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Indication with Further Analysis of Mispricing and Barriers in Arbitrage in Chinese Option Market A Five-Month Study on Sample Option

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Indication with Further Analysis of Mispricing and Barriers in Arbitrage in Chinese Option Market

A Five-Month Study on Sample Option

by

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Abstract

Indication with Further Analysis of Mispricing and Barriers to Arbitrage in Chinese Option Market

A Five-Month Study on Sample Option

by

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Utah State University, 2013

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This thesis presents indication of mispricing of options in the Chinese option market, focusing on the very first and the most representative option in the Chinese option market. I used the Black-Scholes model to calculate the option price and compare the result to its real performance. The mispricing of sample option is statistically significant. With further analysis, I found out that underlying asset price and its volatility are the possible factors that most likely lead to mispricing. Because of the consistent mispricing, I investigated the industrial regulations from the China Securities Regulatory Commission (CSRC) and found proof with examples that barriers to arbitrages do affect the consistent mispricing. The barriers prevent arbitrageurs to take full advantage of mispriced options and stocks.

(26 Pages)

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Background

On Aug 22nd, 2005, Baosteel's call option, known as Baosteel JTB1 (580000), began being traded in the Shanghai Stock Exchange. It initiated the new Chinese option market. Until Dec 31st, 2009, there were, in total, 55 options traded in the Chinese stock market, 38 in the Shanghai Stock Exchange, and 17 in the Shenzhen Stock Exchange. In 2007, despite the fact that the Chinese option market is outnumbered compared to the option market in the Hong Kong (there were around 4500 options in the Hong Kong option market), the trading volume and the number of transactions made in the Chinese option market had outperformed the Hong Kong option market and ranked No. 1 in option markets across the world. For a pre-mature market with such high trading volume and transactions made, experts started to examine whether there were mispricing issues in the market. In this empirical study, I use a widely used model, the Black-Scholes model, to testify the mispricing issues.

Barriers to Arbitrage

In mature markets, such as the U.S and European markets, when there is a mispricing on an option, it will be arbitraged away as people start trading for an arbitrage, such as short selling. Because of the nature of trading for the purpose of maximizing profit, the window for arbitrage is always short. It is also an efficient way to keep the option reflecting its real value or at least close to its real value. However, compared to mature markets, the Chinese stock market is regulated under different rules. There are five major differences:

1. No short selling for stocks (before 2010)
2. T+1 trading rule for stocks and T+0 trading rule for options

3. Limited volatility on stocks and options

4. Noise traders and limited size of the option market

With short selling, investors in the market can react to arbitrage opportunities in time. Figure 1 shows the short selling process in mature markets and potential difference in Chinese market. Investors who realize an overpriced stock P at its current price at $12 per share may borrow 100 shares of stock P. Investors sell out 100 shares of stock P next hour, after it reaches its real value at price $10 per share. Now, despite the cost on commissions, there is a $200 arbitrage profit. It also fixes mispricing issues by increasing the supply of stock P in the market. Unfortunately, in the Chinese market, the lack of a short selling mechanism does not allow investors to react fast enough to arbitrage. Even if short selling is allowed, under the constraint of the T+1 trading rule that stocks cannot be traded until the next trading day after being bought in, investors are bearing more risk of losing arbitrage opportunities or losing money with longer holding periods for stocks.

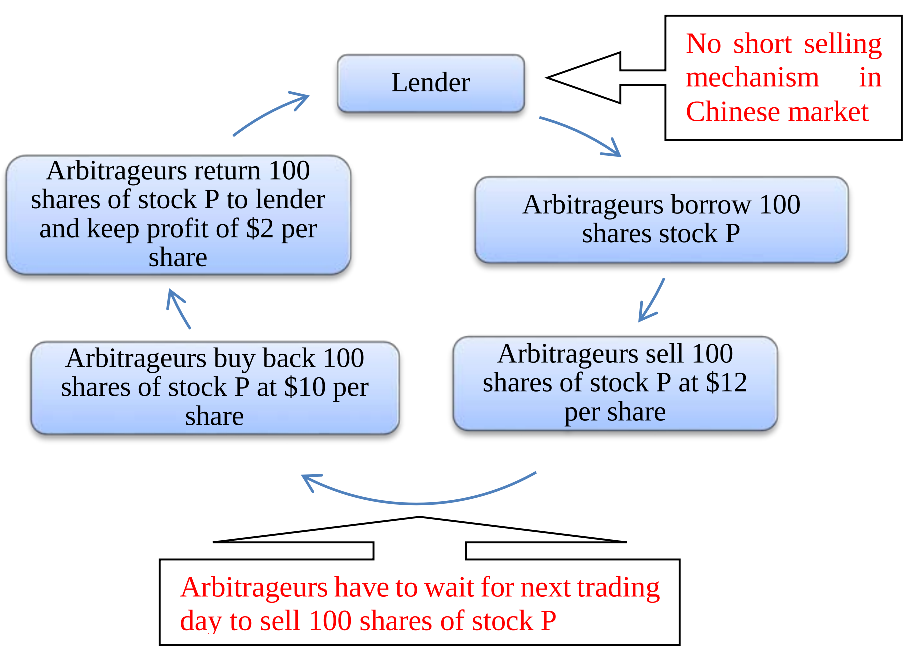


Figure 1. The flow chart of short selling process in mature markets and potential differences in Chinese market.

Investors who make decision on selling, holding, and buying trades with neither inside information nor fundamental data are called noise traders. In the Chinese market, there are lots of noise traders. Noise traders tend to follow the trends and over-react to good and bad news. When arbitrageurs are outmatched in numbers by noise traders, arbitrageurs are not be able to take full advantages of arbitrage opportunities. As with the example of stock P, with short selling mechanism, arbitrageurs would get the profit and fix overpricing of stock P. But when the impacts on the market from arbitrageurs are outmatched by noise traders, arbitrageurs' behavior would be limited. If noise traders are going to be consistently optimistic or pessimistic on stock prices, the arbitraging trades would not be able to fix the existing mispricing and arbitrageurs may be exposed to the risk.

Assuming, in the stock P example, while arbitrageurs try to obtain profit by short selling stock P, noise traders are consistently optimistic about stock P. The price of stock P may keep going up with a smaller supply of stock P in the market. This increases the risk of arbitrageurs buying back stock P and returning stocks to the lender. In the case of Baosteel JTB1, on Oct 27th, 2005, Baosteel JTB1 reached its lowest price at 0.69. Because investors in China, especially individual investors, are in favor of technical analysis, they considered this lowest price as a support level. Since then, without significant changes in its underlying asset, Baosteel JTB1 started the new round of rebound.

