implementation in India

3.1 Introduction

While indexing may seem like an easy strategy to implement, in practice, fund managers often face problems in replicating the benchmark index returns. The index represents a mathematical calculation derived from a portfolio of securities that are not subject to the same market frictions as those faced by index mutual funds. Index funds incur transactions costs that are associated with portfolio implementation, re-balancing and capital flows.

The first index fund in India was launched in June 1999. While the index fund industry in India is still young, most major fund houses already have funds tracking an index. Index funds seek to deliver index returns. However, replicating index performance may not be as easy as it seems. In the developed markets, on a year–by–year basis, even the most established index funds have not been able to consistently match their benchmark index returns (Chiang 1998). In the Indian context, while some index funds have been able to consistently attain low levels of tracking error, there do seem to be periods where certain index funds incur unusually high tracking errors, and appear to depart from the discipline of indexation (Fernandes 2003). Even if we only focus on the best-performing funds, i.e. those incurring the lowest tracking error, the magnitude of the tracking error that we see in India is considerably in excess of the best values seen worldwide.

In this chapter we focus on issues concerning implementation of index funds. We seek to offer some ideas on how index funds can be managed better. We seek to gain insights into how these funds can use index futures to reduce tracking error. We also hope to get a sense of how much reduction in tracking error can be obtained by the use of index futures. To study the effectiveness of using Nifty futures for index replication, we study the correlation between Nifty spot and one–month Nifty futures. We use rolling window estimates of the correlation to see how it has changed over a period. We find that the one–month Nifty futures are highly correlated with the Nifty spot and hence would prove to be effective in replicating the index. The rolling window correlations since inception of the futures market show values between 0.93 and 0.97.

Index funds incur tracking error for a variety of reasons. Factors driving tracking error include transactions costs, fund cash flows, uninvested/buffer cash, treatment of dividends by the index, corporate actions, and index composition changes. The liquidity of the underlying index securities also has implications for transaction costs (in terms of impact cost) and in turn the tracking error incurred by funds. We focus on tracking error arising out of uninvested/buffer cash and delays in dividend receipts.

Open ended index funds are faced with subscriptions and redemptions. When subscriptions happen, the fund is required to invest the money across index stocks and when redemptions happen, the fund is required to sell part of its index portfolio to generate cash. In order to handle redemptions, index funds usually maintain buffer cash. This buffer cash is typically invested into liquid instruments which lie at the near–end of the zero coupon yield curve. To the extent of buffer cash held, the fund has a $\beta < 1$, which in turn results in tracking error.

Using the single market model framework, we expect an index fund to normally suffer only the variance of errors as the tracking error. However. to the extent that $\beta \neq 1$, the index fund additionally suffers tracking error. For example. if the market has a daily volatility of 1.4 and the beta of the index fund is 0.98, this suggests that the index fund would incur an additional daily tracking error of 0.028 or 0.44% annualised. If a fund holds a fixed fraction of cash and does perfect indexation with the remainder, we would notice the following observable effects: (a) a highly stable beta which is less than one, (b) alpha of roughly 0 (c) an error variance of roughly 0 and (d) R^2 close to 1.

We simulate two funds, one naively holds buffer cash while the other holds buffer cash and uses index futures to bring it beta back to one. We see the extent to which the use of index futures reduces the tracking error of the fund. We also study index funds in India which exhibit the above symptoms of tracking error arising due to buffer cash, namely the IDBI Index I-Nit'99 fund and the Templeton Franklin India index fund. We assume that fund beta falls short of one solely due to reasons of buffer cash held by the fund. For these funds, we calculate the actual tracking error incurred and compare it with the tracking error that the funds would incur had they to readjust their betas using Nifty futures. Our findings show significant reductions in tracking error are possible by using index futures. Across the funds under study, we see a reduction in tracking error in the range of about 50 to 68 basis points.

Most equity indexes assume that dividends are paid on the ex–date and are reinvested immediately. Unfortunately, in the real world, index funds receive money well after ex–date. Often it could take several weeks before the dividends come in the hands of the fund. Due to this delay in receipt of dividend, in a rising market, the fund suffers cash drag and will lag the market. In a falling market, the reverse is true. To study the magnitude of tracking error incurred due to dividend delays and the extent to which this can be avoided, we simulate a 50 crore fund indexed to the Nifty. We assume that the fund perfectly tracks the index, and that tracking error comes purely out of dividend delays. The index incorporates dividends on ex–dividend date, but the fund receives dividends three weeks later. We calculate the tracking error for the fund under the following situations: (a) Index stocks go ex–dividend, the fund does nothing and suffers tracking error due to delays in dividend receipts. (b) Index stocks go ex–dividend, the fund takes a long position in one month Nifty futures contracts to the extent of dividend declared. Our findings show that delays in dividend receipts add significantly to tracking error. The use of the index futures market can reduce this tracking error by about 30–35 basis points.

In summary, our study shows that significant improvements in index fund performance are possible by using index futures. The high correlation between the Nifty spot and one–month futures suggests that these could be effectively used for reducing tracking error caused both due to buffer cash held and due to delays in dividend receipts. While implementing index funds using index futures, the fund would have to bear in mind the existence of factors such as impact costs, initial margins and MTM margins to be paid on the futures positions. To the extent these exist, the benefits of using the futures market would reduce. However, the magnitude of reduction in tracking error obtained by futures usage far outweighs the costs involved.

The remainder of this study is organised as follows. Section 2 is a survey of literature on index fund implementation. Section 3 outlines the motivation and goals of the study. Section 4 describes the methodology that is used in this paper. Section 5 documents the findings of the study, Section 6 highlights some implementation issues. Finally, Section 7 concludes.

3.2 Issues

The main challenge in managing an index fund is to minimise the tracking error. Most fund managers are subject to a limit on ex–ante tracking error (C.Blitz & Hottinga 2001). In the index world every basis point counts. To track the index closely, the fund manager must choose the right approach to index fund implementation. An equity index portfolio can be established either by purchasing equities directly, or by getting exposure to a particular index by using derivatives. The most straightforward approach is to purchase a full set of the index stocks in the exact proportions as they exist in the index. This is called full replication and is the most appropriate implementation strategy when all the stocks in the index are liquid. When an index contains stocks that are less liquid, optimisation may be used, but this method requires good historical data for the stocks in the index. Sampling is typically used when the stocks in the index are not liquid and historical data is insufficient to be able to properly develop a good factor model.

In a frictionless world, constructing index funds is a simple task. However, in the real world, index fund implementation involves transactions costs that are associated with portfolio implementation, re-balancing and capital flows. either due to additions or deletions of constituents or due to corporate restructuring. The index assumes that the theoretical portfolio's new weights to each security can be achieved automatically. However, for the index fund, realigning the portfolio to mimic the underlying benchmarks involves physical trading in stocks and the transactions costs incurred thereby.

The other approach to indexing is a derivatives based approach. In this, the exposure to the underlying index is obtained through the purchase of futures contracts Mason et al. (1995). The dynamics of a derivatives–based strategy is fairly simple. Instead of buying physical securities to replicate the index, futures contracts are purchased, with cash invested to yield a short–term interest rate. The arbitrage relationship between the spot and the futures will ensure that the profits/losses on the futures and the interest earned on the invested cash will closely track the total return on the index. Miller &

Meckel (1999) focus on the use of derivatives contracts to index a portfolio and generate enhanced returns in the process. In most markets, where the rates of return embedded in index futures prices are slightly in excess of the riskless rate of return, the 'synthetic index fund' can systematically earn slightly higher returns than the index. While derivatives–based indexing is increasingly becoming popular (Miller & Meckel 1999), in this study we do not look at the implementation of this strategy. We try to understand how a cash–based full replication index fund can make use of index futures to reduce tracking error.

3.3 Motivation and goals of the study

While some index funds in India appear to have obtained consistently low levels of tracking error, the magnitude of tracking error obtained by these funds in India is far greater than that exhibited by the best performing funds worldwide. Since the goal of an index fund is to minimise tracking error, even a few basis points of savings in tracking error directly contributes to the funds performance. While funds could incur tracking error due to numerous reasons, in this study we try to measure the impact of two factors on tracking error, buffer cash held and delays in dividend receipts.

These two issues are directly relevant insofar as they appear to be prominent sources of index fund tracking error. In addition, the ideas used in addressing these problems may pave the way for other innovations in index fund management in India. This study seeks to answer the following questions

- Q1 How can index funds achieve their target levels of buffer cash, in order to cope with most redemptions, but obtain lower levels of tracking error while doing so? In other words, how best can buffer cash be implemented?
- Q2 How can index funds reduce tracking error which results from delays in receipts of dividends?

The main idea in the study is to use the index futures to reduce this tracking error. We seek some ideas on how index funds could be implemented using index futures and to what extent their usage would reduce the fund tracking error.

3.4 Methodology

3.4.1 Measuring Nifty basis risk

The Nifty futures market is a fairly young market that commenced in 2000. While the volumes on the market have increased greatly, there doesn't seem to be much arbitrage capital coming into the market. (Shah 2003) expresses concerns about mispricing in this market due to lack of systematic arbitraguers. To study the effectiveness of Nifty futures for index replication, we examine the correlation between Nifty spot and one–month Nifty futures. To the extent that the correlation is imperfect, the Nifty futures would fail to track the Nifty spot, and prove to be a flawed instrument for obtaining index tracking. We use rolling window estimates of the correlation to see how it has changed over time.

3.4.2 Uninvested/buffer cash

As a result of ongoing subscriptions and redemptions, open–ended index mutual funds engage in trading. Upon subscriptions, they are required to rapidly invest the cash flow across index securities, and upon redemptions, to sell securities to generate cash. Index funds often maintain buffer–cash to meet redemptions. This gives $\beta < 1$ and innately yields tracking error.

In the market model

$$r_j = \alpha + \beta r_M + \epsilon$$

where $r_M \sim N(0, \sigma_M^2)$. The index fund normally needs to only suffer $\text{Var}(\epsilon)$ as the tracking error. However, to the extent that $\beta \neq 1$, the index fund additionally suffers tracking error to the tune of $(1-\beta)^2\sigma_M^2$.

For example, if $\sigma_M = 1.4$ and $\beta = 0.98$, this suggests that the additional tracking error incurred by the fund, $\sigma_{e_p} = 0.028$ or 0.44% annualised. The variance of Nifty is higher as compared to the variance of indexes in most countries. Hence handling the buffer cash problem becomes an important issue in the Indian setting.

Assume a fund holds a particular level of buffer cash, and does perfect indexing with the non–buffer amount. Under the single market model framework, we expect to observe the following effects in the data:

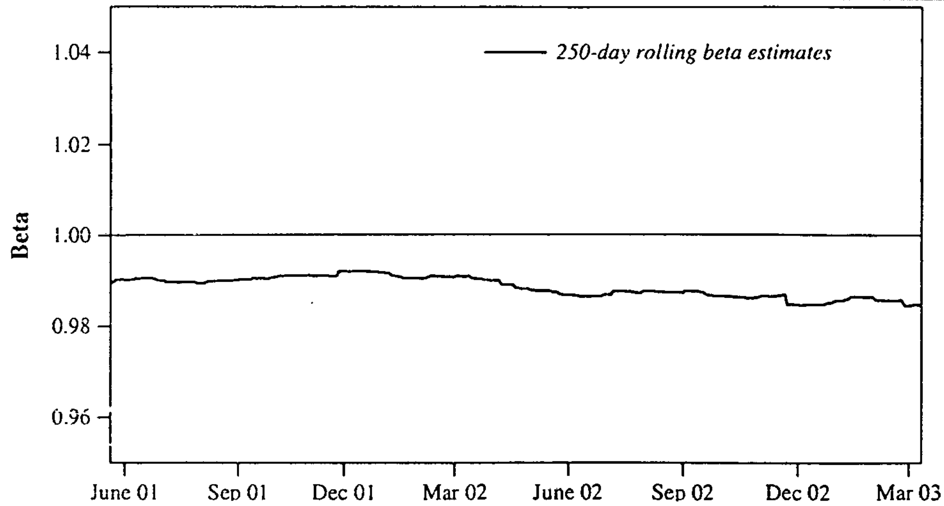

Figure 3.1: Rolling β estimates: IDBI I-Nit'99

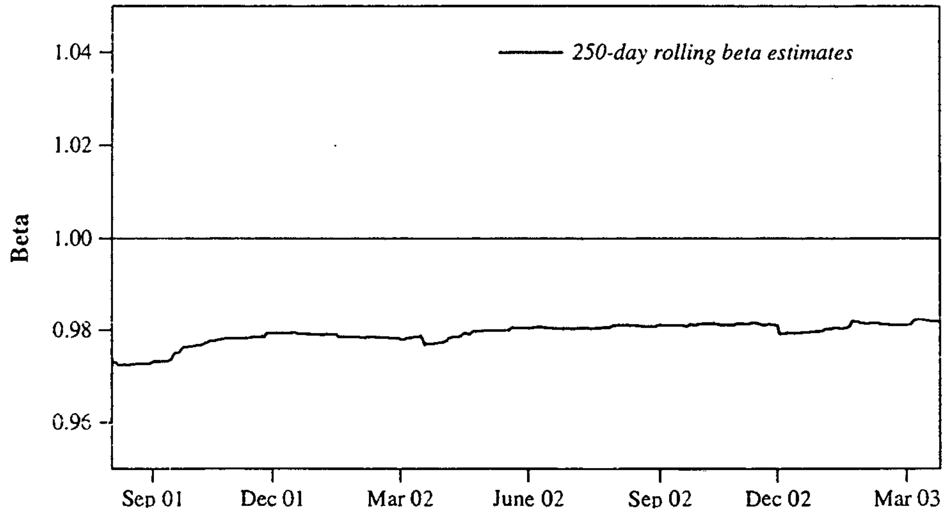

Figure 3.2: Rolling β estimates: Templeton Franklin index fund

1. A highly stable $\beta = 1 - \lambda$,
2. We should not get $\beta > 1$.
3. $\text{Var}(\epsilon) \approx 0$.
4. $\alpha \approx 0$.
5. $R^2 \approx 1$.

In a study on evaluation of index fund performance in India, Fernandes (2003) looks at buffer cash as a source of tracking error. Under the single market model framework, the

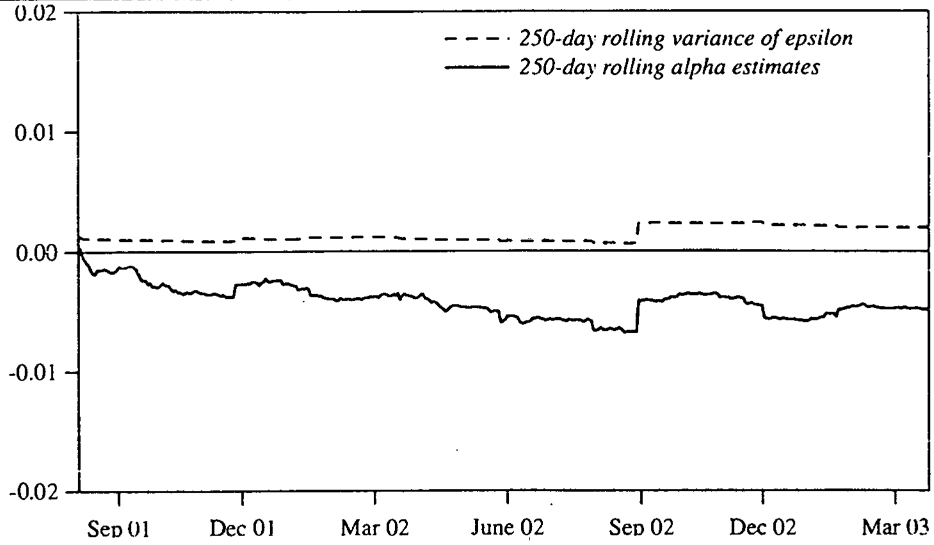

Figure 3.3: Rolling $Var(\epsilon)$ and α: IDBI I-Nit'99

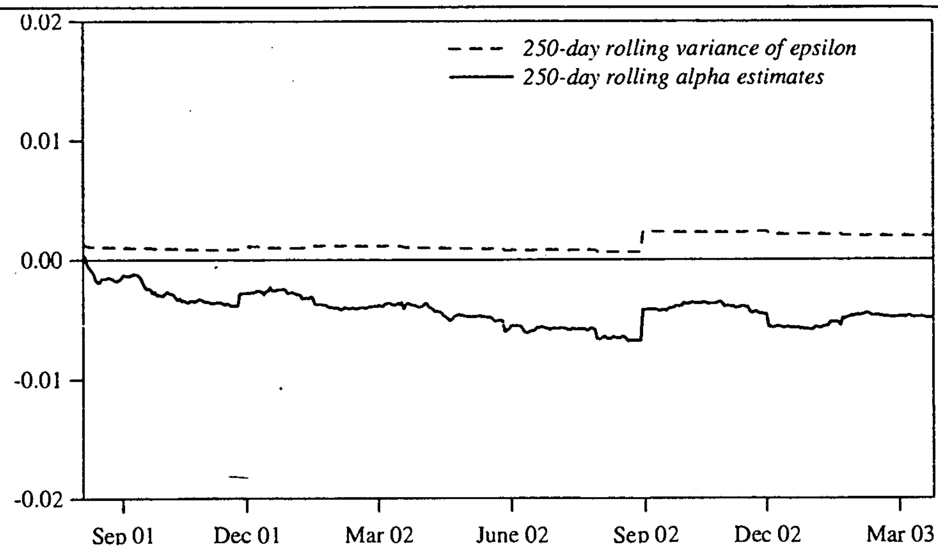

Figure 3.4: Rolling $Var(\epsilon)$ and α estimates: Templeton Franklin

β, α and ϵ for the various funds are estimated. Findings of this study show some funds having a highly stable beta with the R^2 of the regression almost equal to one. These findings suggest that the funds seem to exhibit strong symptoms of holding 1% to 3% buffer cash. We use these funds for the present study, namely the IDBI I-Nit'99 index fund and the Templeton Franklin index funds. Figure 3.1 to Figure 3.4 show the above parameters for the two funds under study.

