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Diversification Premium on Indian ADRs During the Financial Crisis

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DIVERSIFICATION PREMIUM ON INDIAN ADRs DURING THE FINANCIAL CRISIS

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Abstract

Non-arbitrage asset pricing has been an avenue of unending interest to financial academics and practitioners alike. With increased capital outflow being permitted by developing economies, investors now have easy access to securities issued by foreign firms. The issue investigated in this research is concerned with the persistent presence of arbitrage opportunities between depository receipts and domestic stocks of Indian firms during the recent financial crisis. Instead of being priced in parity with one another during the crisis, ADRs of Indian firms were overpriced by as much as 70% for months on end. This thesis investigates the reasons giving rise to this premium by analyzing causes like benefits from diversification and liquidity.

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I'd like to take this opportunity to thank my parents for their immense contribution to my life. Their years of hard-work and sacrifice made my dream to study in the United States a reality, and I'm deeply grateful for everything they've done—and still do—for me.

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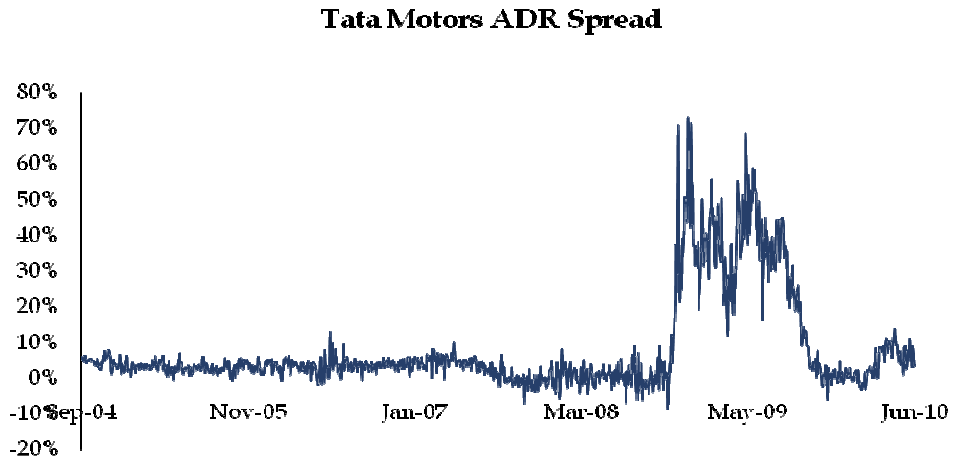
1. Introduction

While the recent economic downturn undoubtedly led to severe loss of capital, the impact of the crisis on financial instruments was not restricted merely to rapid erosion in capital markets, but also exerted its influence by changing the relationships between various asset classes: during this period of economic upheaval, the price of gold was observed to be strongly correlated with stock indices (a fact at direct odds with the long held notion of gold serving as a natural hedge to equity investments), near-zero interest rates failed to lower inflation, and the theory that international markets had decoupled from the United States suffered a setback as emerging markets followed the developed economies into a downward spiral.

An asset class that was deeply affected by the recession, but did not receive mainstream attention when compared to the ones above, was that of dual-listed shares. As firms in developing countries fostered an increasingly global outlook over the last two decades, American Depository Receipts became a common method for foreign firms to raise capital. Being derivative instruments with company stock as their underlying asset, ADRs usually trade close to parity with their domestic stocks, with their returns almost completely being dependent on underlying stock and foreign exchange movements. While ADRs listings in the United States have traded at a slight premium (~2%) to their underlying stocks historically, during the financial crisis this premium was observed to be as wide as 70% for a significant length of time for certain firms. A time-series depicting

this trend in the spread between the underlying stock and the ADR of Tata Motors, an Indian auto manufacturer, is shown below.



This research aims to investigate potential causes that led to such significant premiums on ADRs during the financial crisis. By examining whether the relationship between returns on ADRs and those on underlying stocks, equity indices and foreign exchange movements changed during the recession, the thesis will focus on ADRs issued by Indian companies to research whether investors enjoyed an additional diversification premium by investing in ADRs during the recession. If dual-listed shares succeeded in offering lower risk along with higher returns due to exposure to emerging markets, investors could attain a better risk-reward tradeoff characterized by a higher Sharpe Ratio through holding a portfolio of ADRs in addition to a diversified portfolio of US equity, thereby justifying a high premium on ADRs.

2. Literature Review

Asset pricing has long been the subject of research for financial theoreticians. Ever since Markowitz's (1952) research on the subject, diversification has been an important topic in the realm of finance. His suggestion that investors consider variance of return to be undesirable proved to be groundbreaking—focus now lay not merely on enhancing expected returns, but reaching an optimum level conditioned on an investor's risk profile. Over the second half of the twentieth century, as the world of financial securities grew, so did the possibility of diversification; investors could now choose not only between stocks, bonds, currencies and commodities, but also invest across borders through depository receipts.

Though depository receipts have been in existence since before the Great Depression, it was only in the 1990s that they gained enough popularity to be considered an asset class in their own right. Consequently, much of the characteristics of ADRs and GDRs as securities must be inferred from corresponding research devoted to international equities and markets. The first inquiry into the existence of coupling between global markets was conducted by Grubel (1968), who reported low and statistically insignificant correlations between returns of various global indices, providing evidence to suggest that systematic risk of aggregate portfolios could potentially be reduced by investing across borders. Contrary to the findings of Grubel, Bennet and Keller (1988) discovered strong linkages

between global equity markets, and along with Becker (1990), suggested that these linkages limited the gains from international diversification.

If the majority of the post-war period saw the United States consolidating its position as the economic leader of the world, the first decade of the twenty-first century has belonged to emerging markets, especially Brazil, Russia, India and China (colloquially known as the "BRIC Nations"). Benefiting from consistently high economic growth, firms from emerging markets have lately sought to increase their global presence, and have seen depository receipts as an effective way to tap international capital. The Indian economy benefited from financial sector reforms in 1991, when foreign institutional investors (FII) were allowed access to the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE), and Indian corporations were permitted to raise capital from foreign investors through Global Depository Receipts (GDR) and American Depository Receipts (ADR). In addition, the launch of Foreign Currency Convertible Bonds (FCCB) allowed firms to access debt capital markets and opened the untapped Indian corporate debt sector to global investors.

Economic liberalization in India stimulated research on the specific characteristics and prospects of Indian capital markets. Ignatius (1992), found no evidence of integration between returns on the BSE Sensex and the S&P 500. Furthering his research, Jayaraman, Shastri and Tandon (1993) indicated that ADR listing led to a permanently higher volatility in underlying stocks from developing countries, possibly due to stringent

disclosure requirements for ADRs, which would consequently impact domestic stock movement as well.

The first inquiry into the persistence of premiums in the ADR market for Asian stocks was conducted by Jithendranathan, Nirmalanandan and Tandon (2000), who found that GDRs traded at a considerable premium to their underlying stock price consistently. They determined that as ADRs are not easily fungible due to government restrictions, investors view ADRs and stocks as differentiated securities. Contrary to the findings of Ignatius (1992), they, along with Hansda and Ray (2002) observed a unidirectional causality from the Nasdaq to the NSE and the BSE, particularly pronounced within technology indices.

Bae, Cha and Cheung (1999) sought to expand Lau and Dlitz's (1994) research that international listings do not give rise to arbitrage opportunities as market imperfections are not readily apparent. They used returns from 23 companies listed both on the Stock Exchange of Hong Kong (SEHK) and the London Stock Exchange (LSE) to determine whether transmission of price information ran in one direction or both. Bae, Cha and Cheung believed that the absence of simultaneous trading on the two markets on account of time-difference presented an ideal setting to research market efficiency, and by using dual-listed stocks in place of broader indices, they would gain precision while addressing information flows between markets. Through their findings, they discerned that though information flows reflected in security prices are indeed bidirectional, the impact of the LSE on the SEHK is stronger than the other way around.