For stocks, the volatility of every trading day is $\pm$10 percent. For options, the limit for trading day T is Limit up = Option's Closing Price $_{T-1}$ + (Underlying Asset's Closing Price $_{T-1}$ * 10%) * 125% * Exercise Ratio. And for limit down for trading day T is Limit down = Option's Closing Price $_{T-1}$ - (Underlying Asset's Closing Price $_{T-1}$ * 10%) * 125% * Exercise Ratio. This policy, in some ways, is protection for the stocks (options) and its investors from excessive increasing or decreasing. However, it also has its down side. Stocks and options can still be traded when they are at the limit up/down without going further up/down, despite the trading volume. It prevents the stocks and options from performing the way they should be.

For example, yesterday closing price of a call option with an exercise ratio of 1:1 was $5, and its underlying assets' closing price yesterday was $20. For today's trading, the underlying assets limit up and down would be $22 and $18. This call option would have a limit down at $2.5 per share and a limit up at $7.5 per share. Investors can still trade on this call option after it reaches its limit up or down. It will never go lower than $2.5 per share or higher than $7.5 per share, even as continuous trading may result in a higher volatility without the limits. This matches the result of excessive annualized implied volatility from Table 5 (Table 5 can be found on page 18).

In common cases, when arbitrageurs realize an arbitrage opportunity on options, they would perform a conversion to obtain risk-free profit by longing underlying stock, buying its put options, and selling its call options at the same time in order to hedge their risk.

For instance, suppose stock A is trading at $100 per share in August while its call option in September is trading at $4, and its put option in September is trading at $3. The arbitrageurs would long 100 shares of stock A and its put option and sell a call option with total cost of $10000 + $300 - $400 = $9900. Assuming stock A's price goes up to $110 per share, put option expires worthless, and call option would expire in the money and get assigned. The arbitrageurs sell 100 shares of stock A as required at $10000 for a profit of $10000 - $9900 = $100. If, instead, the price of stock A drops to $90 per share, call option expires worthless, and put option expires in the money. Arbitrageurs would exercise put option to sell 100 shares of stock A at $10000 for a profit of $10000 - $9900 = $100 as well.

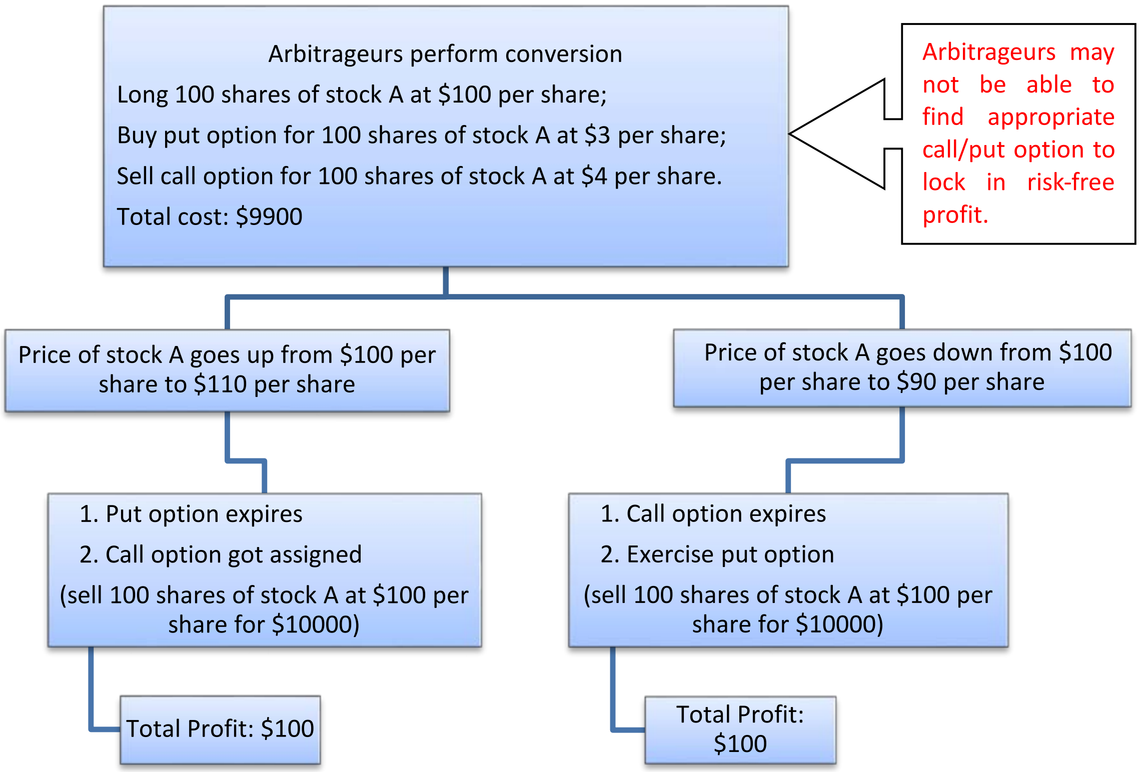


Figure 2. Conversion arbitrage process in mature markets and potential difference in Chinese market.

In the Chinese market, since the option market is new, the size of the market is limited. There are limited numbers and kinds of options. Arbitrageurs sometimes cannot find the option they need to hedge their risk for arbitraging. In the example of stock A, if there is no put option for stock A, arbitrageurs would bear the risk of the price going down and they would not be able to perform conversion to obtain risk-free profit. Figure 2 shows the conversion arbitrage process in mature markets and potential difference in Chinese market.

The Black-Scholes model

In this study, our Baosteel JTB1, a European call option [1], its payoff at maturity T with a strike price K and price of underlying asset at maturity S(T) is:

$$C(T) = MAX\ [S(T) - K, 0]$$

If S(T) > K at maturity, the option would be exercised to buy underlying asset at K and then sold for net payoff S(T) – K. If S(T) < K, then the option would not be exercised. The Black-Scholes formula for pricing call option at T=0 before maturity is given by:

$$C(0) = S(0)*N(d_1) - e^{-r*T} * K*N(d_2)$$

where N(d) is the cumulative probability distribution for variables with a standard normal distribution of 0 mean and a standard deviation of 1. Here r is the continuously compounded risk-free interest rate, while d_1 and d_2 are as shown as:

$$d_1 = \frac{\ln\frac{S(0)}{K} + (r + 0.5 * \sigma^2) * T}{\sigma * \sqrt{T}}$$

$$d_2 = \frac{\ln\frac{S(0)}{K} + (r - 0.5 * \sigma^2) * T}{\sigma * \sqrt{T}} = d_1 - \sigma\sqrt{T}$$

Introduction of Baosteel

Baoshan Iron & Steel Co., Ltd (hereinafter referred as Baosteel Co., Ltd.) is the largest and most advanced integrated steel company in China. Baosteel Co., Ltd is also recognized as a world leading steel company by the global steel market. According to World Steel Dynamics, the company ranks No. 3 in the world in terms of comprehensive competency; it is also believed to have the greatest development potential. On Dec 6^{th}, 2004, Baosteel

Co., Ltd's credit rating was raised from BBB to BBB+ by Standard & Poor's. The expectation on credit rating as stable. On July, 2005, Baosteel Co., Ltd was ranked No. 309 in Fortune's top global 500 companies. Originally Baosteel is founded as Solely State-Founded Enterprise, which is under the regulation of the Enterprise Law in China. On Oct 2005, it reformed and switched to State-Owned Sole Corporation, which is regulated by the Company Law in China.