We assume that the fund does perfect indexation with a fraction λ of its corpus and maintains a buffer cash of $(1 - \lambda)$. The fund has $\beta < 1$. We propose that to the extent of buffer cash held, the fund takes a long index futures position. This pushes the beta of the fund back to 1.0. Index futures are particularly appealing because futures enable replication using a single contract. If the prices on the index futures market are purely determined by the *cost of carry* model, the basis risk on the futures will be zero and the long futures position will perfectly track the index. The spot plus futures positions together will yield zero tracking error. In the real world however, basis risk exists. To the extent of basis risk on the futures market, the index fund would obtain imperfect tracking. So the question really boils down to which of the two is the lesser evil – holding buffer cash and suffering tracking error or taking position in an imperfectly correlated futures contract and suffering basis risk of the index futures.

To study the magnitude of error caused by buffer cash and the extent to which use of futures can reduce this error, we do the following:

1. *Simulation using fixed buffer cash*: To study the impact of using index futures to realign the fund β (which we assume is different from the index β only for buffer cash reasons), we simulate two hypothetical funds which follow different approaches to index fund implementation. This simulation uses the historical experience of returns on the Nifty futures.

    - Naive implementation: Fund A buys the spot index using fraction $(1 - \lambda)$ of its funds, maintains λ as buffer cash and has $\beta = 1 - \lambda$ which is < 1.

    - Index futures implementation: Fund B buys spot index using fraction $(1 - \lambda)$ of its funds, maintains λ as buffer cash, buys one month Nifty index futures to the extent of buffer cash maintained and has $\beta = 1$.

2. *Simulation using time-varying buffer cash*: In our empirical work, we know how β varies through time for certain funds(e.g. IDBI I-Nit'99). These are rolling window estimates: at each time t, they show the average that prevailed over the last one year.

    For these funds that exhibit strong symptoms of holding buffer cash, we can simulate implementation of buffer cash using index futures using these daily β estimates. We calculate the following:

    - Actual tracking error incurred.

    - Tracking error that would be incurred had the funds to readjust their betas using Nifty futures.

Company	Ex-dividend date	Dividend receipt date	Delay (days)
VESUVIUS INDIA LTD	26/07/99	12/10/99	79
DR REDDY'S LAB	12/07/99	27/10/99	77
DABUR INDIA LTD	2/08/99	15/10/99	74
TVS SUZUKI LTD	16/08/99	27/10/99	73
APOLLO TYRES LTD	9/08/99	18/10/99	70
PUNJAB TRACTORS	16/08/99	20/10/99	66
GUJARAT AMBUJA CEMENT	23/08/99	25/10/99	64
THERMAX LTD	16/08/99	15/10/99	61
HLL	30/08/99	21/10/99	53
RHONE POULENC (I) LTD	16/08/99	6/10/99	52

Table 3.1: Some evidence on dividend delays in India: 1999

3.4.3 Delays in dividend receipts

The index computation assumes that dividends are paid on the ex–date and are reinvested immediately. In most cases however, index funds receive dividend money well after ex–date. Often it could take several weeks before the dividend comes in the hands of the fund. These delays in dividend receipt have the following consequences.

1. Wrong β
   - These delays in receipt of dividend makes the index fund $\beta < 1$ and results in tracking error.
   - In a rising market, the fund suffers cash drag and will lag the market. In a falling market, the reverse is true.
2. Errors on ex–dividend date and on dividend–receipt date
   - On ex-dividend date, the index incorporates the dividend. the fund NAV shows a lower return.
   - When the fund receives dividend in hand, the fund NAV shows a jump. This gives two errors between fund returns and index returns.

Table 3.1 and Table 3.2 presents some evidence on the delay in dividend receipts observed in India. While the delay in recent periods has reduced, it is still significant enough to add to tracking error. This delay innately introduces tracking error.

At every instance of dividend declaration, the return on the fund deviates from return on the index. On ex-dividend date, the index incorporates the dividend, but the fund does

Company	Ex-dividend date	Dividend receipt date	Delay (days)
ABB LTD	27/03/03	1/07/03	96
SBI	4/07/03	23/07/03	50
ORIENTAL BANK	19/06/03	7/08/03	49
SATYAM COMPUTERS	14/07/03	29/08/03	46
TISCO LTD	9/06/03	25/07/03	46
BPCL LTD	16/07/03	26/08/03	41
HCI TECHNOLOGIES	15/05/03	9/06/03	40
ZEE TELEFILMS	27/10/03	27/11/03	37
MAHINDRA & MAHINDRA	26/06/03	31/07/03	35
TATA POWER	4/07/03	7/08/03	34
NIIT LTD	27/01/03	26/02/03	30
WIPRO LTD	1/09/03	31/09/03	30
BAJAJ AUTO	10/07/03	7/08/03	28
DABUR INDIA LTD	14/09/03	11/08/03	28
HINDALCO LTD	14/7/03	11/08/03	28
TATA TEA LTD	14/08/03	11/07/03	28
INDIAN HOTELS	12/08/03	8/09/03	27
VSNL LTD	13/08/03	8/09/03	26
ASSOCIATED CEMENT	30/06/03	25/09/03	25
DR REDDY'S LAB	8/08/03	4/09/03	25
RELIANCE IND LTD	23/05/03	17/06/03	25
SMITHKLINE CONS	29/07/03	23/08/03	25
HERO HONDA LTD	16/07/03	9/08/03	24
INDIAN PETRO	23/05/03	16/06/03	24
RANBAXY LABS	10/06/03	4/07/03	24
ICICI BANK	4/08/03	27/08/03	23
TATA MOTORS LTD	30/06/03	23/07/03	23
INFOSYS TECH	28/03/03	19/06/03	22
ITC LTD	14/7/03	5/08/03	22
HLL	14/08/03	4/09/03	21
L&T	11/08/03	1/09/03	21
BRITANNIA INDIA	23/07/03	12/08/03	20
SUN PHARMA	20/08/03	19/06/03	15
TATA CHEMICALS	29/05/03	12/06/03	14
BSES LTD	28/08/03	9/09/03	12
COLGATE PALMOLIVE	17/06/03	27/06/03	10
SHIPPING CORPORATION	19/03/03	28/03/03	9

Table 3.2: Some evidence on dividend delays in India: 2003

not actually receive the cash, hence its return lags behind the return shown by the index. When the fund receives dividend in hand, the fund NAV suddenly shows a jump, and there is a spike in the fund return. Figure 3.5 shows the daily returns on the Nifty and the simulated fund for a one-year period. On all three days where the fund received a dividend, we see a spike in daily returns. Fernandes (2003) shows how a single day of large

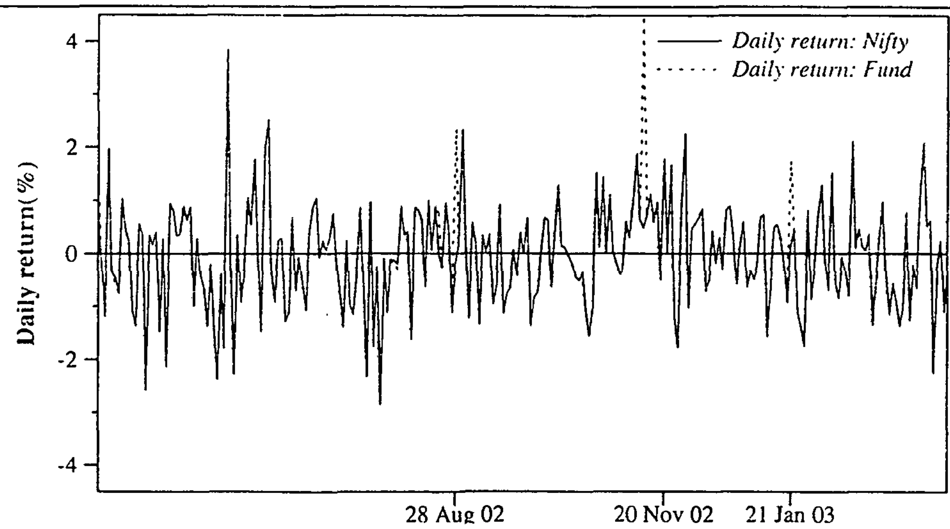

Figure 3.5: Spike in fund returns observed on dividend receipt date

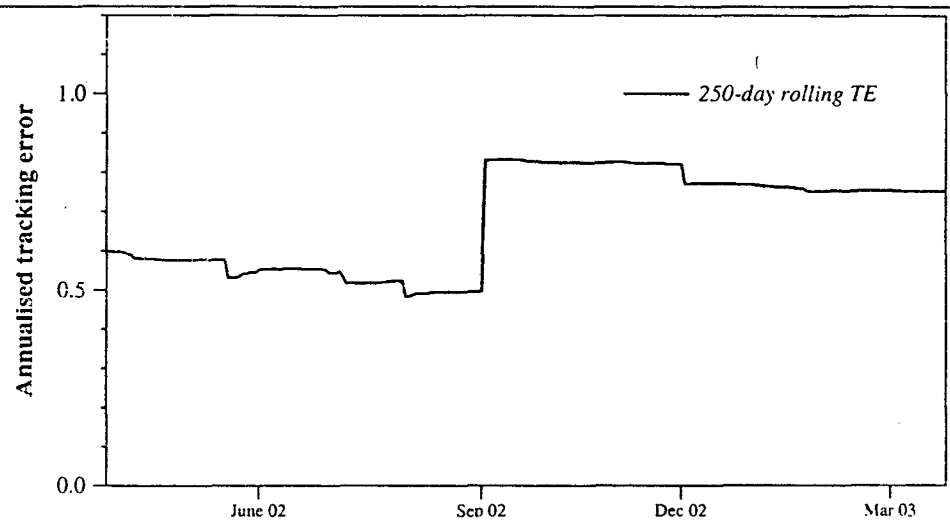

Figure 3.6: IDBI : Effect of dividend

error can throw off the full year's tracking error 'budget' of the fund. Figure 3.6 and Figure 3.7 give the rolling tracking error for the IDBI I'Nit'99 fund and the Templeton Franklin index fund for a one year period ending March 2003. We see a sharp rise in tracking error across the funds around end of August 2002. This coincides with several ex-dividend dates for large stocks like HLL, HPCL and Dr.Reddy's Laboratories lying around this period. Index funds need to be very careful in terms of consistently tracking the index.

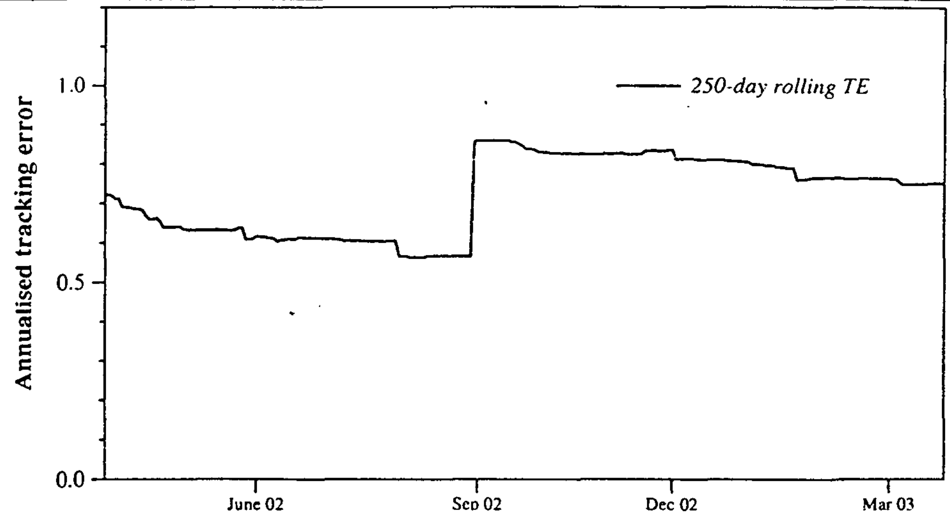

Figure 3.7: Templeton Franklin index fund: Effect of dividend

To show how an index fund can handle the dividend delay problem, we assume that with its existing corpus, the fund does perfect indexation. When an index stock goes ex–dividend, to the extent of dividend to be received, the fund buys index futures. Number of index contracts to be purchased is given by:

$$N = \frac{\text{Dividend amount to be received}}{\text{Level of index} \times \text{Index multiplier}}$$

This brings the fund β back to 1. Upon actual receipt of dividend, the fund buys the underlying portfolio and unwinds the position it has taken on the futures market.

To study the magnitude of tracking error caused by delays in dividend receipts and the extent to which use of futures can reduce this error, we do the following:

1. We simulate a 50 crore fund indexed to the Nifty.
2. We assume that the fund perfectly tracks the index, and that tracking error comes purely out of dividend delays.
3. Beginning 12th June 2000, we calculate the tracking error for the fund under the following situations:
   (a) Naive implementation: Index stocks go ex–dividend. The fund does nothing and suffers tracking error due to delays in dividend receipts.
   (b) Index futures implementation: Index stocks go ex–dividend. The fund takes

a long position in one month Nifty futures contracts to the extent of dividend declared, and closes position upon the receipt of dividend.

4. We examine delays of one, three, five and eight weeks.

We find that during the period of our study, there have been about 200 ex-dividend dates for Nifty securities. The dividend amount received by the fund ranges from about Rs.600 to Rs.15,75,000. We only work with instances of dividends where the dividend amount received by the fund is in excess of one Lakh. This leaves us with 9 ex–dividend dates. Ignoring the remaining dividends *understates* the problems in our simulation.

3.5 Nuances of futures implementation

For the purpose of this study, we assume that funds take position in the futures market to the extent of buffer cash/dividend expected. When buffer cash increases, the funds buy futures, when buffer cash falls, the funds sell futures. Similarly when an index stock goes ex–dividend, the fund buys futures. When dividends come in hand, the fund invests in the index and closes out the futures positions.

By definition, the performance of a futures contract should closely approximate the performance of the underlying asset. If bought at fair value and held to expiration, a futures contract should have a return equal to the cash instrument – assuming that the cash component is invested in instruments at the near–end of the zero coupon yield curve. However there a few issues that need to be borne in mind before index fund managers begin adopting the futures strategies we mention. A variety of factors determine how successfully these strategies can be implemented.