Hansda and Ray (2003) expanded their earlier research on stock market indices to include specific stocks. Examining returns on 10 ADRs, they found the existence of a bidirectional relationship between the underlying stock and the ADR listing, as opposed to a unidirectional flow between the corresponding stock indices. In addition, they also investigated impulse transmission between ADRs and stocks, and discovered that a standard deviation shock in the close quote of the ADR will lead to a higher open quote on the Indian exchange in the next trading session. Both markets were found to be efficient in transmitting price information across the dual listed entities, preventing arbitrage. Of particular note was the fact that these relationships held even before two-way fungibility of Indian ADRs was permitted by the Reserve Bank of India (RBI) in February 2002, which by facilitating the hitherto banned conversion of stocks to depository receipts further limited the scope of arbitrage.

The determinants of ADR returns was investigated by Chakrabarti (2003), who reasoned that as ADRs were derivative securities, controlling for transaction costs and investment restrictions, it would be possible to arbitrage ADRs with underlying stocks if exchange rate movements and returns on underlying stocks did not explain ADR returns completely. Chakrabarti reported that ADRs enjoy premiums ranging from 1.6% for VSNL to as much as 68% for Infosys, as compared to their corresponding Indian listings. These premiums, however, remained relatively stable over time, especially in the case of non-technology listings. Chakrabarti also found lower than expected correlations for ADRs compared to both stock prices and exchange rates. Despite being claims on the same cash-flows, correlation with underlying stocks varied between 0.18 and 0.72, while

the average correlation of ADR returns with stock price movements was 0.1. Even though ADR returns had low correlation with underlying stock returns and exchange rates, no evidence for systematic bias in ADR returns was found, as excess return over underlying stock was not significantly different from 0. Another finding presented in the paper was the temporary existence of a positive effect on underlying stock price under the event of a new ADR issuance— cumulative abnormal returns over the 20 trading day period immediately following a depository listing were found to be significantly higher for most ADRs, indicating some "irrational exuberance" associated with ADR issues, which may decline with time. The overall findings indicated that idiosyncratic market factors not captured in major US indices, affected ADR price movements.

On account of being quoted in dollars, ADRs protect their investors from explicit foreign exchange risk. However, one would expect that the price of an ADR would reflect not only the value of the underlying stock, but also track movements in exchange rates. Furthermore, as trading hours of the US markets do not completely coincide with the market on which the underlying issue is listed, it is possible for predictability patterns to exist. ADR market efficiency was first examined by Rosenthal (1983), who found the existence of weak-form efficiency, due to the absence of abnormal returns. Kim, Szakmary and Mathur (1999) conducted a more robust inquiry into ADR price transmission and informational efficiency by using a vector autoregression (VAR) model to study how fluctuation in underlying shares, foreign exchange and the US market index impact returns on ADRs. After determining that ADRs over-react to the US market index but under-react to changes in exchange rates and underlying stock prices, they shocked

the ADR prices with impulses to the explanatory variables. After seeing that currency shocks lasted longer compared to other impulses, they deduced that ADR market participants are unable to fully grasp the volatility of currency markets and are unsure of their expected movements. On the basis of their findings, Kim, Szakmary and Mathur concluded that ADRs initially over-react to changes in the US market, while not fully reflecting foreign influences.

While ADRs do, on average, have a lower trading volume than their underlying security, data from 2005 onwards indicates that their prices weren't stale. Lo and MacKinlay (1990) and Brennan, Jegadeesh and Swaminathan (1993) found that lead-lag cross-autocorrelations are often found due to their being a difference in the time taken by stocks to react to macro-economic factors common to all stocks. Chordia and Swaminathan (2000) refer to this phenomenon as the speed of adjustment hypothesis, and contend that these lead-lag patterns aren't arbitraged away because of high trading costs. They found that trading volume is a significant determinant of lead-lag patterns observed in stock returns, as low volume stocks and portfolios respond to market information at a slower pace than stocks and portfolios that are traded frequently. Holding firm size constant, Chordia and Swaminathan found that lagged high volume portfolio returns can predict current low volume portfolio returns. They reasoned that if security prices adjust slowly to information, then one positive return is likely to be followed by another, giving rise to positive autocorrelation. Further, due to the magnitude of autocorrelations and cross-autocorrelations, they deduced that non-trading cannot be the sole explanation for their results.

Pioneering research in the field of ADR liquidity was conducted by Amihud (2002), who, on the basis of his illiquidity measure, concluded that over time, expected market illiquidity gives rise to a liquidity premium in ADR returns.[1] Acharya and Pederson (2005) used the Amihud measure to investigate how asset prices were affected by liquidity risk, and found evidence to suggest that a liquidity adjusted model is more accurate in predicting ADR returns, as liquidity in ADR often varies.

Further research on the determinants of ADR spreads by Kadapakkam and Kumar found that the differences in liquidity and market sensitivity between ADRs and their underlying stocks does not explain ADR premiums. They, along with Puthenpurackal (2006) found that ADR premiums were reduced when a firm made a follow-on ADR issue.

The empirical tests presented in this research aim to further Hansda and Ray's research on the relationship between ADR open quotes and domestic stock closing quotes, to investigate whether the closing quotes for Indian ADRs are Granger caused by the previous trading session's close in India, and vice-versa. After establishing the causal direction(s), this thesis analyzes determinants of ADR spreads to bring forth reasons as to why premiums on ADRs like Tata Motors widened to as high as 70% during the financial crisis, while they usually remain in the 3 – 5% range. The recession witnessed

[1] Amihud's Illiquidity Measure = $\frac{1}{D_t}\sum_{d=1}^{D_t}\frac{|R^{i,d}|}{Vol^{i,d}}$; where D_t is the number of trading days in a month, and $R^{i,d}$ and $Vol^{i,d}$ are Returns and Trading Volume for ADR i on day d

international markets decoupling from one-another, and exhibiting volatile, idiosyncratic movements. Using VAR models for daily returns, this thesis investigates how ADRs, being derivative instruments reflecting equity claims, behaved during the tumultuous recession.

After having established causality patterns for the stock returns, this paper will examine potential explanations for the consistently higher ADR prices. One such reason might be benefits from diversification—if a portfolio of the S&P Index in combination with the ADRs has a higher Sharpe ratio than the market portfolio, it could be that American investors are paying a premium to better diversify themselves. Methods suggested by Shanken (1996) and Opdyke (2005) are used in this research to determine a statistically significant Sharpe ratio for the constructed portfolios.

3. A Brief Overview of Depository Receipts in India

Depository Receipts were first introduced by J.P. Morgan in 1927, and were mostly unsponsored for the first few decades of their history, without any major financial institution being required to underwrite the depository offering. With economies over the globe becoming more liberal, the Depository Receipts market in the United States began to develop—in 1994 alone, approximately $20 billion was raised through ADR issues (Chakrabarti, 2003). A number of institutions provide depository services today, including J.P. Morgan, Deutsche Bank, BNY Mellon and Citi.