Empirical Study

The data used in this empirical study is based on the five-month performance of Baosteel stock and Baosteel JTB1, including high frequency data of historical Baosteel price, historical daily closing prices of the Baosteel JTB1 [2]. Table 1 shows the details in contract of Baosteel JTB1.

Table 1. Contract of Baosteel JTB1.

Stock	Baosteel JTB1	**Settlement Method**	Physical Delivery
Trading Code	580000	**Shares Issued**	3.877 Billion
Type	European Call	**Trading Date**	Aug 22nd, 2005 to Aug 30th 2006
Right Proportion	1	**Ending Date**	Aug 30th, 2006
Underlying Asset	G Baosteel (600019.SH)	**Days**	373
Strike Price (RMB)	4.5	**Exercise Brief**	ES060830
Issued By	Baosteel	**Exercise Code**	582000

Table 1 shows the details about the Baosteel JTB1, including the key variables I need for running the Black-Scholes model: strike price and total days for trading.

Table 2 (Table 2 be found at page 16) shows the daily closing price of Baosteel, the underlying asset of Baosteel JTB1, years left on the option, which is calculated by dividing number of days left by 365, and the observed call option price for every trading day from Aug 22nd, 2005 to Feb 28th, 2006.

According to the Black-Scholes model:

$$d_1 = \frac{\ln\frac{S(0)}{K} + (r + 0.5 * \sigma^2) * T}{\sigma * \sqrt{T}}$$

$$d_2 = \frac{\ln\frac{S(0)}{K} + (r - 0.5 * \sigma^2) * T}{\sigma * \sqrt{T}} = d_1 - \sigma\sqrt{T}$$

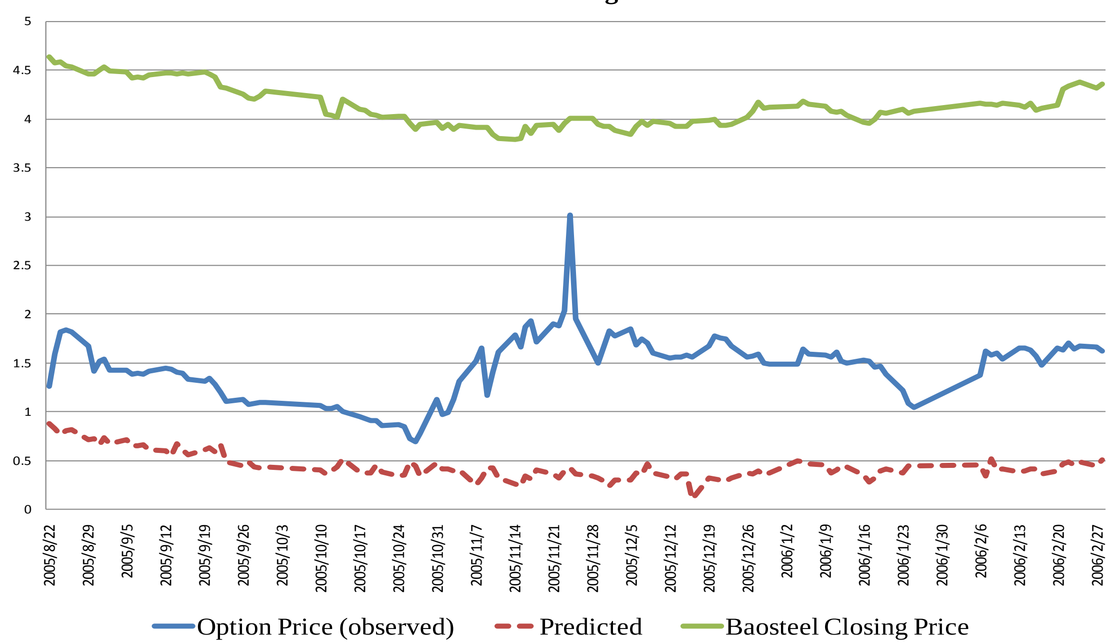
$$C(0) = S(0)*N(d_1) - e^{-r*T} * K*N(d_2)$$

where N(d) is the standard normal distribution function; σ is the volatility (standard deviation of the return on a stock); r is the continuously compounded risk-free interest rate; T is the time left until maturity in year; K is the strike price on stock; S is the current stock price.

Based on the empirical data collected from Aug 22nd, 2005 to Feb 28th, 2006, I calculated the annualized historical volatility of Baosteel for every trading day based on the high frequency data. This high frequency data contains the daily price changes for, on average, every 11 seconds across the data. The risk-free rate was 3.3% from the 7 years national bonds yield to maturity from 2005 (r=3.3%). Years left, calculated by dividing the number of days left on the option by 365. I used the Black-Scholes model to calculate the daily, theoretically-predicted call option price for Baosteel JTB1. Table 3 below shows the comparison.

In Table 3 (Table 3 can be found at page 17), the result shows that based on the theoretical predicted prices, over the 5 month period from Aug 22nd, 2005 to Feb 28th, 2006, the prices I observed were overpriced on every trading day during the period. Through graph 4, the observation shows the observed Baosteel JTB1 call option has been overpriced over the five-month trading time in the sample.

Graph 4. Trend of Baosteel JTB1 Option Price (Predicted and Observed) and Baosteel Closing Price



For statistic support, I used a t-test to test the hypothesis on overpricing. The null hypothesis (H_0) is that this call option was not overpriced, and the alternative hypothesis (H_a) is that this call option was overpriced. The average difference between the predicted call price and observed call price is 101.21 percent. The standard deviation

$$H_0\text{: } \mu \leq 0$$
$$H_a\text{: } \mu > 0$$

The t-test formula I used is:

$$t_{n-1} = \frac{\overline{X} - \mu}{s/\sqrt{n}}$$

where μ stands for the average of population I used the average predicted price difference, which is 0.0 percent. $\overline{X}$ stands for the average observed price difference of the sample, and s stands for the standard deviation of the sample. Table 4 shows the result.