3.5.1 Futures mispricing(Basis risk)

Basis risk on a futures contract is the mispricing of the contract relative to its 'fair value'. Depending on the demand/supply in the market at any given point in time, futures contracts will trade cheap or expensive. Buying futures when they are expensive would lead to underperformance, while buying futures when they are cheap would lead to overperformance. Either way, this would result in imperfect tracking of the index.

3.5.2 Futures rollover

Futures contracts have a finite life. In India, futures contracts expire every three months. At any point in time, there is a one–month, two--month and three-month futures contract on the Nifty available for trading. The most liquid contract is the one–month futures contract, we have used this contract in our study. Both in the case of buffer cash and dividend handling, funds may require to take futures positions for more than a month at a time. In such situations, they will have to go in for a futures rollover, which involves closing one contract(near term) and the purchase of another contract(the next one–month contract). Just as futures can trade cheap or expensive, so can the monthly roll. This could add to imperfect tracking of the underlying index.

3.5.3 Transactions costs

Transactions costs on the futures market are lower than that on the spot. As a thumb rule, costs of trading on the futures market are typically one–tenth the cost of trading on the spot. However, any cost will result in underperformance as compared to the index.

3.5.4 Margins

Buying futures contracts involves posting margins. Funds would need to post initial margins while entering into the contract and maintain mark–to–market margins upon incurring losses. So long as the amount of loss is small, these margins could be paid out of the buffer cash held. Large losses on the futures position may require selling securities to generate cash.

3.6 FINDINGS

3.6.1 Effectiveness of one–month Nifty futures contract

To study the effectiveness of using Nifty futures for index replication, we study the correlation between Nifty spot and one–month Nifty futures. We use rolling window estimates of the correlation to see how it has changed over a period. We find the correlation to be fairly stable around 0.95. Over the period 2001-2003, the liquidity of the futures

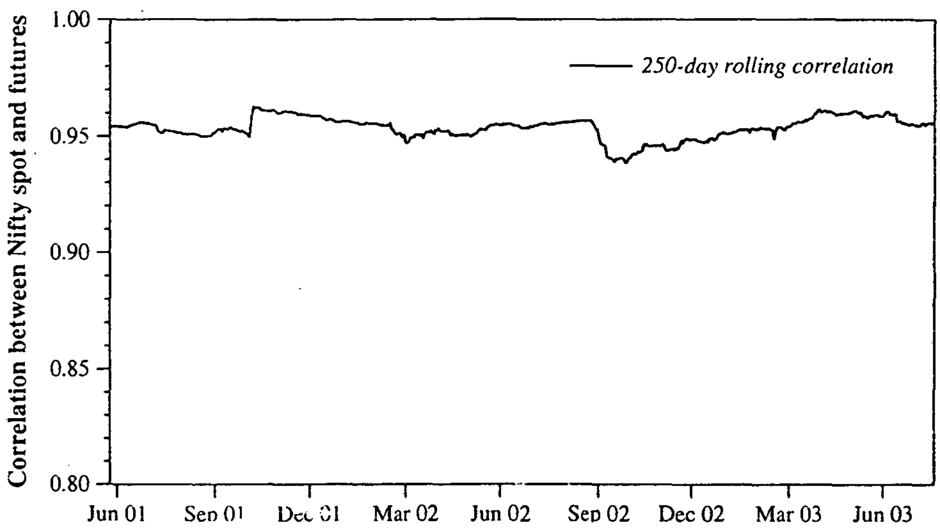

Figure 3.8: Correlation between Nifty spot and futures

market has grown tremendously, however the basis risk on the index futures does not seem to have dropped. Figure 3.8 gives the 250–day rolling correlation between the Nifty spot and one–month Nifty futures. Though not perfect, the correlation is high enough to enable the usage of the futures contract for the purpose of tracking the spot.

3.6.2 Using futures to handle the buffer cash problem

We study the magnitude of error caused by buffer cash and the extent to which use of futures can reduce this error by a simulation using: (a) fixed buffer cash, and (b) time varying buffer cash.

Fixed buffer cash

We simulate two index funds which follow different strategies. Fund A buys the spot index and naively holds a fraction of its corpus as buffer cash. Fund B buys spot index, buys one month Nifty index futures to the extent of buffer cash maintained and brings its beta back to one. We calculate the tracking error incurred by both the funds for various levels of buffer cash held. Figure 3.9 shows the tracking error incurred by the two funds. While the basis risk of the Nifty futures does not permit perfect replication by Fund B, the reduction in tracking error for Fund B is significant.

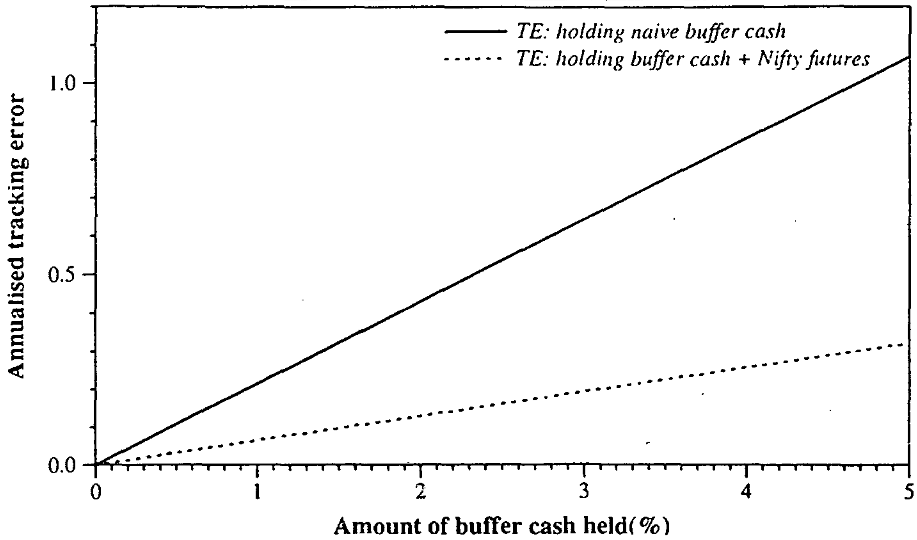

Figure 3.9: Tracking error incurred under different implementation strategies

Fund	TE without using futures	TE using futures
IDBI I-Nit'99 Index Fund	0.65	0.1434
Templeton Franklin India Index Fund	0.71	0.1212
Templeton Franklin India Tax Fund	0.77	0.0965

Table 3.3: Reduction obtained in tracking error

Time–varying buffer cash

We study the IDBI Index I-Nit fund and the Templeton index fund, both of which exhibit strong symptoms of tracking error arising out of buffer cash held. For the purpose of knowing how much position to take in the futures market, we assume that the funds hold buffer cash to the extent of $(1-\beta)$. In real life, the fund would know how much buffer cash it actually holds and would simply take a futures position to that extent. We calculate the actual tracking error incurred by these two funds and the tracking error that they would have incurred, had they to readjust their betas using one–month Nifty futures.

Table 3.4 gives the tracking error incurred by the funds with and without the use of index futures. Across the funds, we see a reduction in tracking error to the extent of 50 to 68 basis points. In an index world where every basis point counts, this reduction in tracking error is significant. Figure 3.10 and Figure 3.11 give the 250–day rolling window tracking

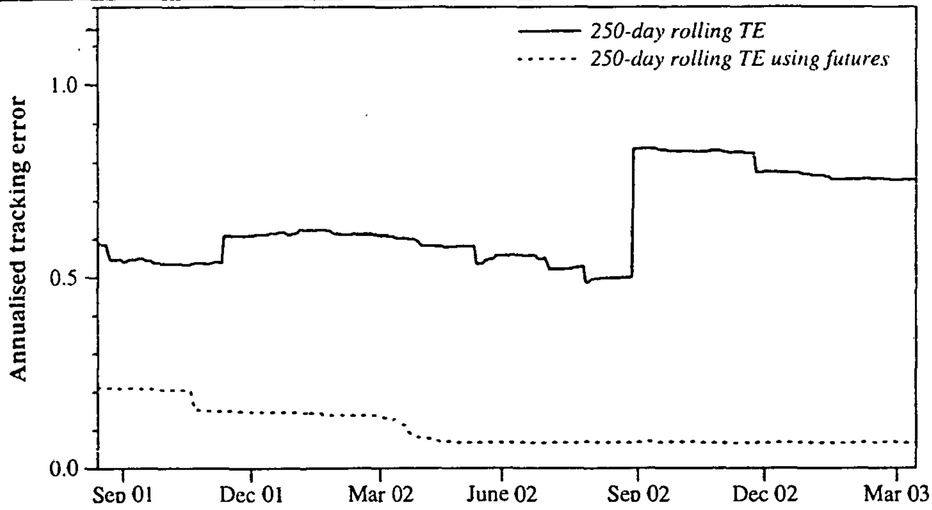

Figure 3.10: Tracking error incurred under different implementation strategies

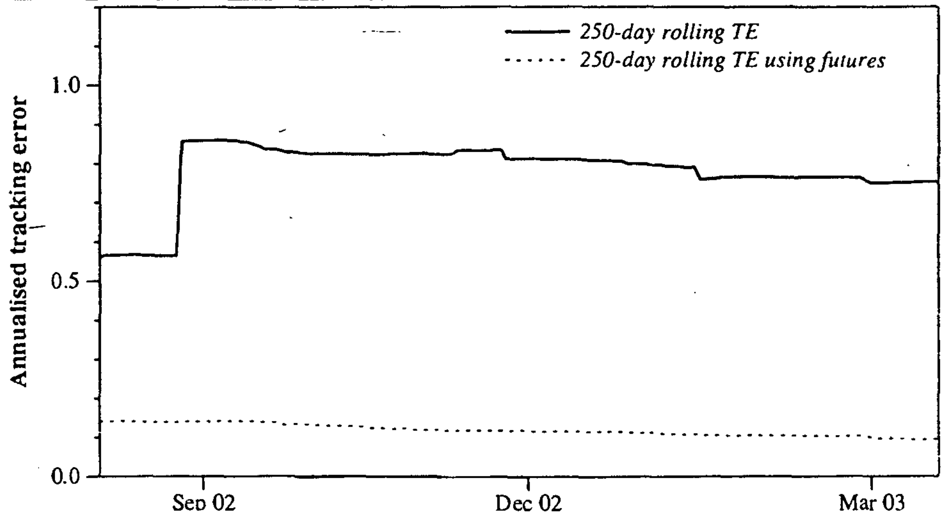

Figure 3.11: Tracking error incurred under different implementation strategies

error for these funds under the two methods of implementation. The gains from using index futures are large and consistent over both the funds.

3.6.3 Using futures to handle the dividend delay problem

To study the magnitude of tracking error caused by delays in dividend receipts and the extent to which use of futures can reduce this error, we simulate an index fund. The fund has a corpus of Rs.50 Crore and an NAV of Rs.10 on 12th June 2000, day one of the fund. For different dividend delays, we calculate the TE incurred by the fund under the following situations:

1. The fund does not take any futures positions and incurs tracking error.
2. The fund takes long futures position on ex-dividend date to correct for tracking error due to the delayed receipts of dividend.

Our findings show that dividend delays contribute significantly to tracking error. A fund that takes a long futures position on the ex-dividend day, can avoid sudden deviations from index returns and hence obtain large reductions in tracking error as compared to a fund that does not use futures.

For various periods of delay in dividend receipt, we calculate the tracking error obtained by the simulated index fund in two situations. One, where the fund does nothing as stocks go ex–dividend, and two, where on the day an index stock goes ex–dividend, the fund takes a long position in one month Nifty futures contracts to the extent of dividend it will receive. Figure 3.12 to Figure 3.15 show the rolling tracking error incurred by the fund for one week, three weeks, five weeks and eight weeks delay in receiving dividends. The figures show that the increase in tracking error caused due to a single instance of a delayed receipt of dividend, has a prolonged impact on the tracking error of the fund. The jumps in levels of tracking error in the figures show that higher the dividend amount received, higher is its continued impact on tracking error. Whatever be the delay in receipt of dividends, use of index futures contracts, can significantly reduce the tracking error.

Table 3.4 gives the annualised tracking error that the fund would incur with and without the use of the index futures market. We have assumed uniform levels of delays in dividend receipts, that is, one week, three, five weeks and eight weeks, whereas in the real world, these delays would be non–uniform. The tracking error numbers obtained suggest that when there is a delay in receipt of high dividend amounts, its impact on tracking error is much higher than when small dividend amounts are delayed. The surge in tracking error that we see between September 2002 to December 2002 in Figure 3.12 to Figure 3.15 is due to a number of large dividends coming in around this period. Using futures could reduce tracking error by about 20–60 basis points. Figure 3.16 gives the reduction in tracking error obtained across the various period of delays.

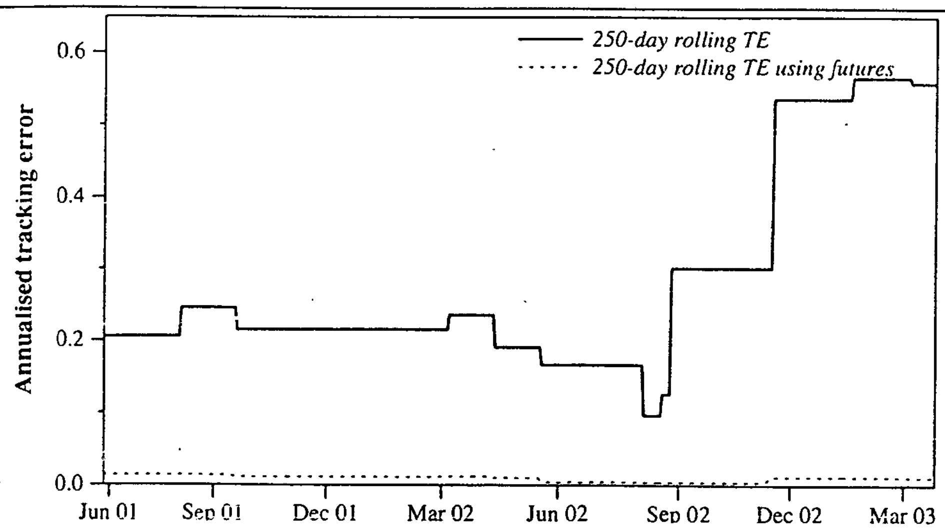

Figure 3.12: Rolling tracking error: one week delay in dividend receipt

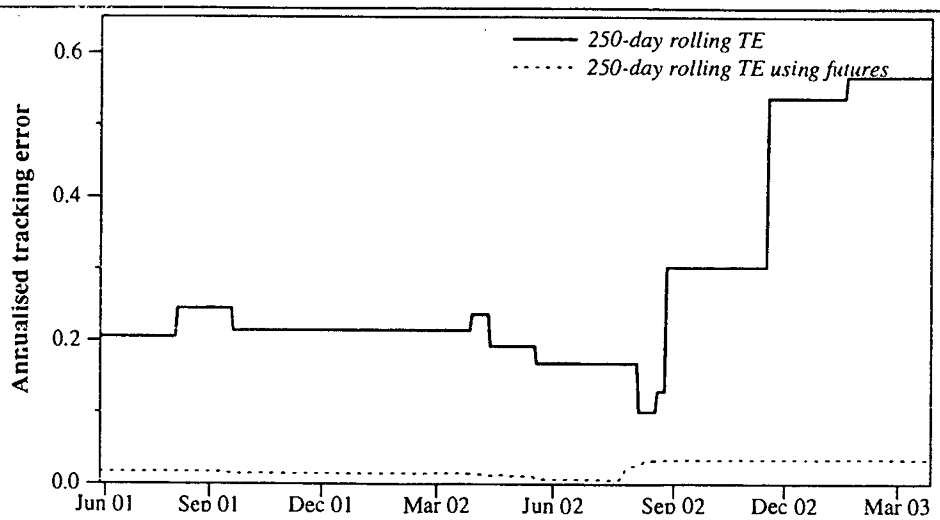

Figure 3.13: Rolling tracking error: three weeks delay in dividend receipt

Delay in dividend receipt	TE: naive implementation	TE: index futures implementation
One week	0.3683	0.0198
Three weeks	0.3690	0.0229
Five weeks	0.3598	0.0208
Eight weeks	0.3657	0.0164