Indian companies became part of the depository bandwagon in a big way starting in the early 90s, when the Indian Government eased norms for foreign investments in Indian firms. Reliance Industries, India's largest company as measured by market capitalization, led the way with the nation's maiden GDR issue of $150 million in 1992. As of June 2010, a total of 309 Indian companies had Depository Receipts trading primarily on the NYSE, Nasdaq, Luxembourg Stock Exchange and the London Stock Exchange.[2] Firms have preferred to list in London or Luxembourg over the United States, as US GAAP requirements are relatively more stringent than the norms for GDR listings. However, due to better investor perception and brand value creation, ADR listings are becoming more popular. The following table shows Indian firms which currently have ADRs:

[2] Bank of New York Mellon Depository Receipts http://www.adrbnymellon.com/ [Access date: Oct 2, 2010]

Company	Industry	Market Capitalization ($ bn)	ADR : Domestic Share Ratio
Dr. Reddy's Laboratories	Pharmaceutical	5.4	1 : 1
HDFC Bank	Bank	26.8	1 : 3
ICICI Bank	Bank	26.3	1 : 2
Infosys Technologies	Software	37.2	1 : 1
Mahanagar Telephone Nigam	Telecom	0.9	1 : 2
Patni Computer Systems	Software	1.3	1 : 2
Rediff.com India*	Software	0.1	2 : 1
Mahindra Satyam#	Software	3.5	1 : 2
Sterlite Industries	Metals & Mining	3.1	1 : 1
Tata Communications	Telecom	2.1	1 : 2
Tata Motors	Automobile	10.6	1 : 1
Wipro	Software	33.6	1 : 1
WNS Holdings*	Support Services	0.4	1 : 1

* Rediff.com and WNS Holdings are not publicly traded in India

Source: Bank of New York Mellon, Bloomberg

On January 7, 2009, executives of Satyam confessed to falsifying accounts to the tune of $6 billion. The firm was sold to Mahindra (and renamed to Mahindra Satyam), and was delisted from the NYSE on October 14, 2010[3] [4]

[3] Mahindra Satyam's ADRs Delist from NYSE: http://www.gossone.com/business/mahindra-satyams-adrs-delist-from-nyse [Access date: November 7, 2010]

[4] Satyam scam now at Rs 24,000 crore & counting: Times of India, August 19, 2010: http://timesofindia.indiatimes.com/business/india-business/Satyam-scam-now-at-Rs-24000-crore-counting/articleshow/6333974.cms [Access date: November 7, 2010]

Depository Receipts got a shot in the arm from the regulators on February 13, 2002, when two-way fungibility in DRs was permitted by the Reserve Bank of India. Prior to this date, the government heavily restricted the conversion of domestic stocks into DRs, preventing potential arbitrage. Shares and FCCBs issued against depository receipts are considered foreign direct investment (FDI), and as such, cannot exceed 51% of the subscribed equity value of the issuer (Hansda and Ray, 2002). India's Depository Receipt story came a full-circle when on June 11, 2010, Standard Chartered issued the first Indian Depository Receipt to be traded on the National Stock Exchange, with an issue size of $590 million.[5]

Arbitrage in ADRs of Indian firms is not possible on a continuous basis, as trading hours in India and the United States do not overlap. Hansda and Ray (2003), observed a high positive correlation between the close and open quotes on underlying stocks and ADRs respectively, and vice-versa. This result is unsurprising, as non-synchronous trading hours on the two markets would lead to the closing price of one security to heavily influence in the opening of the other security.

The chart below shows the trading hours in India and the United States.[6]

Day T			Day T+1
BSE / NSE Opens	BSE / NSE Closes	Nasdaq / NYSE Opens	Nasdaq / NYSE Closes
↓	↓	↓	↓
9:00 hrs	16:00 hrs	20:00 hrs	2:30 hrs

[5] The Economic Times. June 11, 2010. *Standard Chartered IDR lists at Rs. 106 on the NSE*
[6] Adapted from: Hansda and Ray, 2003. In January, 2010, the Indian markets announced that trading would begin an hour early, from 9:00 am instead of 10:00 am

4. Data

This paper uses daily ADRs returns for Indian firms from January 2005 through June 2010. According to the Depository Receipt directory maintained by BNY Mellon, there are currently 13 ADRs issued by Indian firms. 2 of these do not trade in India, and another was listed in June 2007, making it impossible to analyze their comparative behaviors before and after the recession. Therefore, the final data sample consisted of daily returns on and volumes of ADRs and the underlying stocks of 10 Indian firms. The data was downloaded from the database maintained by Center for Research in Security Prices by Wharton Research Data Services. The average daily returns and volumes of the Indian stocks and their ADRs are shown in Table 1.

Other variables used in the data analyses included daily returns on the S&P 500 Index, the CBOE Volatility Index (VIX), the National Stock Exchange of India Index (Nifty) and the US Dollar - Indian Rupee exchange rate. The daily data for these variables was obtained from Bloomberg.

The summary statistics for these variables are shown in Table 2. The Appendix also shows the summary statistics for the daily spreads between the ADR and the domestic stock prices (shown as a percentage of domestic stock prices).

4.1 Stationarity

Non-stationarity of the daily returns used, if present, could have far-reaching effects on the behavior of the time-series. Most notably, it could give rise to "spurious" regressions, that is, regressing one return on another could yield a high R^2 even if the two series were completely uncorrelated.

The Augmented Dickey-Fuller Test Statistic was used to determine the stationarity of the time-series used in this paper, using the following test equation: $\Delta y_t = \theta y_{t-1} + \alpha \Delta y_{t-1}$: where y_t represents the return on the time-series.[7] The appropriate number of lags to use was determined to be 1 for all data-sets used, according to the Akaike Information Criterion. The Augmented Dickey-Fuller Test Statistics tests the following hypothesis[8]:

$H_0 : \theta = 0$ (The data is non-stationary, and needs to be differenced to induce stationarity) vs.

$H_1 : \theta < 1$ (The data is stationary)

As indicated by the Dickey-Fuller Test Statistic for each regression, the daily stock and ADR returns for the 10 firms in the sample did not contain a unit-root, and were stationary. The value of the test statistic is shown in Table 4.

[7] Fomby, T., *Augmented Dickey-Fuller Unit Root Tests* http://faculty.smu.edu/tfomby/eco6375/BJ%20Notes/ADF%20Notes.pdf [Access date: Oct 2, 2010]
[8] ibid

5. Methodology

5.1 Variables

5.11 Daily Returns and Percentage Changes

The price levels at the end of each trading day were used to compute daily returns for the ten ADRs and domestic stocks in the sample, using the formula:

$$\text{Return}_t = \frac{\text{Level}_t}{\text{Level}_{t-1}} - 1$$

The exercise to compute daily returns was repeated to compute daily percentage changes for the S&P 500, the Nifty, the VIX and the USD – INR exchange rate.

5.12 Daily Spreads (ADR Premiums)

The research conducted in this paper focuses on how the spreads between the ADRs and the domestic stock prices behaved during the recession, and whether this behavior was different from that exhibited before the recession. For the purposes of this paper, the spread is defined as:

$$\text{Spread}_t = \frac{\text{Price}_{US_t}}{\text{Price}_{India_t} \times \text{Ratio}},$$

Where Ratio signifies the number of domestic shares an ADR is equivalent to.

5.13 Volume

Volume represents the number of shares and depository receipts traded on the Indian and the American exchanges on a daily basis. To investigate whether unequal liquidity in the two markets was responsible for the spreads between the ADR and the stock prices, a variable representing the difference in trading volume was created. $\text{Vol Dif} = \text{Volume}_{\text{India}} - \text{Volume}_{\text{US}} \times \text{Ratio}$. The US Volume was magnified by the ADR ratio to reflect the actual claims on the common equity made on the trading day, and to maintain consistency with the Indian volume numbers.

5.2 Empirical Tests

5.21 Diversification with ADRs

Investment choices are determined by risk aversion and expectations for the risk-return trade-off of an optimally risky portfolio. While emerging markets like India and China offer prospects for a much higher rate of return than a mature market like the United States, these markets are also fraught with extremely high levels of volatility. Consequently, investors might not be attracted to international securities purely on a risk-reward basis.

During the financial crisis, however, equity markets in the United States experienced unprecedented levels of volatility—in December 2008, the CBOE

VIX reached an all time high of 80.9, up more than 300% from levels a quarter ago. With the S&P 500 offering a low expected return despite such high volatility, dual-listed stocks issued by international companies presented a much more attractive investment proposition—while less volatility vis-à-vis the S&P 500 compared to before, they still offered a significantly higher return, leading to a better Sharpe Ratio for investors.

