SIMULATED TRADING-AN ANALYSIS OF PAIRS TRADING

Group 5

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1. Introduction

In this report, we explain and analyze a trading strategy, popularly known as Pairs trading. We begin by explaining what a pair trading strategy entails. Since there are various ways of implementing the strategy, we describe the methodology selected by us in section 3. Thereafter, we look at the returns from the strategy and benchmark it to the S&P 500 index in Section 4. In section 5, we examine the risks involved in pairs trading. Section 6 looks at some of the limitations we faced while trading and Section 7 points out some mistakes we made. Finally, we discuss some risk control measures in Section 8 and conclude in Section 9 with comments on whether we would implement the strategy in real life and if so, with what changes.

2. Pairs Trading

Pairs trading involves the simultaneous purchase of a stock and sale of another stock in order to gain from the spread between the two securities. The aim is to find two securities which have deviated from their historical relationship and are expected to revert back to the mean relation.

There are two groups of pairs trading strategies based respectively on fundamental and technical analysis. In the fundamental analysis, extensive company research is conducted to identify stocks, generally within the same industry, which are expected to move together. This strategy is limited to large investors with substantial funds to carry out the detailed analysis. In the more common technical analysis based pairs trading, stocks are analyzed using statistical techniques to identify pairs and deviations are recognized with convergence-divergence frameworks using historical means or more sophisticated indicators like Bollinger bands or Relative Strength Index. Here, the pairs identified may or may not be from the same industry.

3. Methodology

We selected to implement pairs trading based on technical analysis for ease and convenience. Such a strategy involves two main steps – selecting the pairs and identifying trading signals. There are various alternatives available for both the steps leading to different strategies. For the first step of identifying the pairs, the following are some of the techniques used:

- A simple correlation of prices of pairs of securities is computed. Pairs with the highest correlation are then selected for trading purpose.
- A regression line is estimated for each stock using the stock price series and then pairs are selected based on correlation between the residuals from these regression lines.
- Stock prices are normalized by subtracting the mean prices and dividing by the standard deviation. Correlation between these normalized prices is then used to select pairs.

For identifying the trading signals, the trader monitors certain indicators against their historical averages and takes any deviation beyond reasonable limits as a signal for trade. Here, the options are in the indicator which can be monitored:

- In the most simplistic case, one can monitor the spread between the prices of the two stocks.
- An improvement is to monitor the price ratio instead of absolute price levels. This helps to make the analysis dollar neutral and based on the pair rather than individual securities.
- Ranks can be computed for absolute price levels or for the residuals of regression lines estimated above. The spread between these ranks can then be used to signal possible trades.

For the purpose of this project, we chose to select the stocks based on correlation between the residuals and used ranks for these residuals as signals for trades. The consideration set consisted of the top 100 stocks and the bottom 50 stocks on the S&P 500 based on market capitalization. This was done to see if there were greater correlations between large small stocks rather than within large stocks. This can be expected since the small stocks tend to

follow the larger stocks within the same industry. For calculating the residuals, we estimate a regression line using the stock price data for the last one year from October 9, 2003 to October 8, 2004. The residuals, computed using this regression line, were used to compute the correlation and stocks with a correlation above 0.87 were selected. This resulted in 15 pairs of stocks comprising of 20 stocks with certain stocks repeated in multiple pairs. A summary of the pairs is given below:

	Company 1				Company 2			Correlation
Scrip Code	Name	Industry	Mkt. Cap.	Scrip Code	Name	Industry	Mkt. Cap.	
CSCO	Cisco Systems	Communications Equipment	126 030 000 000	TWX	Time Warner Inc.	Media	73 209 824 336	0,8801
CSCO	Cisco Systems	Communications Equipment	126 030 000 000	HPQ	Hewlett-Packard	Computers & Peripherals	54 297 340 973	0,8900
CSCO	Cisco Systems	Communications Equipment	126 030 000 000	TER	Teradyne Inc.	Semiconductor & Semiconductor Equipment	2 839 490 713	0,8967
AIG	American Int'l. Group	Insurance	196 003 188 260	DCN	Dana Corp.	Auto Components	2 817 757 731	0,8732
AIG	American Int'l. Group	Insurance	196 003 188 260	PKI	PerkinElmer	Health Care Equipment & Supplies	2 536 709 801	0,8736
JPM	JPMorgan Chase & Co.	Diversified Financial Services	82 917 542 380	PGL	Peoples Energy	Gas Utilities	1 571 672 544	0,8723
MWD	Morgan Stanley	Capital Markets	61 469 619 733	MER	Merrill Lynch	Capital Markets	55 746 022 057	0,8842
TWX	Time Warner Inc.	Media	73 209 824 336	GM	General Motors	Automobiles	31 256 636 919	0,9231
GS	Goldman Sachs Group	Capital Markets	49 331 900 937	TXN	Texas Instruments	Semiconductor & Semiconductor Equipment	33 962 934 792	0,8802
HPQ	Hewlett-Packard	Computers & Peripherals	54 297 340 973	TER	Teradyne Inc.	Semiconductor & Semiconductor Equipment	2 839 490 713	0,8740
GM	General Motors	Automobiles	31 256 636 919	F	Ford Motor	Automobiles	25 919 369 170	0,8769
MOT	Motorola Inc.	Communications Equipment	38 157 652 320	ANDW	Andrew Corp.	Communications Equipment	2 080 000 000	0,8721
CD	Cendant Corporation	Commercial Services & Supplies	27 936 048 572	CR	Crane Company	Machinery	1 955 505 753	0,8826
TER	Teradyne Inc.	Semiconductor & Semiconductor Equipment	2 839 490 713	NVDA	NVIDIA Corp.	Semiconductor & Semiconductor Equipment	2 420 000 000	0,8736
NVDA	NVIDIA Corp.	Semiconductor & Semiconductor Equipment	2 420 000 000	CR	Cendant Corporation	Machinery	27 936 048 572	0,8954