Table 3.4: Reduction in tracking error obtained

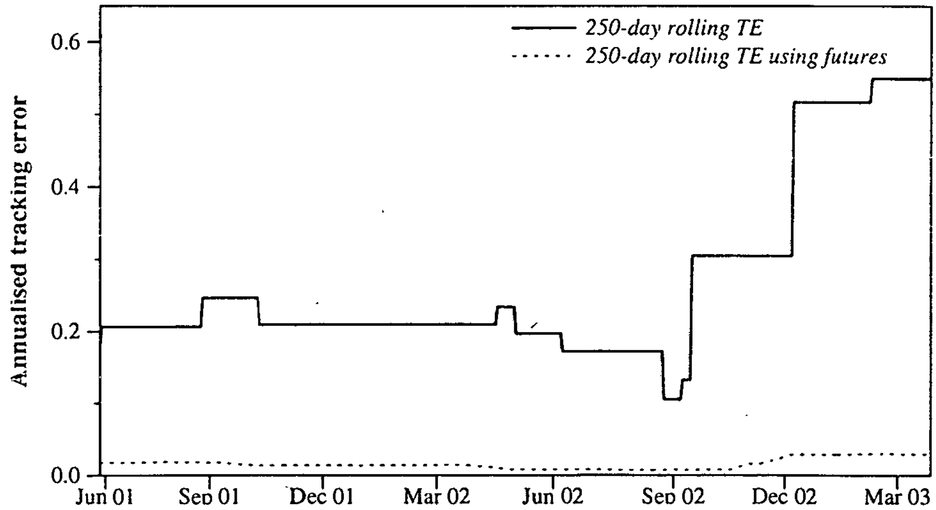

Figure 3.14: Rolling tracking error: five weeks delay in dividend receipt

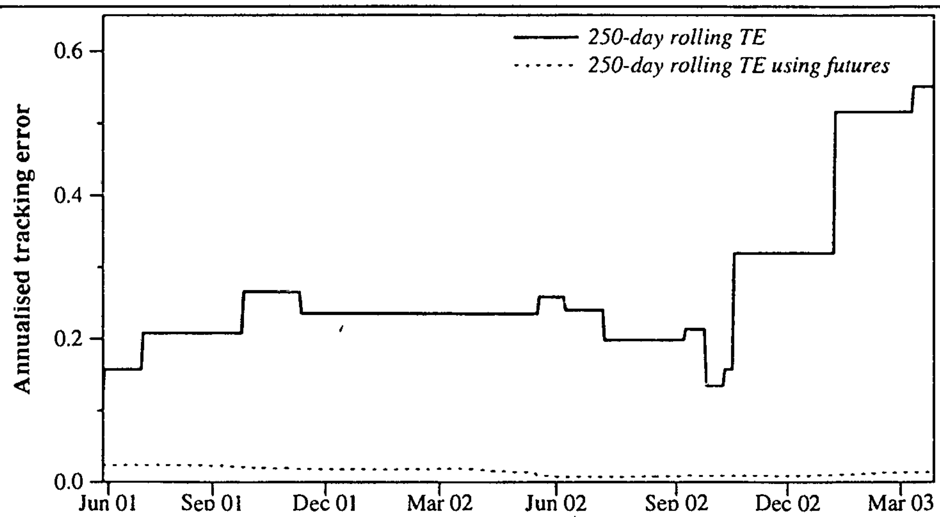

Figure 3.15: Rolling tracking error: eight weeks delay in dividend receipt

Figure 3.16 gives the tracking error obtained by the fund by taking a long futures position to the extent of dividends to be received. In this study we are using the one–month futures contract for obtaining index exposure. Longer dividend delays would involve going in for futures rollovers. However, it seems very clear that the use of futures can significantly reduce tracking error due to delayed receipts of dividends.

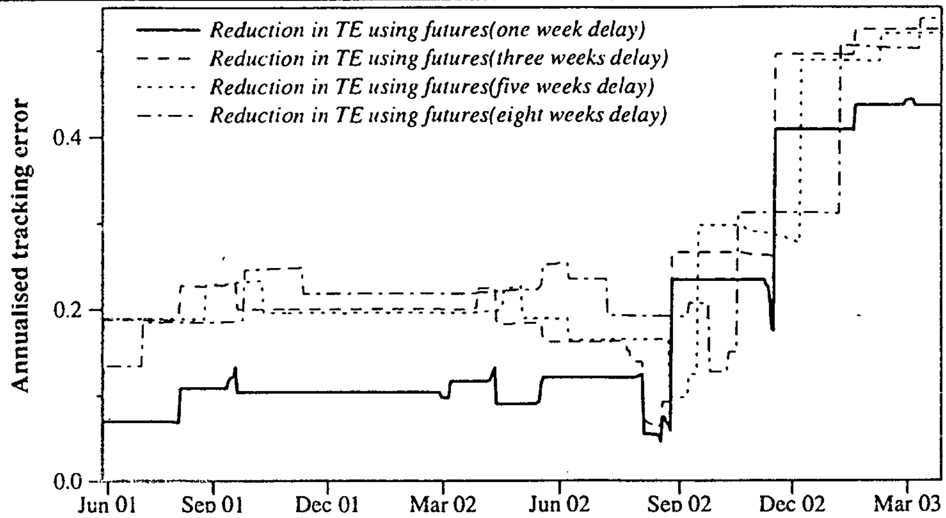

Figure 3.16: Reduction in tracking error using futures

3.7 Conclusion

In this study, we look at the use of futures markets for improving index fund implementation in India. We do not look at the use of index futures in terms of creating a synthetic index fund, but in terms of its use as an adjunct to trading in stocks. Index funds incur tracking error on account of the buffer cash they hold. To the extent of buffer cash held, the beta of the index fund is less than that of the index. Similarly index funds incur tracking error due to delays in dividend receipts. We use index futures to try to reduce the tracking error due to these two causes. Trading in index futures provides a number of advantages. Use of futures enable index replication using a single contract. Another advantage is the relatively low transactions cost as measured by market impact cost. As a rule of thumb, trading in futures involves one–tenth the transactions costs of trading in stocks.

To find out the effectiveness of using index futures for index fund implementation, we study the correlation between Nifty spot and one–month Nifty futures. The average correlation works out to be about 0.95. Using a 250–day rolling window we find the correlation since inception of the index futures market to be between 0.93 and 0.97. The imperfect yet high correlation suggests that index futures could be effectively used for replicating the spot.

We use the futures market to tackle the buffer cash problem. Both in case of the simulated funds as well as in the case of real world index funds in India, we find that use of futures significantly reduces tracking error. We see a reduction in tracking error to the extent of

50 to 68 basis points across the funds under study.

Delays in dividend receipts result in increased tracking error. We simulate an index fund to study the impact of this. Our findings suggest that dividend delays add significantly to the fund's tracking error. The use of index futures market can correct most of the tracking error that the fund would incur on account of dividend delays.

Our findings show that index funds can effectively use the index futures market to reduce tracking error arising out of buffer cash and delays in dividend receipts. Due to basis risk of the index futures, the funds would not be able to obtain perfect replication and zero tracking error. However, as against taking no action and suffering tracking error, the benefits of using this strategy are clearly evident.

Chapter 4

Conclusion

Approaches to portfolio management can be divided into two broad categories - active and passive. Active strategies rely on the belief that skillful investors can out–perform the market by exercising activities such as market timing and stock picking. While active strategies have always been popular with investors, in recent years passive investment strategies have gained attention, especially among mutual fund managers and pension funds. These strategies are adopted by investors who believe that financial markets are efficient and it is therefore impossible to consistently beat the aggregate market return. A passive strategy that attempts to reproduce as closely as possible the performance of a theoretical index representing the market, is called an index tracking strategy.

Index tracking strategy is a fairly well established strategy in the developed markets. It scores on account of the cost advantage it provides by way of reduced expense ratios and transactions costs. Monitoring the performance of an index fund boils down to simply observing its tracking error. Tracking error summarises the extent to which the index fund is able to accurately track the underlying index. Index fund managers seek to minimise tracking error. From the viewpoint of an investor, an index fund which experiences a large tracking error is a source of risk since it might not replicate the returns on the index in the future. The burgeoning growth in index funds and index related investments seems to indicate that indexing works as a longterm strategy.

The index fund industry in India is relatively young. However, given the growth in number of index funds during the last two years, one could infer that it is a strategy that is gaining importance. Indexing as a strategy may play a major role in public policy formulation. The

Dave Committee on pension reforms in India has recommended that equity investments by pension funds should exclusively be done using index funds.

However, despite the increasing popularity of passive investment strategies, the attention given in academic literature to performance of index funds as measured by tracking error, and to implementation and algorithmic problems arising in the process of index tracking is relatively small compared to the numerous articles dedicated to the classical problem of portfolio risk and return optimisation. In the Indian context, while the recommendation that pension investments should only go into index funds is entirely defensible using conceptual arguments, we need to verify the extent to which accurate tracking is attainable under Indian conditions. In this study we look at two aspects of index funds implementation in India (a) Evaluation of index funds in India (b) Improving index fund implementation in India. We seek to answer the following questions:

Q1 What are the difficulties faced in measuring tracking error and how can they be overcome?

Q2 What is the overall experience with tracking error of the competing index fund products in India today? Which are the index funds with the best fidelity?

Q3 Can we decipher the source of tracking error? Is tracking error arising due to buffer cash maintained or due to active management at the fund?

Q4 What can we say about the determinants of tracking error?

Q5 Can the index futures market be used to implement index funds more efficiently?

Q6 How can index funds achieve their target levels of buffer cash, in order to cope with most redemptions, but obtain lower levels of tracking error while doing so? In other words, how best can buffer cash be implemented?

Q7 How can index funds reduce tracking error which results from delays in receipts of dividends?

Performance evaluation of an index fund involves studying its tracking error. A good index fund is one that closely tracks index performance and obtains a very low tracking error. It is argued that in developing countries, where the equity market is illiquid, the tracking error of index funds can be fairly large, thus diminishing the benefits from indexation. In this study we make a systematic effort to measure and understand the tracking error of index funds in India.

We argue that correct index fund tracking error calculations require great care in data handling – by fund managers in terms of providing daily NAVs, dividend and expenses related data, and by index providers in terms of providing a neat time–series of daily index values and impact cost data for various basket sizes. It should be possible for an external observer to simulate an ideal index fund, assume zero transactions costs, and replicate the index. Our study shows how small mistakes in data handling can generate huge tracking errors. One problem faced is that of missing data – days where index values are available, but fund NAV values are not. Using a simulation, we show that a modest incidence of missing data can lead to an economically significant upward bias in the apparent tracking error. We offer an alternative heuristic for measuring tracking error which is unbiased in the face of such missing data.

Tracking error is typically measured as the standard deviation of difference between index returns and fund returns. The goal of an index fund is to minimise the tracking error. International evidence suggests that index funds incur a tracking error in the range of 4 basis points to about 120 basis points. We compute tracking error for the four longest existing index funds in India. Over comparable time–periods, we observe tracking error in the range of 68 basis points to 1097 basis points. We perform rolling window calculations of tracking error and find that the Templeton Franklin funds have consistently shown low tracking error since inception. Our rolling tracking error calculations to study the time–dynamics of tracking error suggest a *learning effect* over time. IDBI Index I-Nit Fund appears to have learned how to do index fund management and improved substantially over recent periods. The UTI Nifty Index Fund exhibits unacceptably large tracking errors through out.

We go on to seek some insights into the sources of tracking error. Open-ended funds in India need to maintain buffer cash to meet redemptions. To the extent that a fund maintains buffer cash, it has $\beta \neq 1$. This inevitably induces tracking error. In addition, a fund could also incur tracking error due to active management. These constitute two competing hypotheses about the sources of tracking error.

We seek to obtain insights into this question using the single market model. We hypothesise that if the fund holds a fixed fraction of cash and does perfect indexation with the remainder, we would observe the following observable effects: (a) a highly stable beta which is less than one, (b) alpha of roughly 0 and (c) an error variance of roughly 0. Except in the case of UTI Nifty Index Fund, we observe a highly stable beta, and alpha and variance of errors approximately equal to zero. We find that in the case of the UTI, where tracking error is clearly present, the buffer cash hypothesis does not serve to explain the bulk of tracking error.

We also explore the relationship between index volatility and index fund tracking error. When the index is more volatile, we expect index fund tracking error to be larger. If the index fund is perfectly aligned with the index, the volatility of the underlying index will not result in tracking error. Since the index fund owns exactly the same portfolio as the index, however volatile the index movements are, the fund will perfectly track them. If however, due to active management reasons, the index fund portfolio does not perfectly mirror the index, volatility of the underlying index will result in tracking error.

We model the time–varying volatility of Nifty returns using the AR(1)–GARCH(1,1) model and try to explain tracking error in terms of index volatility. We find that there is, indeed, a positive correlation between Nifty volatility and index fund tracking error. There is a remarkable homogeneity in the volatility – tracking error relationship across different funds.

While some funds show periods of unacceptably high tracking error, the consistency in performance of the better run funds suggests that it is possible to attain fairly low levels of tracking error under Indian conditions. However, the levels of tracking error obtained by funds in India fall far short of the tracking errors obtained by well–run funds worldwide. There is a need to consider implementation strategies that could reduce the tracking error of Indian index funds to more acceptable levels.

Focusing on issues concerning implementation of index funds, we seek to offer some new ideas on how index funds can be managed better. We seek to understand how index funds can use index futures to reduce tracking error. To study the effectiveness of using Nifty futures for index replication, we study the correlation between Nifty spot and one–month Nifty futures. We use rolling window estimates of the correlation to see how it has changed over a period. We find that the one–month Nifty futures are highly correlated with the Nifty spot and hence would prove to be effective in replicating the index. The rolling window correlations since inception of the futures market show values between 0.93 and 0.97.

Index funds incur tracking error for a variety of reasons. Factors driving tracking error include transactions costs, fund cash flows, uninvested/buffer cash, treatment of dividends by the index, corporate actions, and index composition changes. The liquidity of the underlying index securities also has implications for transaction costs (in terms of impact cost) and in turn the tracking error incurred by funds. We focus on tracking error arising out of uninvested buffer cash and delays in dividend receipts.

Open ended index funds are faced with subscriptions and redemptions. When subscriptions happen the fund is required to invest the money across index stocks and when redemptions happen, the fund is required to sell part of its index portfolio to generate cash. In order to handle redemptions, index funds typically maintain buffer cash. This buffer cash is typically invested into liquid instruments which lie at the near–end of the zero coupon yield curve. To the extent of buffer cash held, the fund has a $\beta < 1$, which in turn results in tracking error.

Using the single market model framework, we expect an index fund to normally suffer only the variance of errors as the tracking error. However, to the extent that $\beta \neq 1$, the index fund additionally suffers tracking error. For example, if the market has a daily volatility of 1.4 and the beta of the index fund is 0.98, this suggests that the index fund would incur and additional daily tracking error of 0.028 or 0.44% annualised. If a fund holds a fixed fraction of cash and does perfect indexation with the remainder, we would observe the following observable effects: (a) a highly stable beta which is less than one, (b) alpha of roughly 0 (c) an error variance of roughly 0 and (d) an R^2 that is close to 1.

We simulate two funds, one that uses futures to handle the tracking error arising out of buffer cash and the other that does nothing. We see the extent to which the use of index futures reduces the tracking error for the fund. We also study index funds in India which exhibit the above symptoms of tracking error arising due to buffer cash, namely the IDBI Index I-Nit fund and the Templeton Franklin index fund. We assume that fund beta falls short of one solely because of the buffer cash held by it. For these funds, we calculate the actual tracking error incurred and compare it with the tracking error that the funds would incurred had they to readjust their betas using Nifty futures. Both in case of the simulated funds as well as in the case of real world index funds in India, we find that use of futures significantly reduces tracking error. Across the funds under study, we see a reduction in tracking error in the range of about 50 to 68 basis points.