To investigate the hypothesis of the existence of a diversification premium on ADRs, the Markowitz model for Mean Variance Portfolio Optimization was implemented for daily returns on the S&P 500 and an equal weighted portfolio of the ten ADRs used in the sample. In an effort to partially compensate for the weakness of using historical returns as an estimate for the future, expected returns for the recession were calculated using daily returns from January 2005 through November 2007, the period immediately before the advent of the financial crisis. Summary statistics for expected returns, volatility and correlation between daily returns for the portfolio of ADRs and the S&P 500 are shown in Table 5.

5.211 Minimum Variance Portfolio

To analyze efficient diversification, the opportunity set for investors was assumed to consist of two risky assets, the S&P 500 and a portfolio of ADRs, and a riskless asset, 10 year US Treasury Rate. The two risky securities had a slight negative correlation (~ -1%), thus offering investors the opportunity to diversify effectively.

The variance of the two-asset portfolio is given by:

$$\sigma_p^2 = w_{S\&P}^2\sigma_{S\&P}^2 + w_{S\&P}^2\sigma_{S\&P}^2 + 2w_{S\&P}w_{ADR}Cov(r_{S\&P}, r_{ADR})$$

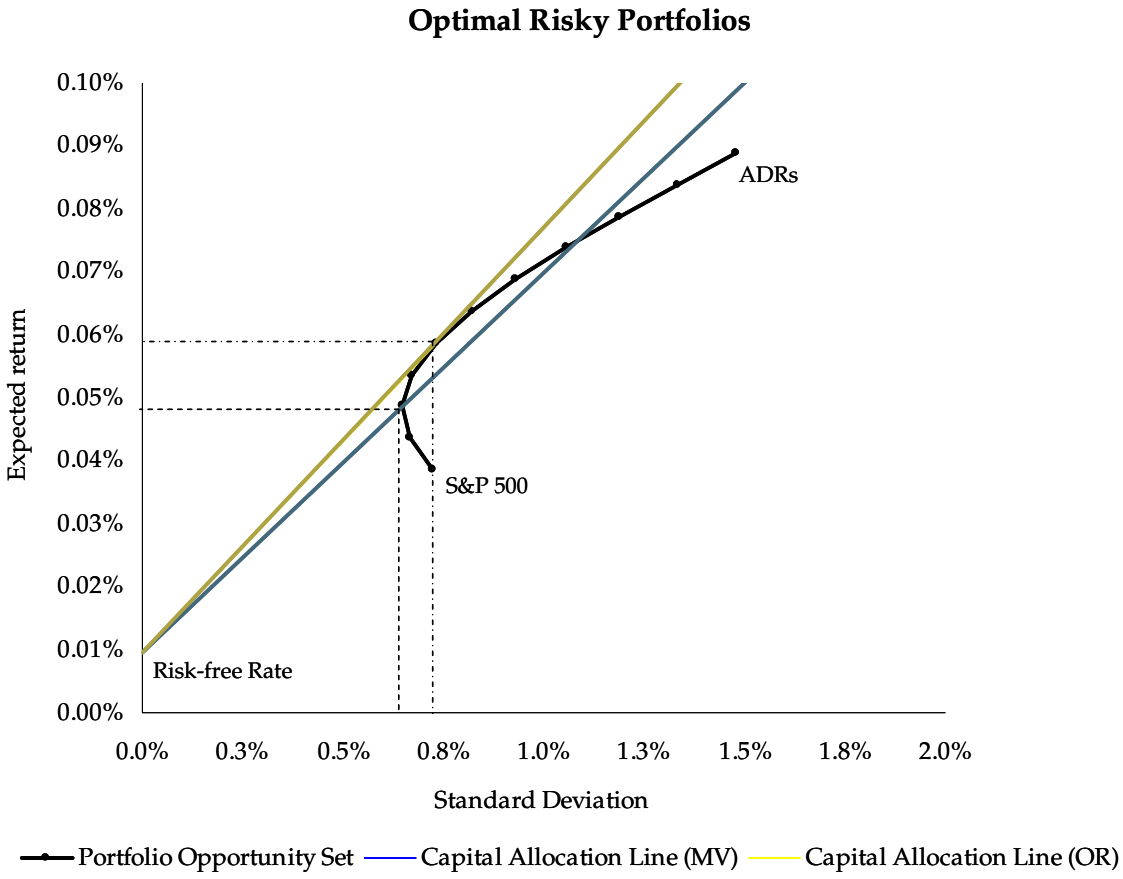
As the S&P 500 is, on average, less volatile compared to ADRs, the variance of the portfolio was minimized with an 80.4% capital allocation in the S&P 500, at a level of 0.65% per day (shown in Table 6).

5.212 Optimal Risky Portfolio

The hypothesis that investors viewed ADRs as effective diversifiers during the financial crisis would be strengthened if the tangency portfolio of the Capital Allocation Line (CAL) with the opportunity set of risky assets was close to the minimum variance portfolio during the recession. If this were true, it would imply that because investors could raise their risk-reward tradeoff to an optimal level while being exposed to the least possible volatility, they were willing to pay a premium to diversify their investment portfolios by holding ADRs.

The risk-reward tradeoff of an asset is quantified the slope of its Capital Allocation Line, the Sharpe Ratio. The Sharpe ratio is a measure of the risk premium offered by an asset for unit standard deviation. An asset with the highest attainable Sharpe ratio, characterized by a steepest CAL tangential to the opportunity set of risky assets, is therefore the most preferable to the investor. The optimal CAL is also known as the Capital Markets Line (CML).

The opportunity set of risky assets, the CML, and the CAL through the minimum variance portfolio are shown below. The summary statistics of the figure below are displayed in Table 6.



5.213 Statistical Significance of the Difference in Sharpe Ratios

As seen from the figure above, the Markowitz optimization algorithm yields an optimal risky portfolio with 60% of an investor's capital deployed in the S&P 500, as compared to 80% for the minimum variance portfolio. The portfolios are reasonably similar—the optimal portfolio yields an expected return of 0.06% and

a daily standard deviation of 0.7%, while the minimum variance portfolio has an expected return and standard deviation of 0.05% and 0.065% respectively.

The Sharpe ratio of the optimal risky portfolio thus created is also superior to that of a portfolio of the riskless asset with the S&P 500, both in terms of risk and return. However, as the arithmetic mean of historical daily returns is used as a proxy for expected returns, it may be the case that the Sharpe ratio for the portfolio of ADRs is higher only in sample, because of the high margin of error induced by the high sample standard deviation.

To test the statistical significance of the difference in Sharpe Ratios of two portfolios, Gibbons, Ross and Shanken (1989) derived a test for the ex ante efficiency of two asset portfolios. Opdyke (2006) derived a test for the significance of the difference in the Sharpe ratio of two portfolios by converting the Hotelling's T^2 F-statistic test developed by Gibbons, Ross and Shanken (1989) into a simpler T-test for difference in means.

If T refers to the number of observations in sample, $\sqrt{T}(\hat{SR}_{diff}) \sim N(0, Var_{diff})$, where

$$Var_{diff} = 1 + \frac{SR_a^2}{4}[\text{Kurtosis(a)} - 1] - SR_a[\text{Skewness(a)}] + 1 + \frac{SR_b^2}{4}[\text{Kurtosis(b)} - 1]$$

$$- SR_b[\text{Skewness(b)}] - 2\left[\rho_{a,b} + \frac{SR_a SR_b}{4}\left[\frac{\mu_{2a,2b}}{\sigma_a^2\sigma_b^2} - 1\right] - \frac{1}{2}SR_a\frac{\mu_{2a,1b}}{\sigma_a^2\sigma_b} - \frac{1}{2}SR_a\frac{\mu_{1a,2b}}{\sigma_a\sigma_b^2}\right]$$

Where, for the two assets a, b:

$$\mu_{2a,\,2b} = E\left[a - E(a))^2 (b - E(b))^2\right], \quad \mu_{1a,\,2b} = E\left[a - E(a))\ \ (b - E(b))^2\right] \text{ and}$$

$$\mu_{2a,\,1b} = E\left[a - E(a))^2 (b - E(b))\right]$$

The results from Opdyke's test are shown in Table 7. The test for the difference in Sharpe ratios of the two portfolios had a T-statistic of only 0.1, indicating that the null hypothesis that the two Sharpe ratios are equal could not be rejected at conventional levels of significance.