Table 4. Result of the t-test on Hypothesis of Overpricing			
Average Predicted (μ)	0.0%	Sample Size (n)	122
Average Observed ($\overline{X}$)	101.2%	Degree of Freedom	121
Standard Deviation (s)	0.370	t-stat	30.2122 *
*Significant at 1 percent level for one-tailed test			

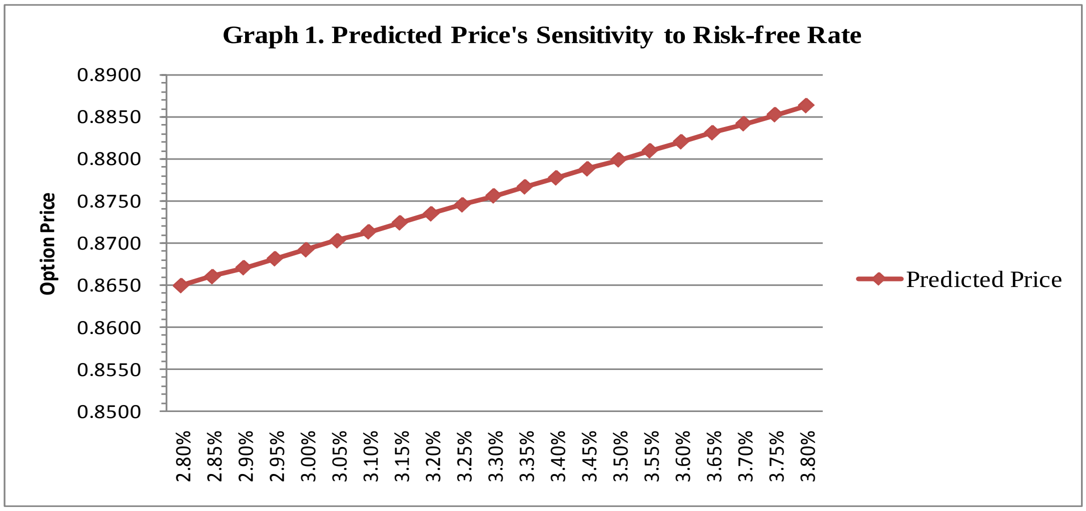
As shown on Table 4, because the result is under the 1 percent significant level, I reject the null hypothesis, which means this call option was overpriced. At this point, I have indicated the mispricing on Baosteel JTB1 call option, specifically overpricing, on Baosteel JTB1. With evidence of mispricing, I continue to look into the model to find potential factors that lead to mispricing.

Further Empirical Analysis

In the Black-Scholes model, there are 5 variables: the underlying asset's price, the strike price, the risk-free rate, the annual volatility, and time left on the option. I compared the option price sensitivity on each factor (except the strike price and time left on the option, because they are subjective variables that cannot be manipulated) based on the first trading day of the option [3].

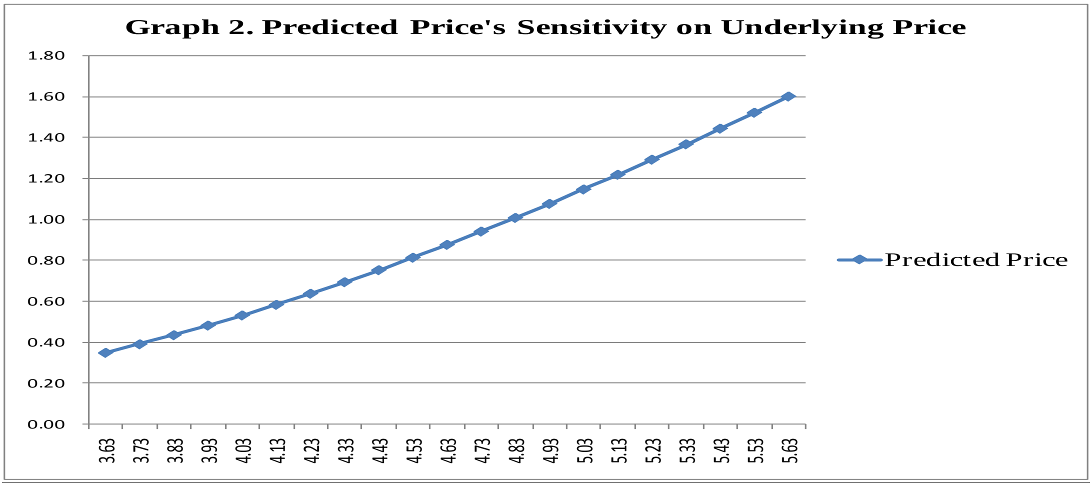
1. Option Price's Sensitivity on Risk-free Rate

From the data I had, the risk-free rate for the period was 3.30%. To examine the impact, I picked up the range [2.80%, 3.80%], while holding the other variables (S = 4.63, T = 1.0219, K = 4.50, Volatility = 40.4684%). I ran the data through the Black-Scholes model and the following graph 1 shows the result of the impact of the change of risk-free rate. The option price's sensitivity to risk-free rate is also called Rho in Greeks.



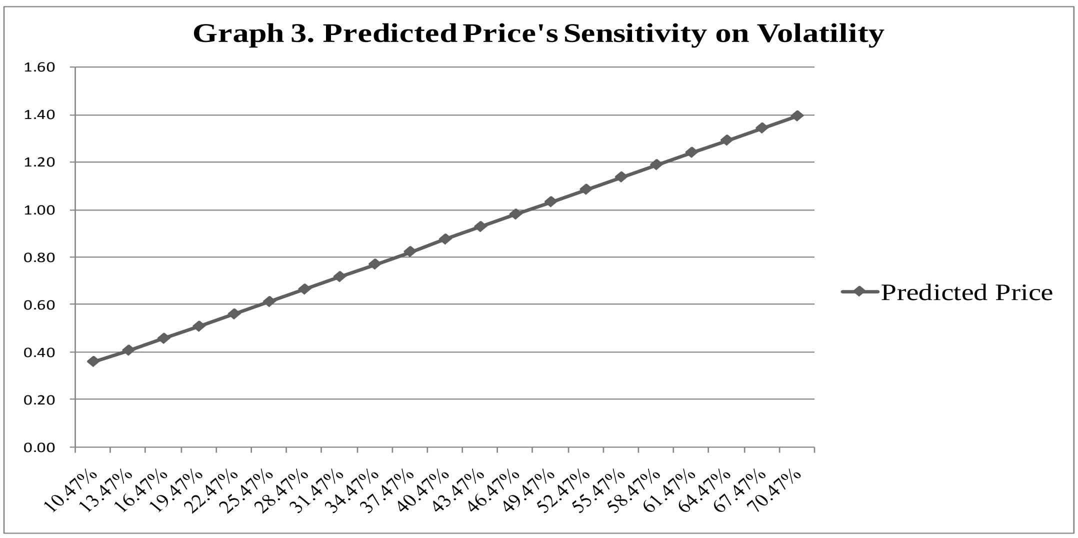
2. Option Price's Sensitivity on Underlying Asset's Price