Most equity indexes assume that dividends are paid on the ex–date and are reinvested immediately. Unfortunately, in the real world, index funds receive money well after ex–date. Often it could take several weeks before the dividends come in the hands of the fund. Due to this delay in receipt of dividend, in a rising market, the fund suffers cash drag and will lag the market. In a falling market, the reverse is true. To study the magnitude of tracking error incurred due to dividend delays and the extent to which this can be avoided, we simulate a 10 crore fund indexed to the Nifty. We assume that the fund perfectly tracks the index, and that tracking error comes purely out of dividend delays. The index incorporates dividends on ex–dividend date, but the fund receives dividends three weeks later. We calculate the tracking error for the fund under the following situations: (a) Index stocks go ex–dividend, the fund does nothing and suffers tracking error due delays in dividend receipts. (b) Index stocks go ex–dividend, the fund takes a long position in one month Nifty futures contracts to the extent of dividend declared. Our findings show that delays in dividend receipts add significantly to tracking error. Longer delays in receiving dividends after ex–dividend date, have a greater impact on tracking error. The use of index futures market can correct most of the tracking error that the fund would incur on account of dividend delays.

Our study shows that significant improvements in fund performance are possible by using index futures. While perfect replication may not be possible due to basis risk on the futures market, as against taking no action and suffering tracking error, the benefits of using this strategy are clearly evident. The high correlation between the Nifty spot and one–month futures suggest that these could be effectively used for reducing tracking error caused both due to buffer cash held and due to delays in dividend receipts. While implementing index funds using index futures, the fund would have to bear in mind the existence of factors such as impact costs, initial margins and MTM margins to be paid on the futures positions. To the extent these exist, the benefits of using the futures market would reduce. However, the magnitude of reduction in tracking error obtained by futures usage far outweighs the costs involved.

In conclusion, we present the findings of our study.

1. Correct index fund tracking error calculations require great care in data handling. Missing data can result in exaggerating tracking error, we suggest an alternative heuristic to handle this problem.

2. The consistency and levels of tracking error incurred by some funds in India suggest that it is possible to attain low levels of tracking error under Indian conditions. The two Templeton Franklin funds and the IDBI index fund show the lowest tracking error, while UTI Nifty Index Fund consistently shows high tracking error.

3. Funds hold buffer cash for meeting redemptions. This innately results in tracking error. We use the single market model to give us insights into buffer cash as the source of tracking

error. The model parameters for the Templeton funds and the IDBI fund suggest buffer cash to be a source of their tracking error.

4. There is a positive correlation between the volatility of the underlying index and tracking error obtained. The relationship between tracking error and index volatility seems homogeneous across funds.
5. The tracking error incurred by the best run funds in India, is much higher than that exhibited by the best run funds across the world. The high correlation between nifty futures and the spot index suggests that index futures could be used to implement index funds and reduce tracking error.
6. Buffer cash is substantial source of tracking error. Index futures can used to obtain exposure to the index and bring the beta of the index fund in line with the beta of the market. Tracking error caused due to buffer cash held can be significantly reduced using index futures.
7. There are substantial delays between the ex–dividend date and the receipt of dividend. This delay is a source of tracking error. By taking position in the futures market to the extent of dividend expected, tracking error arising out of dividend delays can be effectively reduced.

Appendix A

Modelling Nifty volatility

Historic volatility estimates based on daily squared returns assume that asset returns are independent and identically distributed and the asset return series is generated by a stationary stochastic process. We look at the Nifty returns series and find that it is not well modelled by an independent and identically distributed process. Returns and squared returns show signs of autocorrelation. Figure A.1 shows the time series of daily squared returns and Figure A.2 shows the time–series of annualised volatility(expressed in percent), of continuously compounded returns on the Nifty using rolling windows of 250 days at a time. This roughly corresponds to a window width of one calendar year. Hence at each date, this graph reports the annualised volatility of continuously compounded returns over the last one year.

The summary statistics about the daily returns time–series are as follows:

- Mean daily return of -0.0275 percent per day
- Standard deviation 1.5715. Annualised this works out to around 25%.
- Skewness = -0.1334 and Kurtosis = 5.6902.
- The 95th percentiles are -2.5014 and 2.4131.
- The 99th percentiles are -4.8848 and 4.1379.
- The smallest value was -7.2022% and the largest value was 7.277%. Apart from this extreme value, the next worst return was -6.3095%.

A variety of tests all strongly reject normality. That is also evident with the extreme values

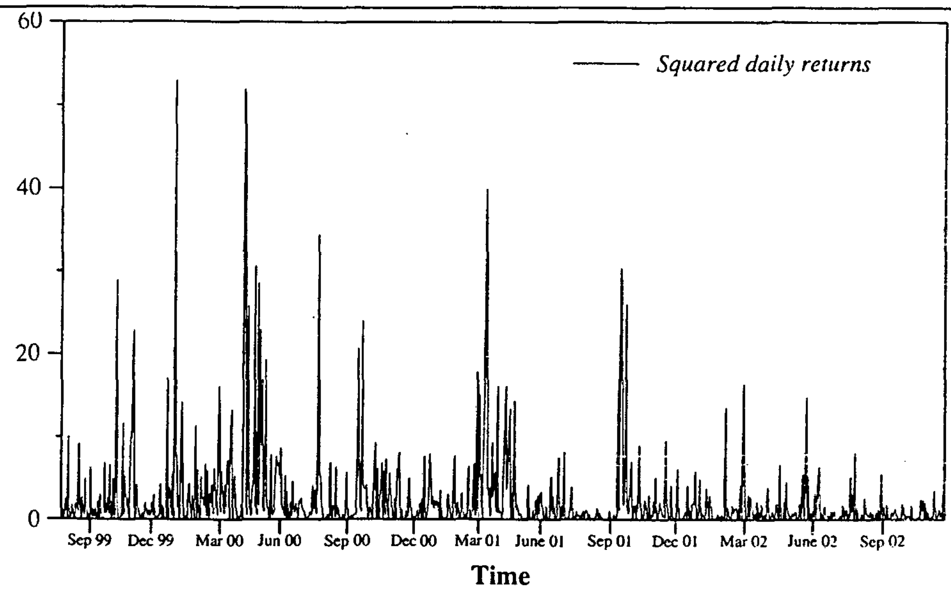

Figure A.1: Time series of daily squared returns on Nifty

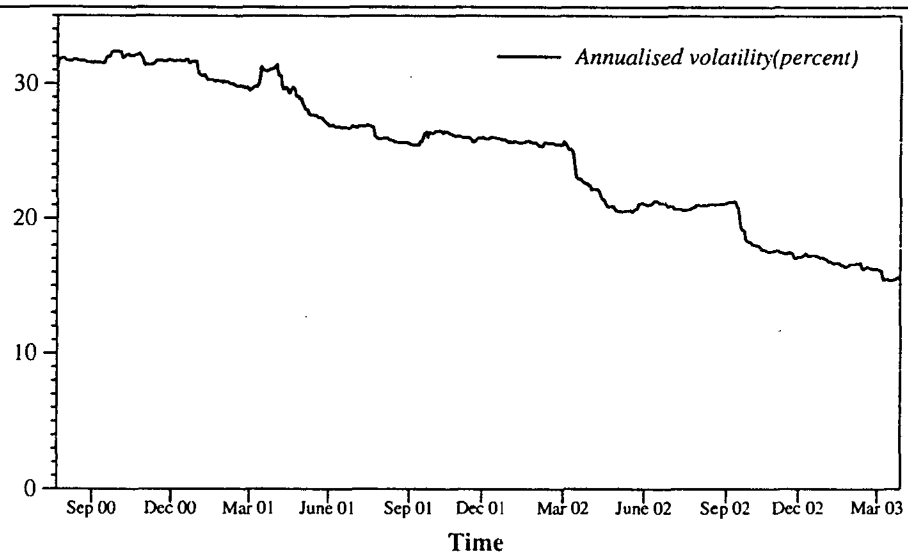

Figure A.2: Rolling window annualised volatility measured as standard deviation of returns

for skewness and kurtosis seen here. Figure A.4 shows the autocorrelation function for the daily returns series. There is some evidence of mean-reversion. Figure A.5 shows the autocorrelation function of squared daily returns on the Nifty. This shows strong short-dated volatility dynamics. The Box-Ljung Q statistic works out to 294, which strongly rejects the null of normality. This is seen visually in Figure A.6, where the deviation from

Parameter	Coefficient	t
Mean equation		
Intercept	0.0378784	0.77
AR(1)	0.0689488	1.76
Volatility equation		
Intercept	0.1242849	5.60
ARCH(1)	0.1401796	7.30
GARCH(1)	0.8120375	41.50

Table A.1: AR(1)- GARCH(1,1) model estimates for daily returns

the best-fit normal distribution is sharply visible.

A time–series model that could control for the short–dated mean–reversion and short-dated volatility clustering, as seen above, would yield improved forecasts of volatility. We find that the Nifty returns series is well–modelled by the AR(1)–GARCH(1,1) model. The GARCH coefficients add up to near 1, showing very strong volatility persistence(Table A.1).

$$r_t = \alpha_0 + \alpha_1 r_{t-1} + \epsilon_t \tag{A.1}$$

$$H_t = \gamma_0 + \gamma_1 \epsilon_{t-1}^2 + \gamma_2 H_{t-1} \tag{A.2}$$

where $\epsilon_t \sim N(0, H_t)$. Equation A.1 models the autoregressive conditional mean and Equation A.2 models the conditional variance of the Nifty returns series. Using this model we get a daily H_t time–series for Nifty variance. We try to explain tracking error in terms of Nifty volatility measured as the square root of conditional variance, H_t. This is done using the regression:

$$\sigma_{ct} = \alpha_i + \beta_i log(\sigma_{bt}) + \epsilon_t \tag{A.3}$$

We use estimates of σ_e, the tracking error, over one week of fund returns at a time. These weekly estimates of index fund tracking error are regressed against σ_{bt}. weekly estimates of Nifty volatility.

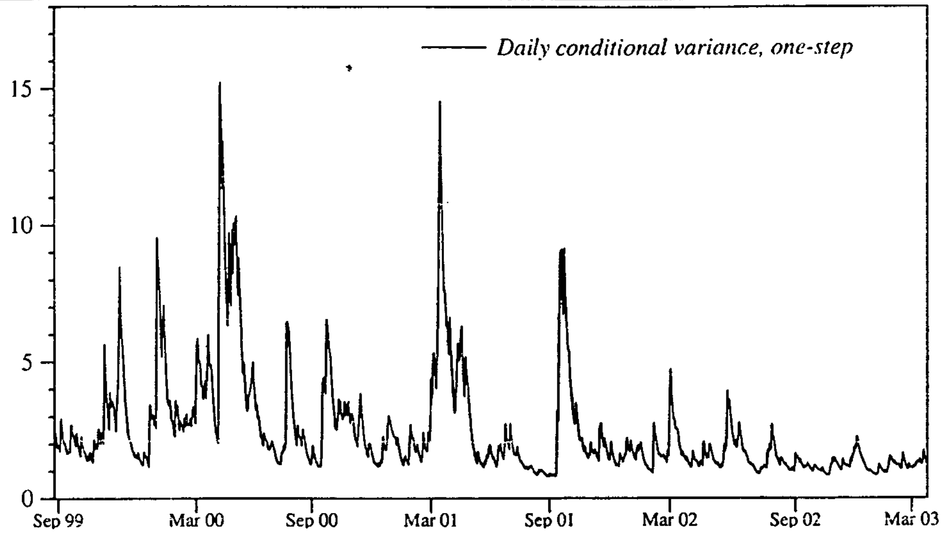

Figure A.3: Variance estimates from AR(1)-GARCH(1,1) model

Table A.1 gives the model parameters for daily returns. Figure A.3 shows variance estimates from this model. We focus on the time–series of standardised residuals, $\epsilon_t = e_t/\sqrt{H_t}$. Figure A.7 shows the kernel density plot of the standardised residuals. This shows a much lower peak when compared with that in Figure A.6. The Box-Ljung Q statistic works out to 57, where the null of i.i.d normal cannot be rejected. Figure A.8 shows the ACF of the standardised residuals and Figure A.9 shows the ACF of the squared standardised residuals. Both of them seem to suggest that time dependence in the returns equation and the volatility appear to have been contained. This diagnostics suggests that we do have a plausible model of volatility dynamics of Nifty returns.