The fact that the test was unable to reject the null hypothesis should not be used to undermine the economic importance of the finding. As noted by Gibbons, Ross and Shanken (1989), the test is not powerful enough to detect economically important deviations. To be statistically significant with a p-value of 5%, the Sharpe ratio for the portfolio of ADRs with the S&P would need to be 0.58, or 13 times the Sharpe ratio of a portfolio of just the S&P with the riskless asset, a figure too large to be attainable.

To infer the economic significance of the difference in Sharpe Ratios of the two portfolios, the M^2 Measure of Performance proposed by Franco and Leah Modigliani can be used (Bodie, et all 2009). To compute this measure, a synthetic portfolio using a riskless asset and the equal-weighted portfolio of ADRs was created, subject to the constraint that the variance of this synthetic portfolio is

equal to that of the S&P 500. Having calculated the weights on the riskless asset and the ADR portfolio that would yield the required variance, the expected return on this synthetic portfolio is compared to that expected by an investor holding the market portfolio. The M^2 statistic is the difference between the expected returns. Similar to the method of adjusting portfolio variance, the economic significance of the risk-reward benefit available to investors was also examined by creating a synthetic portfolio constrained to yield the same return as the S&P 500, and calculating the difference the standard deviation between the two portfolios. Table 8 shows the summary statistics for the two tests.

Pivoting the portfolios on variance to compute the excess return (M^2), and on returns to compute the corresponding metric for lower variance (dubbed G^2), shows the degree of diversification benefits an investor can reap from investing in ADRs. For the same risk as on the S&P 500, an investor can expect a 2.5% per annum premium in returns by investing in ADRs even at the higher price. Is an extra return of 2.5% significant? When considered in the context of US indices yielding 1% annually over the course of the last decade, a 2.5% annual return is an economically meaningful return. Equivalently, for the same return as on the S&P, an investor is exposed to 2.9% less standard deviation over the course of a year.

This is an important result, even in sample. With an optimal portfolio that requires 40% of capital invested in ADRs, investors would be willing to pay extra to enjoy

both higher returns and lower standard deviation. When implied volatility on the S&P 500 rose to all-time high levels during the recession, ADRs became an even more attractive option for portfolio diversification, thereby leading to a rise in their prices. The premiums on ADRs were justified to increase till expected returns on ADRs were lowered to a point where investors would be economically indifferent between the Sharpe ratio of a portfolio with the S&P and the riskless asset, and one which includes these "expensive ADRs," now offering a lower expected return due to higher current prices.

5.214 Correlation with the Market Index

Assets with low or negative correlation with an investment portfolio serve as good hedging instruments that diversify portfolio risk by reducing the standard deviation of daily returns that an investor is exposed to. Gold, for example, was thought to be an ideal hedge for an equity portfolio, at least before the advent of the financial crisis, when returns on gold and equities showed a high positive correlation.

Having discerned that an equal weighted portfolio of ADRs can, indeed, be used as an efficient diversifier, it would be helpful to analyze the relative degree of correlation between daily returns of the ADRs used in the sample with the S&P 500 compared to that of the underlying stocks with the Nifty 50. If ADRs have a weaker correlation with the S&P 500 than underlying stocks do with the Nifty, it would further strengthen the argument for the existence of a persistent

diversification premium on ADRs. Further, if the correlation between the US securities reduced by a comparatively larger magnitude than those in India, one would expect the erstwhile diversification premium on ADRs to increase further. The correlations and premiums of the ADRs and underlying stocks are shown in Table 9.

The data shown in Table 7 has two interesting characteristics that could impact ADR premiums. The correlation between the underlying stocks and the Indian market index is significantly higher than that between the ADRs and the S&P 500 for almost all firms in the sample, both before and during the recession. Secondly, while both correlations weakened during the recession, for the majority of the firms, *correlations in the United States were lowered more drastically than those in India*.

This finding further complements the results of the Markowitz portfolio optimization exercise, as it serves to show that ADRs are not only good diversifiers for an equity portfolio, but they became even better diversifiers during the financial crisis, and indeed better diversifiers for American investors than for their Indian counterparts. This differentiating characteristic of ADRs would lead to a premium in the United States compared to India, and would further distort the premium in the United States' favor during the recession, as was observed.

5.3 Granger Causality

Despite the existence of a diversification premium on ADRs, the instruments still remain derivates of the underlying stock. Consequently, irrespective of the degree to which investors in the United States are raising the price of an ADR, its price fluctuation should still be very strongly correlated with the movements in the price of the underlying stock. In other words, though prices of US listings was higher than those of the Indian stocks, both securities should still hold a strong degree of predictive power for the next immediate trading session, especially as trading sessions of US and Indian markets do not overlap.

F-statistics in time-series data can be used to test whether the lags of one of the included regressors has useful predictive power in the model. The statistic used to test this model is the Granger causality statistic, proposed by Granger (1969). The Granger causality statistic is the F-statistic testing the hypothesis that the coefficients of the lag variables are zero, implying that lagged regressors have no predictive content for the dependent variable (Stock and Watson 2005)

It is important to note that Granger causality is not a test to determine the actual causation in a regression, but simply a test of predictive power. Consequently, some econometricians prefer to use the term “Granger predictability,” instead of “Granger causality.” (Stock and Watson 2005)

The existence of a strong Granger causal relationship between ADRs and their underlying stocks has been documented extensively. Hansda and Ray (2003) found the existence of a bi-directional relationship between close quotes in one market and the open quotes in the other for Indian ADRs.

This thesis aims to extend the existing research into comparing close quotes for ADRs and domestic stocks both before and after the recession, so as to gain a measure of whether one market viewed the other as strong an indicator as before. December 1, 2007 was assumed as the day the recession began, in accordance with the data released by the National Bureau for Economic Research (NBER).

In essence, the following null hypotheses were tested:

H_0^1 : The ADR return on day t-1 does not cause the Domestic stock return on day t ; and

H_0^2 : The Domestic stock return on day t does not cause the ADR return on day t

As trading hours between USA and India do not overlap, it is important to note the trading date for the securities being tested in the regression. The last trade for the underlying stock before the ADR's first trade occurs on the *same* day (India is

9.5 hours ahead of EST), while the last ADR trade before the stock's open quote occurs on the prior day. The values of Granger F-statistics for the regressions are shown in Table 5a and 5b.

The Granger causality tests had the following points of note:

1. The post-recession causal relationship between ADRs and stocks was remarkably weaker in both directions, and was statistically insignificant in the case of Wipro Technology, whose domestic stock was *not* Granger caused by the ADR post-recession (p-value: 0.3)
2. For all ten securities investigated in this research, the dependency of the underlying domestic stock on the ADR was much weaker than that of the ADR on the domestic stock, as indicated by a comparatively lower F-statistic. The relationship, however, was significant, except in the case of Wipro, as described above

There can be a number of economic factors that explain the findings of the Granger causality tests conducted in this research. Though an ADR is an internationally listed security, it represents the claim to the cash-flows of a domestic firm, and as such, the *a priori* expectation would be that ADR price movements would be heavily impacted by the way domestic investors trade. Trading volume, on average, is higher for the Indian stocks than their ADRs. All the currently listed ADRs are, or once were, stocks used to determine the level of the National Stock Exchange's Nifty-50 Index, and are India's blue-chip

companies. If investors in India are benefiting from undisclosed information like earnings estimates of these companies due to the performance of the economy or correlation with other Indian stocks, this information differential would likely be reflected as a strong Granger-causal pattern in the way ADRs are traded. The decoupling of international securities during the financial crisis seems to lend support to the findings that the causal relationships between stocks and ADRs weakened in both directions during the recession. Investors would likely be more swayed by prevalent market trends than by the previous trading session's return on an international market.