According to the historical data, the underlying asset Baosteel's price on the first trading day was 4.63. To test the sensitivity of the option on underlying asset price, I simulated the scenario by picking the range of underlying asset price as [3.63, 5.63] while holding T = 1.0219, K = 4.50, Volatility = 40.4684%, r = 3.30%. Graph 2 shows the result. The option price's sensitivity on underlying asset's price is also called Delta in Greeks.



3. Option Price's Sensitivity on Annual Volatility

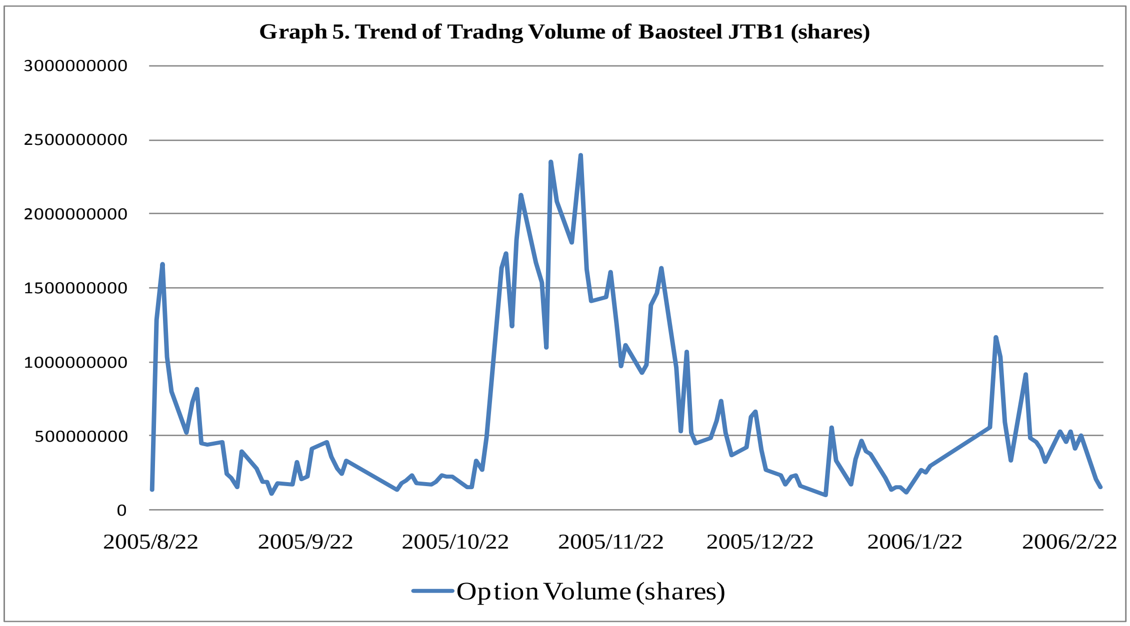
From the high frequency data I collected, I found the volatility for the first trading day for the option was 40.4684%. To simulate the scenario, I picked a Volatility of [10.47%, 70.47%] while holding every other variable constant (T = 1.0219, K = 4.50, S = 4.63, r = 3.30%). The following graph 3 shows the result. The option price's sensitivity is also called Vega in Greeks.

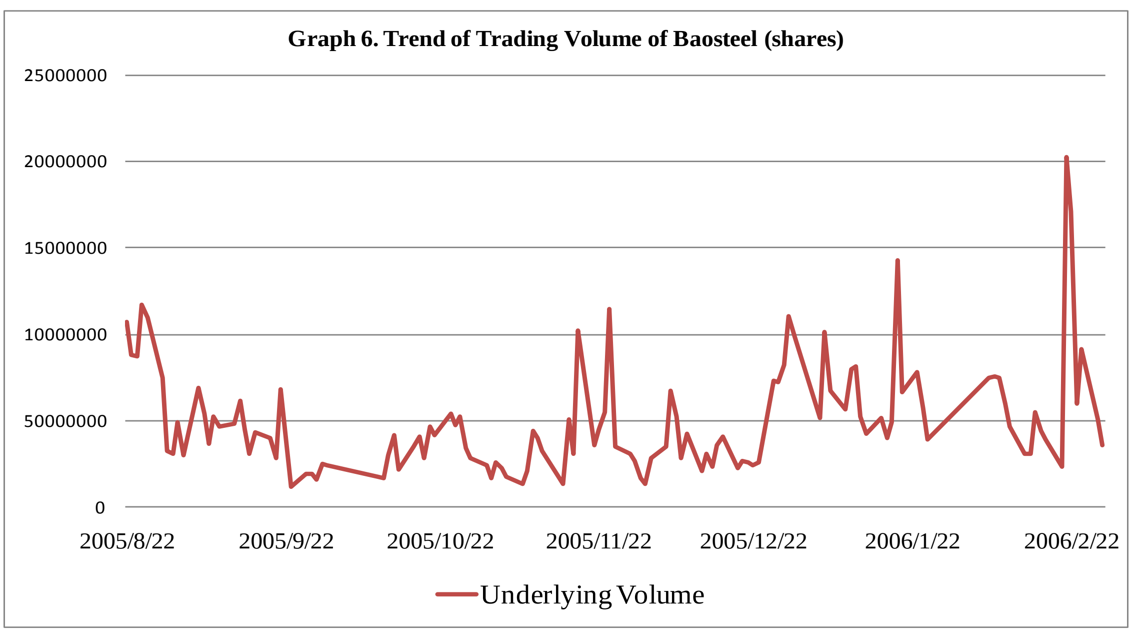


In conclusion, among the three cases, the risk-free rate has only a minor impact on option pricing. The option price is more sensitive to underlying asset price and annual volatility.