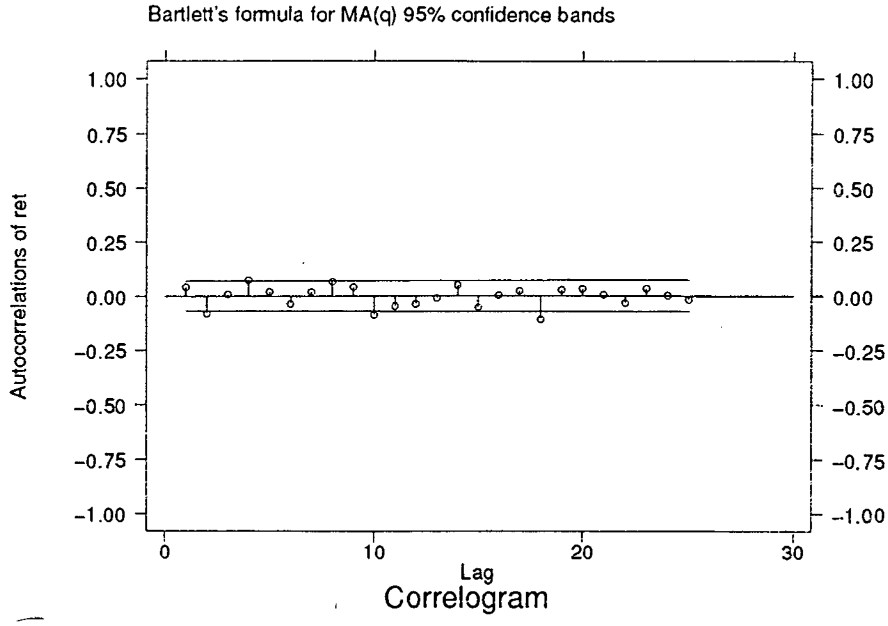

Figure A.4: Autocorrelation function of daily returns

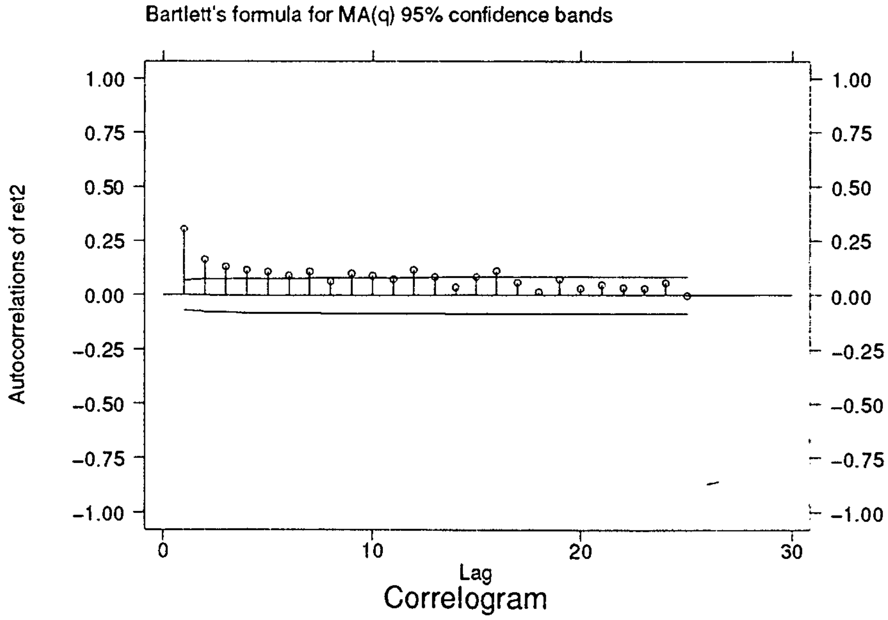

Figure A.5: Autocorrelation function of squared daily returns

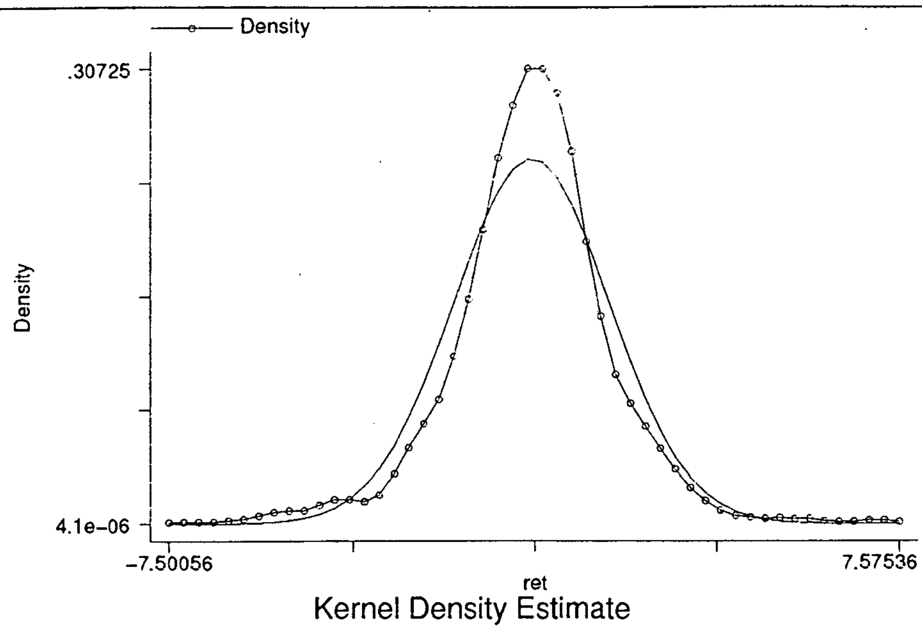

Figure A.6: Kernel density plot of daily returns

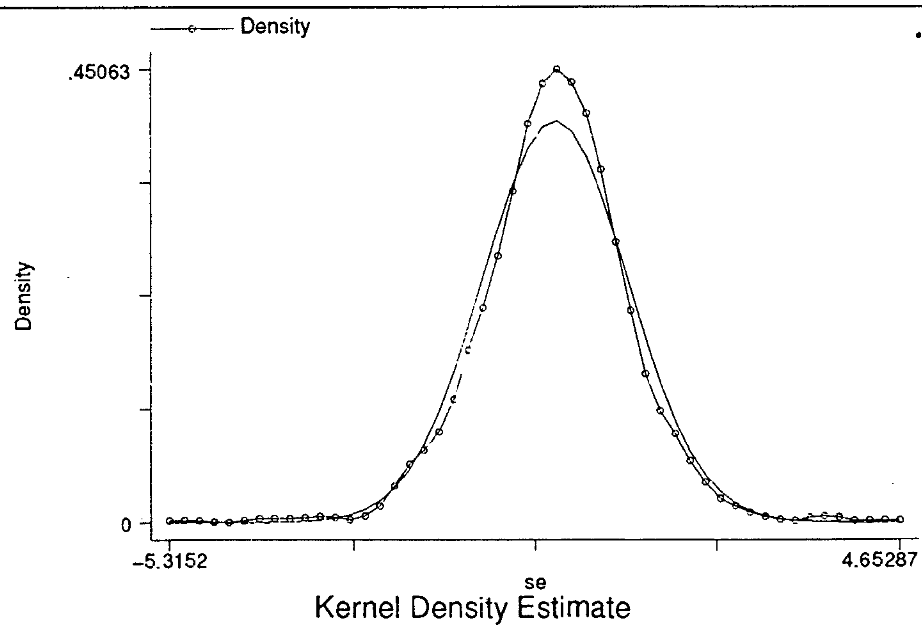

Figure A.7: Kernel density plot of standardised residuals

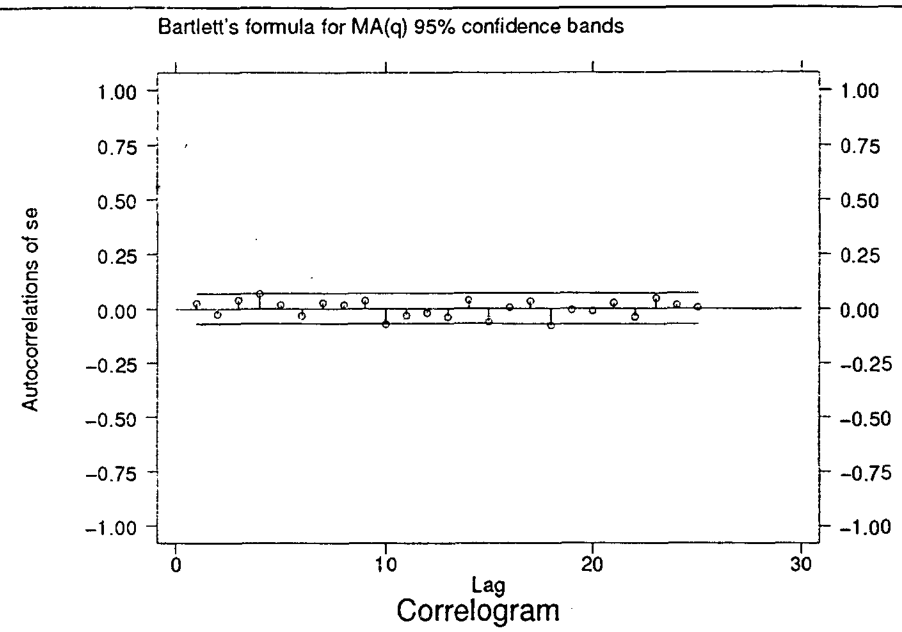

Figure A.8: Autocorrelation function of standardised residuals

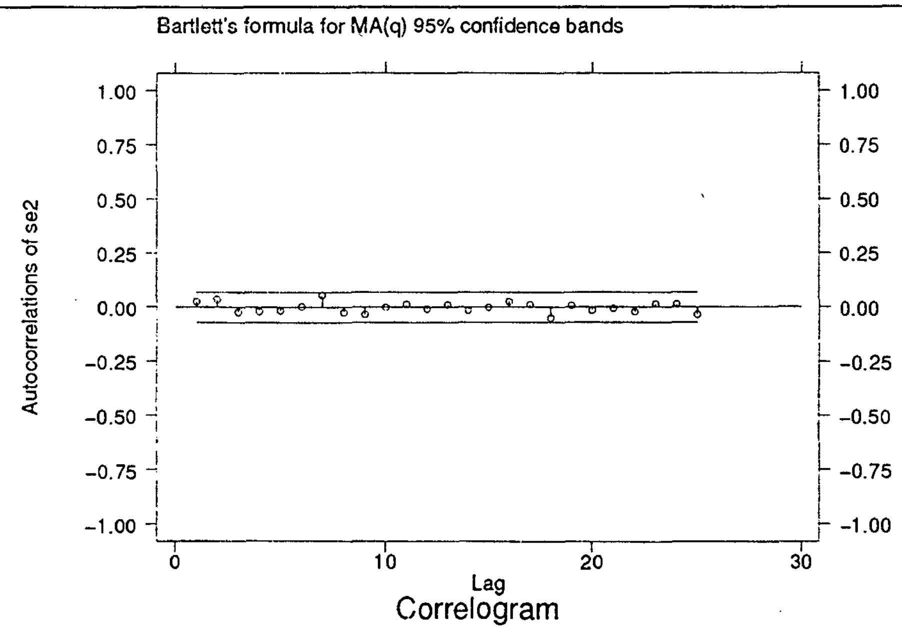

Figure A.9: Autocorrelation function of squared standardised residuals

Appendix B

Programs used in thesis

B.1 Making a grid that provides input for Monte Carlo simulation

```
$!/usr/bin/awk -w
BEGIN {
  for (x=0.01; x<=0.07; x+=0.01)
    for (y=0.001; y<0.016; y+=0.0005)
      print x, y;
}
```

B.2 Monte Carlo simulation

```
#!/usr/bin/perl -w
require '/home/kshama/WORK/INDEXFUNDS/NSE/SRC/ranstdn.pl';

# Simulate a very-long time-series of index and NAV
# with a random number of days where NAV is just missing.

die "Usage: $0 sigma_e non-trading-prob\n" if ($#ARGV != 1);
my($sigma_e) = $ARGV[0];        # true daily TE  eg. 0.063246 daily for 1% ann.
my($ntp) = $ARGV[1];            # Probability of missing data eg. 0.01 for 1%

my($sigmaM) = 1.2;
my($T) = 1000000;
my($t);
```

```
my($M)=1000;
my($nav)=10;
for ($t=1; $t<$T; $t++) {
    my($rM) = &ranstdn() * $sigmaM;
    my($e) = &ranstdn() * $sigma_e;
    my($rN) = $rM + $e;
    $M *= 1 + ($rM/100.0);
    $nav *= 1 + ($rN/100.0);
    if (rand() > $ntp) {
        print "aaa ", $M, " ", $nav, "\n";
    } else {
        print "aaa ", $M, " ", "-", "\n";
    }
}
```

B.3 Feeding data from Monte Carlo simulation into TE calculations

```
#!/bin/bash

# Version 0.0.03

# The scripts takes in the input arguments required by MC.pl
# from a data file called te-3.dat
# It then feeds the data to MC.pl which stores the data in midfile
# The data from midfile is then fed to TEest.pl, after which the midfile
# is deleted

counter=0

rm -fv outfile

cat te-3.dat | while true; do
   counter=$(($counter+1))
   midfile=$counter
   echo SET $midfile
   read x y
   if [ -e $x ]; then
      break
   fi
   ./MC.pl $x $y | ./TEest.pl >> outfile
done
```

```
# now, let's put the input and output files in one single file
paste te-3.dat outfile > result.dat
rm -fv outfile
```

B.4 Estimation of TE using output from the Monte Carlo simulation

```
#!/usr/bin/perl -w

use strict;
use Statistics::Descriptive;

my(@nifty, @nav, @dates, $n);
$n=0;
while (<>) {
    chop;
    my($date, $nifty, $nav) = split();
    $dates[$n] = $date;
    $nifty[$n] = $nifty;
    $nav[$n] = $nav;
    $n++;
}
# n ends up as the number of obs in the 'nifty' and 'nav' vectors.

# Suppose --
# t0 n0
# t1 n1
# t2 missing
# t3 n3
# t4 n4
#
# In the smart method, we skip data for t2 & t3.
# In the dumb method, we skip data for t2 only. We use the fake t3 (getting
#   an elevated TE).

# WARNING
#
# Would we be handling a string of multiple days with missing data?

# Populate smart
my($handle_smart) = Statistics::Descriptive::Full->new();
my($i, $nret, $fundret);
```

```
for ($i=1; $i<$n; $i++) {
    if ($nav[$i] eq "-") {
        $i++;          # <---- This is the key
    }
    elsif ($nav[$i-1] eq "-"){
    }
    else {
        $nret    = 100*(($nifty[$i]/$nifty[$i-1]) - 1);
        $fundret = 100*(($nav[$i]   /$nav[$i-1]   ) - 1);
        $handle_smart->add_data($nret - $fundret);
    }
}

# Populate dumb
my($handle_dumb) = Statistics::Descriptive::Full->new();
for ($i=1; $i<$n; $i++) {
    if ($nav[$i] eq "-") {
        # Just ignore this one.
    } else {
        $nret    = 100*(($nifty[$i]/$nifty[$i-1]) - 1);
        my($lookback)=$i-1;
        while ($nav[$lookback] eq "-") {$lookback--;}
        $fundret = 100*(($nav[$i]   /$nav[$lookback]) - 1);
        $handle_dumb->add_data($nret - $fundret);
    }
}

my($te_dumb) = sqrt(250)*$handle_dumb->standard_deviation();
my($te_smart) = sqrt(250)*$handle_smart->standard_deviation();
printf "Smart = %.4f   Dumb = %.4f   Exaggeration = %.4f\n",
    $te_smart, $te_dumb, $te_dumb-$te_smart;
```

B.5 Calculating log returns

```
#!/usr/bin/perl -w

use strict;
use Statistics::Descriptive;

my(@nifty, @nav, @dates, $n);
$n=0;
```

```
while (<>) {
    chop;
    my($date, $nifty, $nav) = split();
    $dates[$n] = $date;
    $nifty[$n] = $nifty;
    $nav[$n] = $nav;
    $n++;
}
# n ends up as the number of obs in the 'nifty' and 'nav' vectors.

# Suppose --
# t0 n0
# t1 n1
# t2 missing
# t3 n3
# t4 n4
#
# We skip data for t2 & t3.

my(@nret, @fundret, @retdates, @errors, $j, $i);
$j=0;
# i will step in the raw data, j will walk in the nice returns
# data that we are making.
for ($i=1; $i<$n; $i++) {
    if ($nav[$i] eq "-") {
        $i++;
    }
    elsif ($nav[$i-1] eq "-"){
    }
    else {
        $retdates[$j] = $dates[$i];
        $nret[$j]     = 100*log($nifty[$i]/$nifty[$i-1]);
        $fundret[$j] = 100*log($nav[$i]  /$nav[$i-1]);
        $errors[$j] = $nret[$j] - $fundret[$j];
        print "$nret[$j]  \n";
        $j++;
    }
}
```

B.6 Calculating annualised TE

```
#!/usr/bin/perl -w
```

```
use strict;
use Statistics::Descriptive;

my(@nifty, @nav, @dates, $n);
$n=0;
while (<>) {
    chop;
    my($date, $nifty, $nav) = split();
    $dates[$n] = $date;
    $nifty[$n] = $nifty;
    $nav[$n] = $nav;
    $n++;
}

my(@nret, @fundret, @retdates, @errors, $j, $i);
$j=0;
# i will step in the raw data, j will walk in the nice returns
# data that we are making.
for ($i=1; $i<$n; $i++) {
    if ($nav[$i] eq "-") {
        $i++;
    }
    elsif ($nav[$i-1] eq "-"){
    }
    else {
        $retdates[$j] = $dates[$i];
        $nret[$j]     = 100*log($nifty[$i]/$nifty[$i-1]);
        $fundret[$j] = 100*log($nav[$i]  /$nav[$i-1]);
        $errors[$j] = $nret[$j] - $fundret[$j];
        $j++;


    }
}

print "Overall results --\n";
my($handle) = Statistics::Descriptive::Full->new();
$handle->add_data(@errors);
printf "%-30s : %f\n", "Annual standard devn",
sqrt(250)* $handle->standard_deviation();
```

B.7 Calculating rolling window TE

```
#!/usr/bin/perl -w

use strict;
use Statistics::Descriptive;

my(@nifty, @nav, @dates, $n);
$n=0;
while (<>) {
    chop;
    my($date, $nifty, $nav) = split();
    $dates[$n] = $date;
    $nifty[$n] = $nifty;
    $nav[$n] = $nav;
    $n++;
}


my(@nret, @fundret, @retdates, @errors, $j, $i);
$j=0;
# i will step in the raw data, j will walk in the nice returns
# data that we are making.
for ($i=1; $i<$n; $i++) {
    if ($nav[$i] eq "-") {
        $i++;
    }
    elsif ($nav[$i-1] eq "-"){
    }
    else {
        $retdates[$j] = $dates[$i];
        $nret[$j]     = 100*log($nifty[$i]/$nifty[$i-1]);
        $fundret[$j] = 100*log($nav[$i]  /$nav[$i-1]);
        $errors[$j] = $nret[$j] - $fundret[$j];
        $j++;
    }
}

print "Overall results --\n";
my($handle) = Statistics::Descriptive::Full->new();
$handle->add_data(@errors);
printf "%-30s : %d\n", "Number of points", $handle->count();
```

```
printf "%-30s : %f\n", "Standard devn",     $handle->standard_deviation();
my(@percentiles) = (1,99);
my($p);
printf "%-30s : %f\n", "Min",               $handle->min();
for $p (@percentiles) {
    my($tmp) = sprintf "Percentile %4.1f", $p;
    printf "%-30s : %f\n", $tmp,            $handle->percentile($p);
}
printf "%-30s : %f\n", "Max",               $handle->max();

# Now get into rolling windows.
for ($i=250; $i<=$#errors; $i++) {
    my($handle) = Statistics::Descriptive::Full->new();
    for ($j=$i-250; $j<$i; $j++)
    {$handle->add_data($errors[$j]);
 }
    print $retdates[$i], " ", sqrt(250)*$handle->standard_deviation(), "\n";
}
```