The weakening of the Granger causality in both directions hints at decoupling between US and Indian markets, at least when considered in the context of individual stocks. A high disparity in price of the ADR and the underlying stock implies that investors in these two markets disagreed to a certain degree on the future prospects of the firms in question. ADRs during this time, instead of behaving like derivatives, acted like independently existent stocks.

5.4 Cross-sectional robustness in determinants of ADR Returns

Having established that a possible cause for the increase in ADR premiums during the recession might be their increased attractiveness as portfolio diversifiers, this part of the research investigates the actual empirical relationship between returns on ADRs and those on the underlying stock, S&P 500, NSE, VIX, Exchange rate and changes in trading volume changed during the recession. To study whether the relationship between ADR returns and these variables changed during the recession, the joint hypothesis tests proposed by Chow (1960) was used.

The Chow test examines whether coefficients in two linear regressions on data sets are equal and is used mostly in time series analysis to investigate the presence of a structural break after a specified date. The regressions multiply each of the explanatory variables with a binary variable D_t, which equals 0 before the specified date, and 1 after the date

The model is described by Yu (2008) as follows:[9]

$$y_t = \begin{cases} x_t\beta_1 + \varepsilon_t, & t = 1,2,...,r; \\ x_t\beta_2 + \varepsilon_t, & t = r+1, r+2,...n \end{cases}$$

The null hypothesis is that the two coefficients are equal, i.e. $\beta_1 = \beta_2$

[9] F. Yu, *Chow Test* http://www.ssc.wisc.edu/~pyu/710-08/My%20Notes%20710/710-No05-02.22.08.pdf [Access date: November 23, 2010]

The Chow test uses the k restrictions thus put on the data to create an F-test that would examine the significance of the null hypothesis of the coefficients being equal. If SSR_1 is the sum of squared residuals from t = 1 to t = r, SSR_2 the sum of those from t = r + 1 to t = n, and SSR_R be the sum from the entire sample with the constraint that $\beta_1 = \beta_2$, the F-statistic for the test is the following:

$$F = \frac{SSR_R - SSR_U/k}{SSR_U/n - 2k}$$

Where:

SSR_U is the sum of squared residuals SSR_1 and SSR_2,

k is the number of constraints induced by the model, and

n is the total number of observations in the sample

The output from the Chow test conducted on the ten ADRs in the sample is shown in Table 10. On the basis of the test, the null hypothesis of the coefficients for the explanatory variables being the same before and after December 1, 2007 was rejected for all ADRs, thereby showing that the relationship between daily returns and its determinants changed during the recession.

This result further complements the earlier findings that suggested that ADRs enjoyed a significant price premium during the crisis on account of being better

diversifiers than before. While the Markowitz's Portfolio Optimization test gave an intuitive rationale for the existence of a premium on ADRs, the Chow test is more concerned with the actual dynamics of the increase in premium, showing how the actual regression coefficients changed post December 2007.

Over all, there was wide cross-sectional variation between the characteristics of the ten ADRs. This indicates that the relationship changes between ADRs and their determinants weren't robust cross-sectionally.

The commonly observed trends in the relationship between the ADR and the explanatory variables are summarized below.

Underlying Stock:

Consistent with economic intuition, all ADRs had a statistically significant and positive relationship with return on the underlying stock during the previous trading session. The relationship was strongest for Tata Motors, where an incremental return of one percentage point in the stock caused a 0.68 percentage point increase in the ADR return, and lowest for Wipro Technologies, where the slope was only 0.04 percentage points

S&P 500:

When controlled with other explanatory variables which were imperfectly correlated with the S&P 500, the index was a statistically significant determinant of returns for only six of the ten ADRs tested in the sample. The value of the coefficient on the variable was positive for all firms except Patni Computers, indicating that a higher daily return on the S&P would lead to a higher ADR return, all else constant.

During the financial crisis, the coefficient on the S&P 500 was significantly lower than before, indicating a decrease in the Beta of the ADRs with the S&P 500.

National Stock Exchange of India (Nifty):

Similar to the S&P 500, the Nifty was a statistically significant and positive determinant for majority of the ADRs.

The Beta of ADR return to that on the Nifty also diminished during the financial crisis.

CBOE Volatility Index:

Daily returns on ADRs were positively correlated with percentage increases in the implied volatility on the S&P 500, as indicated by the VIX. This relationship remained fairly steady during the crisis for most ADRs. It should be noted that the

VIX reached all-time highs during this period, and stability of the strong positive correlation indicates the simultaneous increase in the S&P volatility, and the super-normal returns on ADRs.

Exchange Rate (USD-INR):

According to Chakrabarti (2003), ADR prices should ideally be completely determined by underlying stock price movements and fluctuations in the exchange rate. All else equal, as the US Dollar becomes more expensive in terms of the Indian rupee, ADR prices should go down, so as to reflect the true Rupee value of the firm's market capitalization. In this sample, however, only seven of the ten firms had a statistically significant relationship between ADR returns and forex movements, and some in a counter-intuitive direction.

The most plausible rationale for this finding is that the majority of the firms with a statistically significant relationship to the exchange rate are integral constituents of the outsourcing industry. As a large proportion of their overall revenues are denominated in US Dollars, a higher USD-INR exchange rate translates to a higher Rupee revenue, leading to improved profitability.

Changes in Trading Volume:

The variable representing change in the difference between daily trading volumes of the stock and the ADRs was used to investigate the existence of a liquidity premium in ADRs. However, the variable was statistically significant for only four of the firms investigated.

It is interesting to note that HDFC Bank and MTNL, two firms for which the relationship was significant, had the highest percentage difference in traded volumes between the stock and the ADR. As the difference between volumes traded rose, so did the premium on the ADRs of the two firms.

6. Conclusion

The objective of this research was to investigate possible reasons that led to a persistent premium for ADRs of Indian firms when compared to their domestically listed stocks, and to gain insight as to why the aforementioned premium on some of these ADRs rose to levels higher than 50% during the financial crisis. To conduct this research, daily returns of ten Indian firms with listed ADRs were used in combination with returns on the Indian and American market indices, implied volatility and foreign exchange movements. As existing literature documents the presence of a premium on ADRs on account of illiquidity, this research specifically investigated the existence of a persistent premium on ADRs on account of them being good diversifiers for portfolios of American investors.

Comparative time-series data from the last five years seems to suggest both the existence of a diversification premium on ADRs, and the increase of this premium during the recession. ADRs were correlated to a weaker degree with the US market than stocks were with the Indian market; this gap widened further during the recession, leading to ADRs becoming even better diversifiers for portfolios during the financial crisis. The change in relationship between the ADRs and the domestic stocks was so strong during the recession that stocks and ADRs decoupled to a great degree, with the Wipro Technology ADR actually losing statistically significant predictive power for the trading stock the next day. Moreover, as ADRs represented claims on earnings of firms in emerging markets, investors expected a substantially higher return for a lower risk by investing in a

portfolio of ADRs with the risk-free rate, than if they invested merely in the US market portfolio. Premiums may also exist due to the lack of simultaneous trading between the Indian and US markets, and restrictions on ADR fungibility and repatriation of stocks between the two countries.