As can be seen from the table, only 4 out of the 15 pairs have stocks in the same industry. Also, 8 of the 15 pairs have combinations of large and small stocks while only 1 pair is between small stocks. This result was somewhat surprising since we would have expected small stocks in an industry to follow the large stocks in the same industry. However, we find that small stocks even tend to follow larger stocks in different industries.

In order to decide on the trading signals, we compute ranks for the residuals of the stocks. These ranks are based on the previous 60 trading days' residuals. This method is borrowed from "A Simplified Approach to Pairs Trading" by Ron McEwan. We then compute the average rank spread between the stocks in each pair and the standard deviation for the rank spreads. A trading signal is recognized as the deviation of the rank spread from Mean ± 2*Std Deviation. The position is doubled if the rank spread crosses Mean ± 3*Std Deviation and closed if the spread falls to within Mean ± Std Deviation.

For simplicity, we computed the rank spreads at the end of each trading day and placed trades to be executed at the start of the next trading day.

We provide at the end of the paper, graphs showing the ranks and their spreads for 5 of the 5 pairs. These were some of the most active pairs. The graph shows how the trading opportunities arise over time. The first graph for each pair shows the ranks of the residuals. In the second graph, rank spreads are shown together with the average spread (black line) and the range of ± Std Deviation and ± 2* Standard deviation. It must be noted that the entering signal is provided when the spread moves out of the 2 standard deviation range and thereafter an exit signal is provided when the spread converges to within 1 standard deviation.

4. Results

We made a total of 55 trades during the trading period from October 11, 2004 to December 3, 2004. Each pair normally required 4 trades, 2 while entering the position and 2 while exiting. In addition, if there were any opportunities for doubling up, an additional 2 trades were made for the pair. This meant a commission of minimum $100 for each position taken. During the last week, we did not enter any new positions since it was risky if the position did not converge within the last week. Three of our positions, two of which we had doubled up in, were open on the close of December 3, 2004.

We started with cash of $1,000,000. The portfolio value of our position as on December 3, 2004 was $1,011,192. This means a return of 1.12% over 39 trading days or 7.17% annual returns. The S&P 500 index grew from 1124.39 to 1191.17 points during the same time implying a return of 5.94% or 8.07% annually.

This shows that we underperformed the index. This is mainly due to two reasons. First, we were unable to execute the strategy completely from the first day onwards as explained in Section 7. Second, we had three open positions as at the end of the trading. These were currently trading at a loss but were expected to converge in the near future.

As compared to the class, we performed almost at the average as can be seen from the following graph. We were ranked between 5th and 6th for most of the trading days.
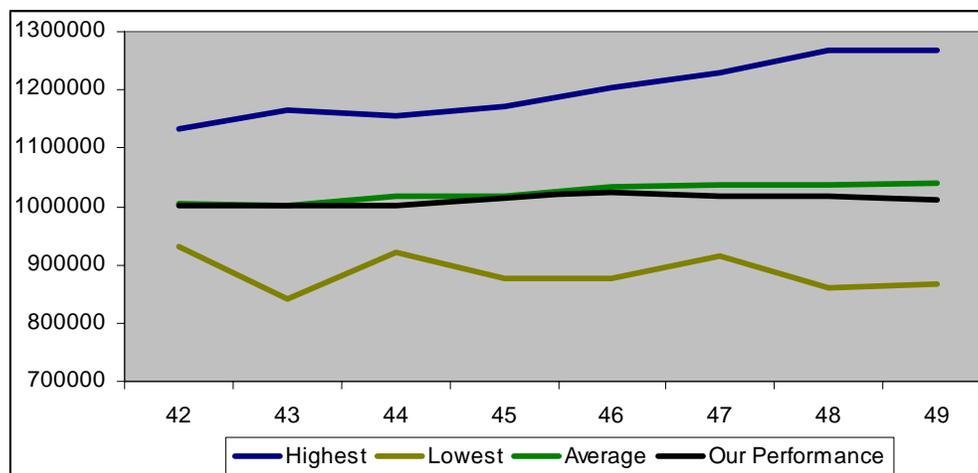
In order to explain the trading strategy better, we now illustrate an example of a pair trade. For the pair Cisco Systems and Time Warner, we found a trading opportunity based on the rank spread as on November 10, 2004. The rank spread had widened to 28 as against the average of -1.17 and standard deviation of 10.73. This indicated a trading opportunity since the spread was higher than the average spread + 2*standard deviation. We entered the position on November 11, 2004 where we bought 9300 shares of Cisco and short sold 9300 shares of Time Warner at a price of 18.50 and 17.11 respectively. On November 15, 2004 the spread converged to 4 which was within the average + standard deviation. Hence, we chose to close this position. On November 16, 2004 we closed the position by selling the shares of