B.8 Single market model regression using STATA

```
#!/usr/bin/xstata-se

infile x y using nret_idbiret.data.
regress y x
predict xb
#outfile xb using predict_xb
graph y xb x, c(.l)s(Oi) saving(idbi_reg_pic)
translate idbi_reg_pic.gph idbi_reg_pic.eps
```

B.9 Single market model parameters for entire dataset

```
#!/usr/bin/perl -w

use strict;
use Statistics::Descriptive;

my(@nifty, @nav, @dates, $n);
```

```
$n=0;
while (<>) {
    chop;
    my($date, $nifty, $nav) = split();
    $dates[$n] = $date;
    $nifty[$n] = $nifty;
    $nav[$n] = $nav;
    $n++;
}

my(@nret, @fundret, @retdates, @errors, $j, $i);
$j=0;
# i will step in the raw data, j will walk in the nice returns
# data that we are making.
for ($i=1; $i<$n; $i++) {
    if ($nav[$i] eq "-") {
        $i++;
    }
    elsif ($nav[$i-1] eq "-"){
    }
    else {
# Continously compounded returns
        open(F,">>/tmp/rawdata.text") or "die horribly 1";
        $retdates[$j] = $dates[$i];
        $nret[$j]     = 100*log($nifty[$i]/$nifty[$i-1]);
        $fundret[$j] = 100*log($nav[$i]  /$nav[$i-1]);
        $errors[$j] = $nret[$j] - $fundret[$j];
        print $fundret[$j]," ",$nret[$j],"\n";
        print F "$nret[$j] $fundret[$j]\n";
        $j++;
        close(F);
    }
}

open(F, ">/tmp/file.do") or "die horribly 2";
print F "infile x y using /tmp/rawdata.text\n";
print F "gen t=_n \n";
print F "tsset t \n";
print F "regress y x\n";
print F "dwstat \n";
print F "prais y x, corc \n";
close(F);
```

```
system("stata < /tmp/file.do >> /tmp/stata.results");
```

B.10 Rolling window regression parameters using STATA

```
#!/usr/bin/perl -w

use strict;
use Statistics::Descriptive;

my(@nifty, @nav, @dates, $n);
$n=0;
while (<>) {
    chop;
    my($date, $nifty, $nav) = split();
    $dates[$n] = $date;
    $nifty[$n] = $nifty;
    $nav[$n] = $nav;
    $n++;
}

my(@nret, @fundret, @retdates, @errors, $j, $i);
$j=0;
# i will step in the raw data, j will walk in the nice returns
# data that we are making.
for ($i=1; $i<$n; $i++) {
    if ($nav[$i] eq "-") {
        $i++;
    }
    elsif ($nav[$i-1] eq "-"){
    }
    else {
# Continously compounded returns
        $retdates[$j] = $dates[$i];
        $nret[$j]    = 100*log($nifty[$i]/$nifty[$i-1]);
        $fundret[$j] = 100*log($nav[$i]  /$nav[$i-1]);
        $errors[$j] = $nret[$j] - $fundret[$j];
        $j++;
    }
}
```

```
# Now get into rolling windows.

for ($i=250; $i<=$#errors; $i++) {
# Make data
    open(F, ">/tmp/rawdata.text") or "die horribly 1";
    for ($j=$i-250; $j<$i; $j++)
    { print F "$nret[$j] $fundret[$j]\n"};
    close(F);
#make .do file
    open(F, ">/tmp/file.do") or "die horribly 2";
    print F "infile x y using /tmp/rawdata.text\n";
    print F "regress y x\n";
    close(F);

#Run stata
    system("stata < /tmp/file.do >> /tmp/stata.results");

#    open(F, "/tmp/stata.results") or "die horribly 4";
#    while (<F>) {
#        if (/x |/) {
#            print $_;
#        }
#    }
#    close(F);

}

#system("grep 'x |' /tmp/stata.results >> /tmp/beta");

#system("awk '{print NR, $3}' /tmp/beta > idbi_beta");
```

B.11 Calculating rolling standard deviation of Nifty

```
#!/usr/bin/perl -w

use strict;
use Statistics::Descriptive;

my(@value, @dates, $n);
$n=0;
while (<>) {
    chop;
```

```
    my($date, $value) = split();
    $dates[$n] = $date;
    $value[$n] = $value;
    $n++;
}

my(@retdates, @nret, $j, $i);
$j=0;
# i will step in the raw data, j will walk in the nice returns
# data that we are making.
for ($i=1; $i<$n; $i++) {
    if ($value[$i] eq "-") {
        $i++;
    }
    elsif ($value[$i-1] eq "-"){
    }
    else {
        $retdates[$j] = $dates[$i];
        $nret[$j]     = log($value[$i]/$value[$i-1]);
        $j++;
    }
}

my($handle) = Statistics::Descriptive::Full->new();
$handle->add_data(@nret);

# Now get into rolling windows.
for ($i=250; $i<=$#nret; $i++) {
    my($handle) = Statistics::Descriptive::Full->new();
    for ($j=$i-250; $j<$i; $j++)
    {$handle->add_data($nret[$j]);
 }
    print $retdates[$i], " ", sqrt(250)*$handle->standard_deviation(), "\n";
}
```

B.12 Calculating weekly TE using daily returns

```
#!/usr/bin/perl -w

use strict;
use Date::Manip;
use Statistics::Descriptive;
```

```
sub help {
    print STDERR "Usage --
     \$ $0 filename

Accepts a file containing daily returns and prints out a file with
  weekly standard deviations of returns. Assumptions: The input file
  contains lines with two fields per line: date and returns. The date
  can be any format you like. The returns should be just p2/p1,
  i.e. should show 1.01 for a 1% increase. One example of a viable
  input file is: 17Jul96 1.022677139191671 18Jul96 1.009602541424497
  19Jul96 1.000527407301462

The output file shows date and standard deviation of returns, one week
  at a time, focusing on fridays. Only complete weeks in the input
  dataset figure in the output.  E.g. if you feed an input file going
  from 2-May-1979 till 31-May-79, you only get three complete weeks,
  ending on fridays 11th, 18th, 25th.  Look --

\[\home\kshama\WORK\THESIS] ./d2w.pl amonth
19790511 0.981589690226529
19790518 1.01451520835032
19790525 0.999361379420453

It will multiply all daily returns of the week that you give it -
weekends included.

Bugs: It uses Date::Manip and so it is slow - 124s of CPU time (on a
Pentium III @ 500 MHz) to process a file of 3717 days.

    exit 1;
}

my($debugging)=0;
&help if ($#ARGV == -1);
my($infile) = $ARGV[0];
die "$0: File $infile does not exist." if (! -f $infile);
my($firstline, $lastline, $firstdate, $lastdate, $sfirstdate, $slastdate);

# 1st date
$firstline=`head -1 $infile`;
($sfirstdate, undef) = split(' ', $firstline);
$firstdate = &ParseDate($sfirstdate);
```

```
die "$0: Parse error for first date $sfirstdate\n" if (! $firstdate);

# last date
$lastline=`tail -1 $infile`;
($slastdate, undef) = split(' ', $lastline);
$lastdate = &ParseDate($slastdate);
die "$0: Parse error for last date $slastdate\n" if (! $lastdate);

print STDERR "I think $infile runs from $firstdate till $lastdate.\n"
    if ($debugging);

# Make a vector of ALL dates from the 1st till last dates (inclusive).
my(@perfectdates);
# Push back by 2 days just in case a dataset started on monday
$firstdate = &DateCalc($firstdate, "- 2 days");
$perfectdates[0] = $firstdate;
my($i)=0;
do {
    $perfectdates[$i+1] = &DateCalc($perfectdates[$i], "+ 1 day");
    $i++;
} while (&Date_Cmp($perfectdates[$i], $lastdate) < 0);

# Read the file and stick data into core in the correct places.
my($nextindex)=0;                # index in @perfectdates
my(@returns);                    # same indexes as @perfectdates
my($previousdate);
while (<>) {
    chop;
    my($rawdate, $r) = split();
    my($nicedate) = &ParseDate($rawdate);
    die "$0: Error in date $rawdate in input stream.\n" if (! $nicedate);

    # A little paranoia...
    die "$0: $rawdate is <= date $previousdate on previous line.\n"
        if ((defined $previousdate)
            &&
            &Date_Cmp($previousdate, $nicedate) >= 0);
    $previousdate = $nicedate;

    while ($perfectdates[$nextindex] ne $nicedate) {
        $nextindex++;
        # A little paranoia...
        die "$0: Blew up searching for $nicedate in perfectdates.\n"
```

```
            if ($nextindex > $#perfectdates);
    }
    $returns[$nextindex] = $r;
}

# Print out the full data structure, just to see things are okay.
if ($debugging) {
    for ($i=0; $i<=$#perfectdates; $i++) {
        if (defined $returns[$i]) {
            print $perfectdates[$i], " ", $returns[$i], "\n";
        } else {
            print $perfectdates[$i], "\n";
        }
    }
}

# We want complete weeks starting from sat and going till fri.
my($firstsat) = &Date_GetNext($perfectdates[0], "Saturday", 1);
my($lastfri)  = &Date_GetPrev($perfectdates[$#perfectdates], "Friday", 1);
print "Will focus on complete weeks from $firstsat to $lastfri\n"
    if ($debugging);
my($low,$hi)=(0,$#perfectdates);
while ($perfectdates[$low] ne $firstsat) {$low++;}
while ($perfectdates[$hi] ne $lastfri)   {$hi--;}
print "That is, from index $low till $hi\n" if ($debugging);

# Now my life is made - I simply walk in one week chunks computing out
# weekly returns and spitting them out.

$i=$low;                        # starts out on a saturday
while (1) {
    my(@retarray);
    # saturday -
    push(@retarray,$returns[$i]) if (defined $returns[$i]); $i++;
    # sunday -
    push(@retarray,$returns[$i]) if (defined $returns[$i]); $i++;
    # monday -
    push(@retarray,$returns[$i]) if (defined $returns[$i]); $i++;
    # tuesday -
    push(@retarray,$returns[$i]) if (defined $returns[$i]); $i++;
    # wednesday -
    push(@retarray,$returns[$i]) if (defined $returns[$i]); $i++;
    # thursday -
```

```
    push(@retarray,$returns[$i]) if (defined $returns[$i]); $i++;
    # friday -
    push(@retarray,$returns[$i]) if (defined $returns[$i]);

 #   print &UnixDate($perfectdates[$i], "%Y%m%d"), " ", @retarray," ";
    print &UnixDate($perfectdates[$i],"%Y/%m/%d")," ";

    my($handle) = Statistics::Descriptive::Full->new();
    $handle->add_data(@retarray);
#    printf "%-30s: %d\n", "Number of points", $handle->count();
#    printf "%-30s: %f\n", "Standard devn", $handle->standard_deviation();
    print $handle->standard_deviation(),"\n";
   exit(0) if ($i >= $hi);      # recall that $hi was on a friday

    $i++;                       # placed on the next saturday.
}
```

B.13 Estimating the AR(1) GARCH(1,1) model using STATA

```
#!/usr/bin/xstata-se

infile ret using ret.
gen t=_n
tsset t

gen e=0
gen se=0
gen se2=0

arch ret, ar(1) arch(1) garch(1)

kdensity ret, normal saving(kden_ret)
translate kden_ret.gph kden_ret.eps

gen ret2 = ret*ret
sfrancia ret2
sktest ret2
wntestq ret2
outfile ret2 using returns_sqr
graph ret2 t, sy(.) co(1) saving(ret2_pic)
```

```
ac ret, lag(25) needle saving(ac_ret_pic)
translate ac_ret_pic.gph ac_ret_pic.eps

ac ret2, lag(25) needle saving(ac_ret2_pic)
translate ac_ret2_pic.gph ac_ret2_pic.eps


* 1. Show me the time-series of Ht over the dataset
predict Ht, variance
outfile Ht using var

set graphics off
graph Ht t, sy(.) co(l) saving(var_pic)
translate var_pic.gph var_pic.eps

* 2. Generate e and e**2
drop e se se2
predict e, residual
outfile e using e_residual

*    Standardise it
gen se = e/sqrt(Ht)
outfile se using std_error
generate se2=se*se
outfile se2 using se_squared
graph se2 t, sy(.) co(l) saving(se2_pic)
translate se2_pic.gph se2_pic.eps

* 3. Test whether they are iid normal.
kdensity se, normal saving(kden_se)
translate kden_se.gph kden_se.eps

sfrancia se
sktest se
wntestq se
ac se, lag(25) needle saving(ac_se_pic)
translate ac_se_pic.gph ac_se_pic.eps

ac se2, lag(25) needle saving(ac_se2_pic)
translate ac_se2_pic.gph ac_se2_pic.eps
```

B.14 Regression: TE on index volatility using STATA

```
#!/usr/bin/xstata-se

infile Nifty_volatility Tracking_error using ln_wk_nifty_idbi.data.
regress Tracking_error Nifty_volatility
predict Nifty_volatilityb
graph Tracking_error Nifty_volatilityb Nifty_volatility,
c(.l)s(Oi) saving(ln_idbi_reg_pic)
translate ln_idbi_reg_pic.gph ln_idbi_reg_pic.eps
```

B.15 Calculation rolling correlation of Nifty using R

```
#!/usr/bin/perl -w

use strict;
use Getopt::Long;

my($N, $help) = (250, 0);
GetOptions('width=i' => \$N,
           'help' => \$help);

if ($help) {
    print STDERR "Usage : $0 [--width N]

The input to this program, on stdin, is a series of the format:

   date  value value
   date  value value
   date  value value
   ...

The program makes a rolling correlation coefficient, using a window
of width N time-periods. If you don't specify N, then it defaults
to 250.

On stdout, the series that is written is a time-series for each
date of the volatility over the last N time-periods.\n";
    exit 1;
}
```

```
my($i, $j);
my($T, @dates, @v1, @v2);
$T=0;
while (<>) {
    chop;
    my($d,$v1,$v2) = split();
    if ((defined $d) && (defined $v1) && (defined $v2)) {
        ($dates[$T], $v1[$T], $v2[$T]) = ($d, $v1, $v2);
        $v1[$T] = undef if (($v1[$T] eq ".") || ($v1[$T] eq ""));
        $v2[$T] = undef if (($v2[$T] eq ".") || ($v2[$T] eq ""));
        $T++;
    }
}
die "$0: I need atleast $N points\n" if ($T < $N);

# Now get into rolling windows.
open(F, "> /tmp/makecorr.r.$$") or die;
print F "
A <- read.table(\"/tmp/window.data.$$\")
cor(A)
";
for ($i=($N-1); $i<$T; $i++) {
    open(F, "> /tmp/window.data.$$") or die;
    for ($j=$i-$N+1; $j<=$i; $j++) {
        print F "$v1[$j] $v2[$j]\n"
            if ((defined $v1[$j]) && (defined $v2[$j]));
    }
    close(F);
    system("R CMD BATCH /tmp/makecorr.r.$$");

    my($rho) = `awk '/^V2/ {print \$2}' makecorr.r.$$.Rout`;
    print "$dates[$i] $rho";
}

system("rm makecorr.r.$$.Rout");
```