Under these circumstances, I inverted the Black-Scholes model, calculated the daily annualized implied volatility based on high frequency data, and compared the result with the daily annualized historical volatility. Table 5 (Table 5 can be found at page 18) shows the annualized implied volatility and annualized historical volatility on a daily basis. Through the five-month-period, the daily annualized implied volatility is on average, 101.21 percent above the daily annualized historical volatility level, which was the volatility the underlying asset has actually performed.

I compared the trends of observed historical prices and theoretical prices, the trend of trading volume on Baosteel and the trend of trading volume on Baosteel JTB1. The results are in graphs 4, 5 and 6 (graph 4 can be found on page 9).





In Graph 4, the observation shows that from the end of October, 2005 to the middle of November, 2005, the Baosteel JTB1 price kept going up while the Baosteel price going down at the same time. This phenomenon is against the theory that the call option pricing is positively related to its underlying asset's price.

Graphs 5 and 6 are showing the trends of trading volume of Baosteel and Baosteel JTB1. The trading volume of Baosteel JTB1 is significantly higher than Baosteel. The graph 5 also shows that Baosteel JTB1 experienced a period of time with large scale trading volume. This momentum matches the phenomenon of Baosteel JTB1's price change. These two facts may indicate that the pricing of Baosteel JTB1 and the relationship between the price of Baosteel and the price of Baosteel JTB1 have been compromised by speculation or manipulation.

I cross-referenced the major news about Baosteel in 2005. From October to November 2005, according to Baosteel's Annual Report 2005 [5], there were several major events, such as signing a new strategic partnership with another leader from its industry and switching from Solely State-founded Enterprise to State-owned Sole Corporation, which is considered a huge potential positive impact on the company. With these proofs, I may conclude that there are sufficient motivations for people or investors speculating and manipulating the market of Baosteel JTB1.

Conclusions

In this study, I conclude that the trading prices of the Baosteel JTB1 in reality are significantly above the prices that I derived from the Black-Scholes model. In this study, different from using estimated given information like some similar studies, such as generally applying historical volatility of the entire five -month-period or 2004-2005, I calculated more accurate annualized volatility that derived from daily volatility based on high frequency data on underlying asset's prices. This made the result more accurate. However, even under this circumstance, the theoretical prices derived based on the Black-Scholes model are still significantly different from our observations. I also notice the irrational behaviors such as negative relationship between Baosteel and Baosteel JTB1's prices and their trading volume. This indicates that there is a possibility that Baosteel JTB1 may be manipulated. Based on the limited size of the market (only 3.877 billion shares were issued), the low price on option, the industrial barriers, and the factitious high trading volume, irrational investing or speculating may be the disruptive force on mispricing of Baosteel JTB1. By using examples and cases, I find explanation of how industrial barriers, under the regulations, lower the market efficiency and lead to mispricing on stocks and options.

Table 2. Historical Data of Baosteel JTB1.

Date	Baosteel Closing	Years Left	Call(observed)
2005/8/22	4.63	1.022	1.26
2005/8/23	4.57	1.019	1.59
2005/8/24	4.58	1.016	1.81
2005/8/25	4.54	1.014	1.83
2005/8/26	4.53	1.011	1.81
2005/8/29	4.46	1.003	1.67
2005/8/30	4.46	1.000	1.41
2005/8/31	4.5	0.997	1.52
2005/9/1	4.53	0.995	1.54
2005/9/2	4.49	0.992	1.42
2005/9/5	4.48	0.984	1.42
2005/9/6	4.41	0.981	1.38
2005/9/7	4.42	0.978	1.39
2005/9/8	4.41	0.975	1.38
2005/9/9	4.45	0.973	1.41
2005/9/12	4.47	0.964	1.44
2005/9/13	4.47	0.962	1.43
2005/9/14	4.46	0.959	1.4
2005/9/15	4.47	0.956	1.39
2005/9/16	4.46	0.953	1.33
2005/9/19	4.48	0.945	1.31
2005/9/20	4.46	0.942	1.34
2005/9/21	4.43	0.940	1.28
2005/9/22	4.32	0.937	1.2
2005/9/23	4.31	0.934	1.1
2005/9/26	4.25	0.926	1.12
2005/9/27	4.21	0.923	1.07
2005/9/28	4.2	0.921	1.08
2005/9/29	4.23	0.918	1.09
2005/9/30	4.28	0.915	1.09
2005/10/10	4.22	0.888	1.06
2005/10/11	4.05	0.885	1.03
2005/10/12	4.04	0.882	1.03
2005/10/13	4.02	0.879	1.05
2005/10/14	4.2	0.877	1
2005/10/17	4.1	0.868	0.95
2005/10/18	4.09	0.866	0.93
2005/10/19	4.05	0.863	0.91
2005/10/20	4.04	0.860	0.91
2005/10/21	4.02	0.858	0.86
2005/10/24	4.03	0.849	0.87
2005/10/25	4.03	0.847	0.84
2005/10/26	3.95	0.844	0.72
2005/10/27	3.89	0.841	0.69
2005/10/28	3.94	0.838	0.77
2005/10/31	3.96	0.830	1.12
2005/11/1	3.9	0.827	0.97
2005/11/2	3.94	0.825	0.99
2005/11/3	3.89	0.822	1.12
2005/11/4	3.93	0.819	1.31
2005/11/7	3.91	0.811	1.51
2005/11/8	3.91	0.808	1.65
2005/11/9	3.91	0.805	1.16
2005/11/10	3.84	0.803	1.4
2005/11/11	3.8	0.800	1.61
2005/11/14	3.79	0.792	1.78
2005/11/15	3.8	0.789	1.66
2005/11/16	3.92	0.786	1.87
2005/11/17	3.85	0.784	1.93
2005/11/18	3.93	0.781	1.71
2005/11/21	3.94	0.773	1.9
2005/11/22	3.88	0.770	1.88
2005/11/23	3.95	0.767	2.03
2005/11/24	4	0.764	3.01
2005/11/25	4.01	0.762	1.95
2005/11/28	4	0.753	1.61
2005/11/29	3.94	0.751	1.49
2005/11/30	3.92	0.748	1.66
2005/12/1	3.92	0.745	1.82
2005/12/2	3.88	0.742	1.77
2005/12/5	3.84	0.734	1.845
2005/12/6	3.92	0.732	1.678
2005/12/7	3.97	0.729	1.742
2005/12/8	3.93	0.726	1.7
2005/12/9	3.97	0.723	1.599
2005/12/12	3.95	0.715	1.55
2005/12/13	3.92	0.712	1.561
2005/12/14	3.92	0.710	1.551
2005/12/15	3.92	0.707	1.577
2005/12/16	3.97	0.704	1.561
2005/12/19	3.98	0.696	1.668
2005/12/20	3.99	0.693	1.774
2005/12/21	3.93	0.690	1.747
2005/12/22	3.93	0.688	1.741
2005/12/23	3.94	0.685	1.668
2005/12/26	4.02	0.677	1.559
2005/12/27	4.08	0.674	1.567
2005/12/28	4.17	0.671	1.582
2005/12/29	4.11	0.668	1.493
2005/12/30	4.12	0.666	1.484
2006/1/4	4.13	0.652	1.484
2006/1/5	4.18	0.649	1.634
2006/1/6	4.15	0.647	1.591
2006/1/9	4.13	0.638	1.581
2006/1/11	4.07	0.633	1.605
2006/1/12	4.08	0.630	1.52
2006/1/13	4.04	0.627	1.499
2006/1/16	3.96	0.619	1.526
2006/1/17	3.95	0.616	1.512
2006/1/18	3.99	0.614	1.455
2006/1/19	4.07	0.611	1.462
2006/1/20	4.06	0.608	1.385
2006/1/23	4.1	0.600	1.212
2006/1/24	4.06	0.597	1.086
2006/1/25	4.08	0.595	1.044
2006/2/6	4.16	0.562	1.372
2006/2/7	4.15	0.559	1.62
2006/2/8	4.15	0.556	1.575
2006/2/9	4.14	0.553	1.599
2006/2/10	4.16	0.551	1.533
2006/2/13	4.14	0.542	1.645
2006/2/14	4.12	0.540	1.646
2006/2/15	4.16	0.537	1.625
2006/2/16	4.09	0.534	1.562
2006/2/17	4.11	0.532	1.476
2006/2/20	4.14	0.523	1.646
2006/2/21	4.3	0.521	1.624
2006/2/22	4.33	0.518	1.698
2006/2/23	4.35	0.515	1.64
2006/2/24	4.37	0.512	1.67
2006/2/27	4.31	0.504	1.66
2006/2/28	4.35	0.501	1.614