Diversification benefits, however, can only partly explain the ADR premium puzzle. The research in this paper shows that on an *ex-ante* basis, investors could expect a 2.5% incremental return by investing in ADRs. The extra price US investors are thus willing to pay can hardly be used to justify a disparity to an extent of 70% of the price between US and India, as was observed at the height of the financial crisis. Deeper research into this occurrence can also focus on the cross-sectional differences in ADR premiums over time. Indian ADRs represent a wide variety of industries, ranging from technology to manufacturing, and it would be helpful to learn economic factors under which individual ADR premiums might rise or fall.

The research conducted in this paper focused on ADRs listed by Indian firms. As the emerging markets story continues, more and more firms from the BRIC nations would likely issue an equity offering in the United States. As the opportunity set of investments increases, it would be interesting to research how investors perceive developing markets like Brazil, Russia and China, and whether ADRs from these countries have characteristics common to those exhibited by Indian firms.

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Appendix

Table 1: Daily Volume and Return

	India		US	
	Volume (thousands)	Return	Volume (thousands)	Return
Dr. Reddy's Lab.	467.8	0.12%	374.4	0.12%
	(348.0)	(2.28%)	(309.2)	(2.37%)
HDFC Bank	1124.4	0.13%	81.1	0.15%
	(404.4)	(2.55%)	(30.9)	(3.51%)
ICICI Bank	5496.5	0.12%	2262.9	0.13%
	(6623.8)	(3.31%)	(1830.6)	(4.15%)
Infosys Technologies	1663.8	0.09%	2169.1	0.08%
	(932.7)	(2.24%)	(1348.2)	(2.74%)
MTNL	1849.1	-0.03%	152.6	-0.02%
	(1857.5)	(2.84%)	(129.0)	(3.53%)
Patni Computers	397.2	0.06%	100.6	0.06%
	(492.9)	(3.31%)	(155.0)	(4.15%)
Mahindra Satyam	1060.2	0.07%	1835.2	-0.07%
	(2035.6)	(4.48%)	(4087.5)	(8.99%)
Tata Communications	1309.9	0.06%	125.1	0.09%
	(2049.2)	(3.30%)	(106.6)	(4.19%)
Tata Motors	2491.8	0.08%	931.4	0.09%
	(2052.1)	(3.15%)	(705.2)	(3.52%)
Wipro Technologies	2002.1	0.08%	648.7	0.02%
	(1252.1)	(2.65%)	(559.1)	(3.85%)

Note: Values in Parenthesis indicate Standard Deviation

Table 2: Spread Statistics for ADRs (% of Indian Stock Price)

	RDY	HDFC	ICICI	INFY	MTNL	TCL	TTM	PTI	SAY	WPRO
Maximum	11.1%	78.5%	64.3%	54.2%	31.4%	23.4%	73.0%	81.5%	466.4%	79.3%
Minimum	(9.9%)	(34.5%)	(24.5%)	(9.0%)	(14.2%)	(12.0%)	(8.3%)	(63.7%)	(201.6%)	--
Mean	0.3%	20.5%	7.4%	11.0%	3.6%	0.0%	8.6%	8.6%	16.5%	28.6%
Standard Deviation	2.4%	18.4%	12.7%	13.4%	7.1%	3.0%	13.1%	23.3%	16.9%	0.1%

Table 3: Summary Statistics for Macro Variables

	S&P	NIFTY	VIX	USD - INR
Maximum	1565.2	6287.9	80.9	52.0
Minimum	676.5	1902.5	9.9	39.3
Mean	1223.1	3850.1	21.6	44.6
Standard Deviation	195.0	1105.1	12.1	2.9

Table 4: Dickey-Fuller Test Statistics

	India		US	
	Statistic	**Interpretation**	**Statistic**	**Interpretation**
Dr. Reddy's Lab.	-33.31*	Stationary	-36.05*	Stationary
HDFC Bank	-29.77*	Stationary	-39.05*	Stationary
ICICI Bank	-28.36*	Stationary	-37.39*	Stationary
Infosys Technologies	-32.76*	Stationary	-37.12*	Stationary
MTNL	-30.30*	Stationary	-35.03*	Stationary
Patni Computers	-27.43*	Stationary	-26.56*	Stationary
Mahindra Satyam	-27.40*	Stationary	-55.31*	Stationary
Tata Communications	-30.87*	Stationary	-38.17*	Stationary
Tata Motors	-27.87*	Stationary	-33.50*	Stationary
Wipro Technologies	-29.39*	Stationary	-33.46*	Stationary

Note: * Significant at 1% level (1% Critical Value: -3.96)

Table 5: Daily Return and Volatility Statistics

	S&P 500	ADRs	Risk-free Rate
Expected Return	0.04%	0.09%	0.01%
Standard Deviation	0.72%	1.48%	--
Sharpe Ratio	4.03%	5.38%	
Correlation		-1.06%	--

Note: The statistics were calculated using daily returns on the S&P 500 and an Equal-weighted portfolio of ADRs from January 2005 to November 2007

Table 6: Minimum Variance and Optimal Risky Portfolios

	Minimum Variance	Optimal Risk-Reward
S&P Proportion	80.4%	60.6%
ADR Proportion	19.6%	39.4%
Expected Return	0.05%	0.06%
Standard Deviation	0.65%	0.73%
Sharpe Ratio	6.11%	6.76%

Table 7: Opdkye's Test

Statistical Significance of the Sharpe Ratio

	S&P 500	Optimal Portfolio
Sharpe Ratio	4.03%	6.76%
Skewness	(0.32)	(0.03)
Kurtosis	2.16	0.58
Correlation	0.57	
Δ Sharpe Ratio	2.73%	
Standard Error	0.27	
T-Statistic	0.10	

Table 8: The M^2 Measure of Performance

Model Inputs	S&P 500	ADRs	Risk Free
Expected Return	0.04%	0.09%	0.01%
Standard Deviation	0.72%	1.48%	- -

Variance Adjusted Portfolio		Return Adjusted Portfolio	
Target Variance	0.72%	Target Return	0.04%
ADR Proportion	49.03%	ADR Proportion	36.74%
Risk-Free Proportion	50.97%	Risk-Free Proportion	63.26%
Portfolio Return	0.05%	Portfolio Standard De	0.54%
Excess Return (M^2)	0.01%	Lower SD (G^2)	0.18%
Annualized M^2	2.49%	Annualized G^2	2.88%

Table 9: Correlation and Premia

	Pre-Recession			Post-Recession		
	Correlation		ADR Premium	Correlation		ADR Premium
	India	USA		India	USA	
Dr. Reddy's Lab. *	5.49%	(1.47%)	0.3%	0.91%	(2.45%)	0.2%
HDFC Bank *	1.10%	0.69%	15.3%	(1.59%)	(7.83%)	33.2%
ICICI Bank *	10.60%	(1.67%)	10.0%	(1.27%)	(8.86%)	0.5%
Infosys Technologies *	3.95%	(3.22%)	14.7%	2.27%	(3.22%)	0.8%
MTNL *	2.67%	(6.26%)	5.0%	4.02%	0.05%	(0.3%)
Patni Computers *	0.20%	5.55%	7.1%	(2.90%)	1.06%	19.7%
Mahindra Satyam	7.53%	(6.36%)	16.0%	1.57%	5.79%	17.0%
Tata Communications *	7.98%	0.62%	(0.0%)	(5.19%)	(13.83%)	4.1%
Tata Motors *	7.41%	(0.41%)	2.4%	(0.35%)	(4.28%)	23.8%
Wipro Technologies	2.16%	(0.48%)	21.6%	(9.95%)	(4.34%)	46.7%

Note:
* signifies firms that were better diversifiers in the United States that in India