B.16 SIMULATING TE FOR EXPOSURE IN SPOT AND FUTURES MARKET

```
#!/usr/bin/perl -w

use strict;
```

```
use Statistics::Descriptive;

my($spot) = $ARGV[0];    # percentage of exposure in spot, e.g. 0.975
my($futures) = $ARGV[1]; # percentage of exposure in futures, e.g. 0.025


my(@nifty, @futures, @dates, $n);
$n=0;
while (<>) {
    chop;
    my($date, $nifty, $futures) = split();
    $dates[$n] = $date;
    $nifty[$n] = $nifty;
    $futures[$n] = $futures;
    $n++;
}

my(@nret, @futret, @fundret, @retdates, @errors, $j, $i);
$j=0;

for ($i=1; $i<$n; $i++) {
    {

        $retdates[$j] = $dates[$i];
        $nret[$j]     = 100*log($nifty[$i]/$nifty[$i-1]);
        print $nret[$j]," ";
        $futret[$j] = 100*log($futures[$i]  /$futures[$i-1]);
        print $futret[$j]," ";
        $fundret[$j]= ($spot * $nret[$j]) + ($futures * $futret[$j]);
        print $fundret[$j],"\n";
        $errors[$j] = $nret[$j] - $fundret[$j];
        $j++;
    }
}


print "Overall results --\n";
my($handle) = Statistics::Descriptive::Full->new();
$handle->add_data(@errors);
printf "%-30s : %d\n", "Number of points", $handle->count();
printf "%-30s : %f\n", "Standard devn",    $handle->standard_deviation();
my(@percentiles) = (1,99);
my($p);
```

```
printf "%-30s : %f\n", "Min",            $handle->min();
for $p (@percentiles) {
    my($tmp) = sprintf "Percentile %4.1f", $p;
    printf "%-30s : %f\n", $tmp,         $handle->percentile($p);
}
printf "%-30s : %f\n", "Max",            $handle->max();

# Now get into rolling windows.
for ($i=250; $i<=$#errors; $i++) {
    my($handle) = Statistics::Descriptive::Full->new();
    for ($j=$i-250; $j<$i; $j++)
    {$handle->add_data($errors[$j]);
 }
    print $retdates[$i], " ", sqrt(250)*$handle->standard_deviation(), "\n";
}
```

B.17 Implementing futures using real fund data: annual TE

```
#!/usr/bin/perl -w

use strict;
use Statistics::Descriptive;

my(@nifty, @futures, @dates, @spotpro, @futurespro, $n);
$n=0;
while (<>) {
    chop;
    my($date, $nifty, $futures, $spotpro, $futurespro) = split();
    $dates[$n] = $date;
    $nifty[$n] = $nifty;
    $futures[$n] = $futures;
    $spotpro[$n] = $spotpro;
    $futurespro[$n] = $futurespro;
    $n++;
}

my(@nret, @futret, @fundret, @fundretmtm, @retdates, @mtm, @errors,
   @errorsmtm,$j, $i);
$j=0;

for ($i=1; $i<$n; $i++) {
    {
```

```
        $retdates[$j] = $dates[$i];
        $nret[$j]     = 100*log($nifty[$i]/$nifty[$i-1]);
        $futret[$j] = 100*log($futures[$i]  /$futures[$i-1]);


        $mtm[$j] = ($futurespro[$i]-$futurespro[$i-1])*
                           ($futures[$i] - $futures[$i-1]);
        $fundretmtm[$j]= ($spotpro[$i] * $nret[$j]) + ($futurespro[$i]
                           * $futret[$j]) + $mtm[$j];
        $errors[$j] = $nret[$j] - $fundretmtm[$j];
        $j++;
    }
}

print "Overall results --\n";
my($handle) = Statistics::Descriptive::Full->new();
$handle->add_data(@errors);
printf "%-30s : %f\n", "Errors", $handle->add_data();
printf "%-30s : %d\n", "Number of points", $handle->count();
printf "%-30s : %f\n", "Standard devn",    $handle->standard_deviation();
```

B.18 Implementing futures using real fund data: rolling window TE

```
#!/usr/bin/perl -w

use strict;
use Statistics::Descriptive;

my(@nifty, @futures, @dates, @spotpro, @futurespro, $n);
$n=0;
while (<>) {
    chop;
    my($date, $nifty, $futures, $spotpro, $futurespro) = split();
    $dates[$n] = $date;
    $nifty[$n] = $nifty;
    $futures[$n] = $futures;
    $spotpro[$n] = $spotpro;
    $futurespro[$n] = $futurespro;
    $n++;
}
```

```
my(@nret, @futret, @fundret, @fundretmtm, @retdates, @mtm, @errors,
   @errorsmtm,$j, $i);
$j=0;

for ($i=1; $i<$n; $i++) {
    {

        $retdates[$j] = $dates[$i];
        $nret[$j]     = 100*log($nifty[$i]/$nifty[$i-1]);
        $futret[$j] = 100*log($futures[$i]  /$futures[$i-1]);


        $mtm[$j] = ($futurespro[$i]-$futurespro[$i-1])*
                         ($futures[$i] - $futures[$i-1]);
        $fundretmtm[$j]= ($spotpro[$i] * $nret[$j]) + ($futurespro[$i]
                         * $futret[$j]) + $mtm[$j];
        $errors[$j] = $nret[$j] - $fundretmtm[$j];
        $j++;
    }
}

print "Overall results --\n";
my($handle) = Statistics::Descriptive::Full->new();
$handle->add_data(@errors);
printf "%-30s : %f\n", "Errors", $handle->add_data();
printf "%-30s : %d\n", "Number of points", $handle->count();
printf "%-30s : %f\n", "Standard devn",    $handle->standard_deviation();
my(@percentiles) = (1,99);
my($p);
printf "%-30s : %f\n", "Min",              $handle->min();
for $p (@percentiles) {
    my($tmp) = sprintf "Percentile %4.1f", $p;
    printf "%-30s : %f\n", $tmp,           $handle->percentile($p);
}
printf "%-30s : %f\n", "Max",              $handle->max();

# Now get into rolling windows.
for ($i=250; $i<=$#errors; $i++) {
    my($handle) = Statistics::Descriptive::Full->new();
    for ($j=$i-250; $j<$i; $j++)
    {$handle->add_data($errors[$j]);
 }
```

```
    print $retdates[$i], " ", sqrt(250)*$handle->standard_deviation(), "\n";
}
```

Bibliography

Beneish, M. & Whaley, R. (1996). An anatomy of the s&p game: the effects of changing the rules. *Journal of finance* **51**(5), 1909–1930. 49, 61

Black, F. (1971). Towards a fully automated exchange, Part I and II. *Financial Analysts Journal.* 39

Blin, J. (1997). Risk structure in Indian stocks. *in* Waghmare (1997). chapter 26, pp. 167–186. 35

Bodie, Z., Kane, A. & Marcus, A. (1989). *Investments.* 1st edn. Richard D. Irwin Inc. 46

Bogle, J. C. (1998). The first index mutual fund. *in* Neubert (1998). chapter 3, pp. 37–78. 19

Brinson, G. P., Hood, R. & Beebower, G. L. (1986). Determinants of portfolio performance. *Financial Analysts Journal* pp. 39–44. 22, 23

Carhart, M. M. (1997). On persistence in mutual fund performance. *Journal of Finance* pp. 57–82. 24, 25, 46, 61

C.Blitz, D. & Hottinga, J. (2001). Tracking error allocation. *Journal of Portfolio Management* pp. 19–25. 84

Chiang, W. C. (1998). Optimizing performance. *in* Neubert (1998). chapter 17, pp. 307–336. 33, 47, 60, 81

Daniel, K., Grinblatt, M., Titman, S. & Wermers, R. (1997). Measuring mutual fund performance with characteristic–based benchmarks. *Journal of Finance.* 61

Dickson, J. M. & Shoven, J. B. (1995). Taxation and mutual funds: an investor perspective. *National Bureau of Economic Research* **9**, 151. 27, 28

Economides, N. & Schwartz, R. A. (1995). Electronic call market trading. *Journal of Portfolio Management*. 40

Ellis, C. D. (1975). The losers game. *Financial Analysts Journal*. 21

Elton, E., Gruber, M. & Blake, C. (1996). The persistence of risk–adjusted mutual fund performance. *Journal of Business* **69**(2), 133–157. 21, 61

Elton, E. J., Gruber, M. J., Das, S. & Hlavka, M. (1993). Efficiency with costly information: a reinterpretaion of evidence from managed portfolios. *RFS* **6**(1), 1–22. 61

Evans, R. E. (1999). *The index fund solution*. Fireside. 24, 148

Fama, E. (1972). Components of investment performance. *Journal of Finance*. 22

Fernandes, K. (2003). Evaluating index fund implementation in india. Technical Report 25. National Stock Exchange of India Research Initiative working paper. 81, 87, 91

Frino, A. & Gallagher, D. R. (1999). Is index performance achievable? an analysis of australian equity index funds. Technical report. University of Sydney. 61

Frino, A. & Gallagher, D. R. (2001). Tracking s&p 500 index funds. *Journal of Portfolio Management* **Fall**, 44–55. 61

Glosten, L. R. (1994). Is the electronic open limit order book inevitable?. *Journal of Finance* **49**, 1127–1161. 39

Good, W. R. & Hermansen, R. W. (1998). *Index your way to investment success*. New York Institute of Finance. 18

Grinblatt, M. & Titman, S. (1984). Portfolio performance evaluation: old issues and new insights. Technical report. ULCA Graduate School of management, University of California. 22

Gruber, M. J. (1996). Another puzzle: The growth in actively managed mutual funds. *Journal of Finance* pp. 783–810. 21, 24, 61

Harris, L. & Gurel, E. (1986). Price and volume effects associated with changes in the S&P 500 list: New evidence for the existence of price pressures. *Journal of Finance* **41**, 815–829. 42

Harrison, A. (1991). New Zealand's index funds. *BARRA Newsletter*. 35

Henriksson, R. & Merton, R. (1981). On market timing and investment performance ii: Statistical procedures for evaluating forecasting skills. *Journal of Finance* **54**, 513–534. 22

Herring, J. L. (1996). When does fund size affect performance?. *Pension Management* **32**(4), 18–20. 29

Hill, J. M. & Naviwala, H. (1999). Synthetic and enhanced index strategies using futures on u.s. indexes. *JPM* pp. 61–74. 36, 37

Indro, D. C., Jiang, C. X., Hu, M. Y. & Lee, W. Y. (1999). Mutual fund performance: does fund size matter?. *Financial Analysts Journal* pp. 74–87. 28

James, E., Ferrier, G., Smallhout, J. & Vittas, D. (1999). Mutual funds and institutional investments: what is the most efficient way to set up individual accounts in a social security system?. Technical Report 7049. NBER. 26

Jansen, R. & van Dijk, R. (2002). Optimal benchmark tracking with small portfolios. *Journal of Portfolio Management* **Winter**, 33–39. 61

Jeffrey, R. H. & Arnott, R. D. (1993). Is your alpha big enough to cover its taxes?. *Journal of Portfolio Management.* 27

Jensen, M. (1968). The performance of mutual funds in the period 1945–64. *Journal of Finance* pp. 389–415. 21

Jensen, M. (1978). Some anomalous evidence regarding market efficiency. *Journal of Financial Economics* **6**, 95–101. 50

Keim, B. (1999). An analysis of mutual fund design: the case of investing in small-cap stocks. *Journal of Finanial Economics* **51**(2), 173–194. 48, 60

Keim, D. & Madhavan, A. (1998). The cost of institutional equity trades. *FAJ* **54**(4), 50–69. 21

Larsen, G. A. & Resnick, B. G. (1998). Empirical insights on indexing. *Journal of Portfolio Management* pp. 51–60. 35, 64

Liesching, R. & Manchanda, V. (1990). Establishing the fund. *in* E. Bishop, ed., 'Indexation'. Euromoney Publications PLC. chapter 7, pp. 93–115. 34

Liu, S., Sheikh, A. & Stefek, D. (1998). Optimal indexing. *in* Neubert (1998). chapter 4, pp. 79–94. 35

Loeb, T. F. (1983). Trading cost: the critical link between investment information and results. *Financial Analysts Journal* pp. 39–43. 28

Lynch, A. W. & Mendenhall, R. R. (1997). New evidence on stock price effects associated with changes in the S&P 500 index. *Journal of Business* **70**(3), 351–383. 42

Malkiel, B. G. (1995). Returns from investing in equity mutual funds 1971 to 1991. *Journal of Finance* pp. 549–572. 21, 46, 61

Malkiel, B. G. (1999). Introduction. in *The index fund solution* Evans (1999). pp. 13–28. 15, 16, 29, 30

Malkiel, B. G. & Radisich, A. (2001). The growth of index funds and the pricing of equity securities. *Journal of Portfolio Management* pp. 9–21. 42

Mariathasan, J. (1997). Guaranteed return funds. *in* Waghmare (1997). chapter 15, pp. 97–108. 53

Mason, S., Merton, R., Perold, A. & Tufano, P. (1995). BEA Associates: Enhanced equity index funds. *in* 'Cases in financial engineering'. Prentice Hall. pp. 751–763. 33, 36, 84

Masters, S. J. (1998). The problem with emerging market indexes. *Journal of Portfolio Management* pp. 93–100. 20

Mehra, R. & Prescott, E. (1985). The equity premium: A puzzle. *Journal of Monetary Economics* **15**, 145–161. 54

Miller, T. & Meckel, T. S. (1999). Beating index funds with derivatives. *Journal of Portfolio Management* pp. 75–87. 36, 84, 85

M.Rudolf, H.J.Wolter & H.Zimmermann (1999). A linear model for tracking error minimization. *Journal of Banking and Finance* **23**, 85–103. 64

Nayak, P. J. (1997). An India managed index fund. *in* Waghmare (1997). chapter 14, pp. 91–97. 51

Neubert, A. S., ed. (1998). *Indexing for maximum investment results.* Glenlake Publishing Company, Ltd. 145, 148, 149

Olmà, A. (1998). Implementing equity index portfolio. *in* Neubert (1998). chapter 11, pp. 221–236. 34

Perold, A. (1988). The implementation shortfall: paper versus reality. *Journal of Portfolio Management* **14**(3), 4–9. 48, 60

Pope, P. & Yadav, P. (1994). Discovering errors in tracking error. *Journal of Portfolio Management* **20**(2), 27–32. 64

Roll, R. (1992). Industrial Structure and the Comparative Behaviour of International Stock Market Indices. *Journal of Finance* **XLVII**(1), 3–42. 64

Roll, R. R. (1977). A critique of the asset pricing theory's tests: Part I. *Journal of Financial Economics* **4**, 120–176. 45

Ross, S. A. (1976). The arbitrage theory of capital asset pricing. *Journal of Economic Theory* **13**, 341–360. 22

Rubinstein, M. (1989). Market basket alternatives. *Financial Analysts Journal* **45**(5), 20–29. 38

Rudd, A. (1980). Optimal selection of passive portfolios. *Financial Management* **Spring**, 57–66. 61

Shah, A. (1999*a*). Institutional change on India's capital markets. *Economic and Political Weekly* **XXXIV**(3–4), 183–194. 30

Shah, A. (2003). Market efficiency on the indian equity derivatives market. *in* 'Derivatives markets in India 2003'. Invest India – Tata McGraw–Hill Series. chapter 5, pp. 99–119. 86

Shah, A. & Fernandes, K. (1999). The role of index funds for pension investment in developing countries. Technical report. World Bank. 47

Shah, A. & Thomas, S. (1998). Market microstructure considerations in index construction. *in* 'CBOT Research Symposium Proceedings'. Chicago Board of Trade. pp. 173–193. 32, 36, 53

Shah, H. (1999*b*). Pension fund investments: Individual choice versus control. Technical report. World Bank. 20

Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *Journal of Finance* XIX(3), 425–442. 68

Shleifer, A. (1986). Do demand–curves for stocks slope down?. *Journal of Finance* **41**, 579–590. 42

Siegel, J. (1998). *Stocks for the Long Run.* McGraw-Hill. 53

Sorensen, E. H., Miller, K. L. & Samak, V. (1998). Allocating between active and passive management. *Financial Analysts Journal* pp. 18–31. 25

Treynor, J. & Mazuy, M. (1966). Can mutual funds outguess the market?. *Harvard Business Review* **44**(4), 131–136. 21

Waghmare, T., ed. (1997). *The future of fund management in India - 1997.* Invest India – Tata McGraw–Hill Series. Tata McGraw–Hill. 145, 148

Wagner, W. H. & Edwards, M. (1993). Best execution. *Financial Analysts Journal* pp. 65–71. 28

Wilcox, J. W. (2000). Better risk management. *JPM* pp. 53–64. 23