Table 3. Comparison of Predicted Prices and Observed Prices.

Date	Call(observed)	Predicted	Difference	Date	Call(observed)	Predicted	Difference
8/22/2005	1.26	0.88	38%	10/11/2005	1.03	0.36	67%
8/23/2005	1.59	0.83	76%	10/12/2005	1.03	0.39	64%
8/24/2005	1.81	0.77	104%	10/13/2005	1.05	0.43	62%
8/25/2005	1.83	0.81	102%	10/14/2005	1	0.51	49%
8/26/2005	1.81	0.81	100%	10/17/2005	0.95	0.56	39%
8/29/2005	1.67	0.71	96%	10/18/2005	0.93	0.37	56%
8/30/2005	1.41	0.73	68%	10/19/2005	0.91	0.37	54%
8/31/2005	1.52	0.66	86%	10/20/2005	0.91	0.45	46%
9/1/2005	1.54	0.73	81%	10/21/2005	0.86	0.38	48%
9/2/2005	1.42	0.66	76%	10/24/2005	0.87	0.34	53%
9/5/2005	1.42	0.71	71%	10/25/2005	0.84	0.36	48%
9/6/2005	1.38	0.65	73%	10/26/2005	0.72	0.49	23%
9/7/2005	1.39	0.65	74%	10/27/2005	0.69	0.45	24%
9/8/2005	1.38	0.65	73%	10/28/2005	0.77	0.34	43%
9/9/2005	1.41	0.60	81%	10/31/2005	1.12	0.48	64%
9/12/2005	1.44	0.60	84%	11/1/2005	0.97	0.41	56%
9/13/2005	1.43	0.55	88%	11/2/2005	0.99	0.41	58%
9/14/2005	1.4	0.67	73%	11/3/2005	1.12	0.40	72%
9/15/2005	1.39	0.60	79%	11/4/2005	1.31	0.41	90%
9/16/2005	1.33	0.56	77%	11/7/2005	1.51	0.25	126%
9/19/2005	1.31	0.61	70%	11/8/2005	1.65	0.32	133%
9/20/2005	1.34	0.63	71%	11/9/2005	1.16	0.43	73%
9/21/2005	1.28	0.59	69%	11/10/2005	1.4	0.42	98%
9/22/2005	1.2	0.66	54%	11/11/2005	1.61	0.32	129%
9/23/2005	1.1	0.49	61%	11/14/2005	1.78	0.26	152%
9/26/2005	1.12	0.45	67%	11/15/2005	1.66	0.23	143%
9/27/2005	1.07	0.49	58%	11/16/2005	1.87	0.34	153%
9/28/2005	1.08	0.43	65%	11/17/2005	1.93	0.31	162%
9/29/2005	1.09	0.42	67%	11/18/2005	1.71	0.40	131%
9/30/2005	1.09	0.44	65%	11/21/2005	1.9	0.36	154%
10/10/2005	1.06	0.40	66%	11/22/2005	1.88	0.32	156%

Date	Call(observed)	Predicted	Difference	Date	Call(observed)	Predicted	Difference
11/23/2005	2.03	0.39	164%	1/9/2006	1.58	0.45	113%
11/24/2005	3.01	0.42	259%	1/11/2006	1.61	0.37	123%
11/25/2005	1.95	0.36	159%	1/12/2006	1.52	0.40	112%
11/28/2005	1.61	0.34	127%	1/13/2006	1.50	0.44	106%
11/29/2005	1.49	0.32	117%	1/16/2006	1.53	0.43	109%
11/30/2005	1.66	0.29	137%	1/17/2006	1.51	0.35	116%
12/1/2005	1.82	0.24	158%	1/18/2006	1.46	0.28	117%
12/2/2005	1.77	0.30	147%	1/19/2006	1.46	0.32	115%
12/5/2005	1.85	0.30	154%	1/20/2006	1.39	0.39	99%
12/6/2005	1.68	0.37	130%	1/23/2006	1.21	0.41	80%
12/7/2005	1.74	0.35	139%	1/24/2006	1.09	0.38	71%
12/8/2005	1.70	0.47	123%	1/25/2006	1.04	0.44	60%
12/9/2005	1.60	0.37	123%	2/6/2006	1.37	0.45	92%
12/12/2005	1.55	0.33	122%	2/7/2006	1.62	0.45	117%
12/13/2005	1.56	0.31	125%	2/8/2006	1.58	0.34	123%
12/14/2005	1.55	0.36	119%	2/9/2006	1.60	0.52	108%
12/15/2005	1.58	0.36	122%	2/10/2006	1.53	0.40	113%
12/16/2005	1.56	0.10	146%	2/13/2006	1.65	0.41	123%
12/19/2005	1.67	0.32	135%	2/14/2006	1.65	0.39	126%
12/20/2005	1.77	0.30	147%	2/15/2006	1.63	0.39	123%
12/21/2005	1.75	0.30	145%	2/16/2006	1.56	0.41	115%
12/22/2005	1.74	0.29	145%	2/17/2006	1.48	0.42	106%
12/23/2005	1.67	0.32	135%	2/20/2006	1.65	0.36	128%
12/26/2005	1.56	0.37	118%	2/21/2006	1.62	0.39	123%
12/27/2005	1.57	0.36	121%	2/22/2006	1.70	0.47	123%
12/28/2005	1.58	0.39	119%	2/23/2006	1.64	0.49	115%
12/29/2005	1.49	0.35	114%	2/24/2006	1.67	0.45	122%
12/30/2005	1.48	0.37	111%	2/27/2006	1.66	0.49	117%
1/4/2006	1.48	0.50	99%	2/28/2006	1.61	0.44	117%
1/5/2006	1.63	0.48	115%	**Average Difference**		**101.21%**	
1/6/2006	1.59	0.46	113%	**Average if no mispricing**		**0%**	
				Standard Deviation		**0.3700**	