Table 10: Chow Test for Change in Relationship between Variables

$$ADR = \alpha + \beta_1 Stock + \beta_2 Nifty + \beta_3 VIX + \beta_4 FX + \beta_5 Volume + \beta_6 D\text{-}Stock + \beta_7 D\text{-}Vol + \beta_8 D\text{-}S\&P + \beta_9 D\text{-}Nifty + \beta_{10} D\text{-}VIX + \beta_{11} D\text{-}FX + \varepsilon$$

	Stock	S&P 500	Nifty	VIX	USD-INR	Volume	D-Stock	D-Vol	D-S&P	D-Nifty	D-VIX	D-FX	F-Stat	D-W Stat
Dr. Reddy's Lab.	0.26*	0.36*	0.14*	0.06*	-0.42	0.06	0.09*	-0.05	-0.37*	-0.10*	-0.07*	0.34	378.89*	1.73
	(16.26)	(2.47)	(3.65)	(3.87)	(-1.91)	(1.27)	(47.52)	(-.94)	(-2.48)	(-2.24)	(-3.57)	(1.41)		
HDFC Bank	0.14*	0.86*	0.40*	0.11*	0.59*	0.11*	0.95*	-0.12*	-0.87*	-0.39*	-0.11*	0.60*	848.29*	1.72
	(8.82)	(5.08)	(8.92)	(5.8)	(-2.3)	(2.16)	(70.83)	(-2.1)	(-2.49)	(-7.46)	(-5.23)	(2.15)		
ICICI Bank	0.10*	0.51*	0.44*	0.11*	-0.80*	0.17*	0.95*	-0.18*	-0.51*	-0.44*	-0.11*	0.75*	793.55*	1.68
	(6.68)	(2.73)	(8.99)	(5.21)	(-2.83)	(2.91)	(68.78)	(-2.82)	(-2.66)	(-7.64)	(-4.63)	(2.45)		
Infosys Technologies	0.15*	0.48*	0.35*	0.04*	-0.56*	-0.14*	0.94*	-0.11*	-0.50*	-0.34*	-0.05*	0.54*	580.08*	1.63
	(8.65)	(3.16)	(8.8)	(2.47)	(-2.43)	(3.04)	(58.62)	(-2.09)	(-3.16)	(-7.33)	(-2.39)	(2.16)		
MTNL	0.23*	0.04	0.20*	0.02	-0.72*	0.13*	0.91*	-0.11	-0.03	-0.17*	-0.02	0.78*	560.90*	1.68
	(13.09)	(.22)	(3.93)	(.79)	(-2.46)	(2.23)	(57.96)	(-1.62)	(-.13)	(-2.89)	(-.68)	(2.43)		
Patni Computers	0.22*	-0.56*	0.07	-0.02	-0.61*	0.06	0.89*	-0.06	0.59*	-0.06	0.03	0.61	471.26*	1.50
	(13.99)	(-2.75)	(1.35)	(-.96)	-(2.00)	(.98)	(48.46)	(-.82)	(2.8)	(-.97)	(1.16)	(1.83)		
Mahindra Satyam	0.04*	0.58*	0.35*	0.07*	-0.45	0.08	1.00*	-0.08	-0.60*	-0.35*	-0.07*	0.41	10761.05*	1.65
	(4.98)	(3.66)	(8.27)	(3.92)	(-1.84)	(1.61)	(255.28)	(-1.43)	(-3.64)	(-7.21)	(-3.65)	(1.56)		
Tata Communications	0.29*	-0.04	0.29*	0.01	-0.92*	-0.11	0.89*	-0.12	0.06	-0.27*	-0.01	0.94*	718.35*	1.66
	(19.31)	(-.21)	(5.4)	(.48)	(-2.96)	(1.77)	(65.54)	(-1.76)	(.29)	(-4.24)	(-.38)	(2.79)		
Tata Motors	0.68*	0.62	0.12	-0.04	-1.01*	-0.01	-0.34*	-0.13	0.37	0.02	0.04	0.74	6.22*	1.57
	(8.93)	(1.84)	(.96)	(-1.17)	(-1.98)	(-.12)	(-4.03)	(-1.08)	(1.06)	(.11)	(.96)	(1.33)		
Wipro Technologies	0.04*	0.10	-0.06	0.01	-0.54	-0.09	0.99*	-0.09	-0.11	0.05	-0.01	0.52	936.24*	1.69
	(2.53)	(.49)	(-1.06)	(.54)	(-1.73)	(1.43)	(74.92)	(-1.33)	(-.51)	(.06)	(-.56)	(1.54)		

Note: 1 Values in Parentheses represent T-Statistics
2 * represents significance at the 5% level
3 Critical value for the dL Durbin-Watson 5% statistic: 1.44

Table 11a: Granger Causality Statistics

F Statistic for the Regression: $ADR_t = \alpha + \beta_1 ADR_{t-1} + \beta_2 Domestic_t + \varepsilon$

	Pre-Recession		Post-Recession	
	F-Statistic	**Implication**	**F-Statistic**	**Implication**
Dr. Reddy's Lab.	275.6 *(0.00)*	Stock → ADR	142.4 *(0.00)*	Stock → ADR
HDFC Bank	142.1 *(0.00)*	Stock → ADR	110.8 *(0.00)*	Stock → ADR
ICICI Bank	123.8 *(0.00)*	Stock → ADR	248.7 *(0.00)*	Stock → ADR
Infosys Technologies	116.9 *(0.00)*	Stock → ADR	130.8 *(0.00)*	Stock → ADR
MTNL	342.4 *(0.00)*	Stock → ADR	209.5 *(0.00)*	Stock → ADR
Patni Computers	234.9 *(0.00)*	Stock → ADR	160.5 *(0.00)*	Stock → ADR
Mahindra Satyam	152.7 *(0.00)*	Stock → ADR	43.4 *(0.00)*	Stock → ADR
Tata Communications	439.1 *(0.00)*	Stock → ADR	171.1 *(0.00)*	Stock → ADR
Tata Motors	579.0 *(0.00)*	Stock → ADR	85.7 *(0.00)*	Stock → ADR
Wipro Technologies	11.9 *(0.00)*	Stock → ADR	14.4 *(0.00)*	Stock → ADR

Note:

1 Values in parentheses indicate P-Values

2 * represents values NOT significant at the 5% level

Table 11b: Granger Causality Statistics

F Statistics for the Regression: $\mathbf{Domestic_t = \alpha + \beta_1 Domestic_{t-1} + \beta_2 ADR_{t-1} + \varepsilon}$

	Pre-Recession		Post-Recession	
	F-Statistic	**Implication**	**F-Statistic**	**Implication**
Dr. Reddy's Lab.	51.8 *(0.00)*	ADR → Stock	15.6 *(0.00)*	ADR → Stock
HDFC Bank	102.5 *(0.00)*	ADR → Stock	37.7 *(0.00)*	ADR → Stock
ICICI Bank	89.0 *(0.00)*	ADR → Stock	61.6 *(0.00)*	ADR → Stock
Infosys Technologies	86.4 *(0.00)*	ADR → Stock	58.6 *(0.00)*	ADR → Stock
MTNL	14.7 *(0.00)*	ADR → Stock	14.5 *(0.00)*	ADR → Stock
Patni Computers	54.2 *(0.00)*	ADR → Stock	7.7 *(0.01)*	ADR → Stock
Mahindra Satyam	69.0 *(0.00)*	ADR → Stock	10.2 *(0.00)*	ADR → Stock
Tata Communications	82.3 *(0.00)*	ADR → Stock	64.2 *(0.00)*	ADR → Stock
Tata Motors	27.9 *(0.00)*	ADR → Stock	35.3 *(0.00)*	ADR → Stock
Wipro Technologies	7.8 *(0.01)*	ADR → Stock	1.1* *(0.30)*	No Relationship

Note:

1 Values in parentheses indicate P-Values

2 * represents values NOT significant at the 5% level