Table 5. Comparison of Historical and Implied Volatility.

Date	Implied Volatility	Historical Volatility	Date	Implied Volatility	Historical Volatility
2005/8/22	62.61%	40.47%	2005/10/11	76.55%	31.88%
2005/8/23	84.80%	40.01%	2005/10/12	77.08%	34.36%
2005/8/24	98.15%	36.18%	2005/10/13	79.41%	37.91%
2005/8/25	101.31%	40.02%	2005/10/14	68.81%	37.35%
2005/8/26	100.64%	40.57%	2005/10/17	69.87%	43.69%
2005/8/29	95.25%	37.26%	2005/10/18	69.03%	32.18%
2005/8/30	79.16%	38.45%	2005/10/19	69.38%	33.23%
2005/8/31	84.41%	33.41%	2005/10/20	69.87%	39.24%
2005/9/1	84.52%	36.59%	2005/10/21	67.32%	34.94%
2005/9/2	78.90%	34.03%	2005/10/24	68.03%	32.37%
2005/9/5	79.67%	37.24%	2005/10/25	66.09%	33.22%
2005/9/6	80.19%	36.13%	2005/10/26	60.97%	44.88%
2005/9/7	80.52%	35.74%	2005/10/27	61.22%	44.12%
2005/9/8	80.43%	36.56%	2005/10/28	65.04%	35.22%
2005/9/9	80.76%	32.30%	2005/10/31	89.50%	44.29%
2005/9/12	82.19%	31.53%	2005/11/1	81.41%	41.67%
2005/9/13	81.69%	28.67%	2005/11/2	81.30%	40.40%
2005/9/14	80.34%	35.96%	2005/11/3	93.11%	41.13%
2005/9/15	79.42%	31.92%	2005/11/4	105.59%	40.63%
2005/9/16	76.18%	29.61%	2005/11/7	122.60%	30.07%
2005/9/19	74.50%	31.89%	2005/11/8	134.01%	35.29%
2005/9/20	77.31%	34.01%	2005/11/9	96.18%	43.08%
2005/9/21	74.89%	32.65%	2005/11/10	118.23%	45.24%
2005/9/22	74.37%	41.17%	2005/11/11	137.71%	39.08%
2005/9/23	68.60%	30.69%	2005/11/14	153.63%	34.76%
2005/9/26	72.59%	30.51%	2005/11/15	142.92%	32.48%
2005/9/27	71.08%	34.19%	2005/11/16	153.85%	36.75%
2005/9/28	72.24%	31.38%	2005/11/17	163.92%	37.01%
2005/9/29	71.80%	29.62%	2005/11/18	140.23%	41.34%
2005/9/30	69.93%	29.00%	2005/11/21	156.60%	38.18%
2005/10/10	71.54%	29.19%	2005/11/22	158.97%	36.93%

Date	Implied Volatility	Historical Volatility	Date	Implied Volatility	Historical Volatility
2005/11/23	168.07%	40.34%	2006/1/9	134.16%	42.64%
2005/11/24	270.84%	40.75%	2006/1/10	135.49%	38.59%
2005/11/25	157.64%	36.00%	2006/1/11	140.23%	41.49%
2005/11/28	130.53%	35.41%	2006/1/12	132.71%	44.10%
2005/11/29	124.29%	36.04%	2006/1/13	133.49%	45.19%
2005/11/30	139.74%	34.05%	2006/1/16	141.37%	41.82%
2005/12/1	153.67%	30.36%	2006/1/17	141.09%	36.75%
2005/12/2	152.17%	36.67%	2006/1/18	133.99%	38.04%
2005/12/5	164.40%	38.21%	2006/1/19	130.36%	41.59%
2005/12/6	145.05%	41.17%	2006/1/20	124.64%	43.35%
2005/12/7	147.80%	37.70%	2006/1/23	108.79%	39.48%
2005/12/8	146.83%	48.05%	2006/1/24	100.63%	46.20%
2005/12/9	136.24%	39.60%	2006/1/25	96.42%	46.14%
2005/12/12	134.07%	37.44%	2006/2/6	122.92%	44.53%
2005/12/13	137.02%	36.73%	2006/2/7	145.70%	36.27%
2005/12/14	136.39%	40.69%	2006/2/8	142.00%	50.59%
2005/12/15	138.83%	40.57%	2006/2/9	145.07%	41.72%
2005/12/16	134.98%	18.90%	2006/2/10	138.30%	41.91%
2005/12/19	144.26%	35.82%	2006/2/13	150.82%	41.08%
2005/12/20	153.11%	34.73%	2006/2/14	152.56%	42.68%
2005/12/21	154.77%	36.07%	2006/2/15	148.41%	42.72%
2005/12/22	154.54%	35.80%	2006/2/16	147.38%	45.82%
2005/12/23	147.81%	37.89%	2006/2/17	138.61%	40.80%
2005/12/26	134.60%	39.52%	2006/2/20	153.65%	42.58%
2005/12/27	132.15%	36.42%	2006/2/21	141.92%	41.96%
2005/12/28	128.67%	35.73%	2006/2/22	147.13%	42.58%
2005/12/29	124.96%	34.75%	2006/2/23	141.03%	39.20%
2005/12/30	123.96%	36.15%	2006/2/24	142.88%	40.95%
2006/1/4	124.75%	45.84%	2006/2/27	146.87%	40.35%
2006/1/5	134.60%	42.89%	2006/2/28	140.62%	43.87%
2006/1/6	133.01%	42.39%			

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