Cisco and buying back shares of Time Warner at 19.43 and 17.39 respectively. Thus the spread between the prices changed from 1.39 to 2.04 giving us a profit of 0.65 per share or $6045. From this we deduct the transaction cost paid ($100) which gives us a profit of $5945.

A summary of all the trades entered into by us is given in the following table:

Date	Security	1st Signal			Date	Double up			Date	Exit			Profit
		Qty	Price	Amount		Qty	Price	Amount		Qty	Price	Amount	
2004-11-03	CSCO	13875	19,62	-272 252,50					2004-11-05	-13875	19,79	274 561,25	
	TWX	-13875	16,47	228 496,25						13875	16,95	-235 206,25	**-4 401,25**
2004-11-03	AIG	-5925	62,01	367 384,25					2004-11-11	5925	60,95	-361 153,75	
	PKI	5925	21,83	-129 367,75						-5925	21,60	127 955,00	**4 817,75**
2004-11-03	JPM	-6000	39,34	236 015,00					2004-11-11	6000	39,20	-235 225,00	
	PGL	6000	44,00	-264 025,00						-6000	44,16	264 935,00	**1 700,00**
2004-11-03	MOT	-7900	17,33	136 882,00					2004-11-11	7900	17,35	-137 090,00	
	ANDW	7900	14,22	-112 363,00						-7900	14,54	114 841,00	**2 270,00**
2004-11-03	NVDA	5725	15,19	-87 127,75					2004-11-05	-5725	17,72	101 422,00	
	CR	-5725	28,27	161 820,75						5725	28,90	-165 477,50	**10 637,50**
2004-11-05	TWX	4425	16,95	-75 028,75					2004-11-11	-4425	17,11	75 686,75	
	GM	-4425	39,74	175 824,50						4425	39,72	-175 786,00	**696,50**
2004-11-05	CD	-4950	21,65	107 142,50					2004-11-11	4950	22,80	-112 885,00	
	CR	4950	28,90	-143 080,00						-4950	29,28	144 911,00	**-3 911,50**
2004-11-11	CSCO	9300	18,50	-172 075,00					2004-11-16	-9300	19,43	180 674,00	
	TWX	-9300	17,11	159 098,00						9300	17,39	-161 752,00	**5 945,00**
2004-11-11	CSCO	8825	18,50	-163 287,50					2004-11-16	-8825	19,43	171 444,75	
	HPQ	-8825	18,91	166 855,75						8825	19,35	-170 788,75	**4 224,25**
2004-11-11	AIG	4000	60,95	-243 825,00					2004-11-30	-4000	63,45	253 775,00	
	PKI	-4000	21,60	86 375,00						4000	21,20	-84 825,00	**11 500,00**
2004-11-11	JPM	3975	39,20	-155 845,00	2004-11-17	2650	38,50	-102 050,00					
	PGL	-3975	44,16	175 511,00		-2650	44,05	116 707,50					**Open**
2004-11-11	TWX	-5850	17,11	100 068,50	2004-11-22	-5850	17,42	101 882,00					
	GM	5850	39,72	-232 387,00		5850	38,76	-226 771,00					**Open**
2004-11-11	MOT	10425	17,35	-180 898,75					2004-11-22	-10425	18,03	187 937,75	
	ANDW	-10425	14,54	151 554,50						10425	14,35	-149 623,75	**8 969,75**
2004-11-17	CD	9650.00	22,58	-217 922,00									
	CR	-9650.00	29,50	284 650,00									**Open**

Some of the interesting results from our trading experience are now described. When we began trading we were under the impression that we might not get too many trading opportunities and those that arise will take some time to close. However, during the trading we found frequent opportunities and the positions were really held short term over a few days. Hence, while initially we were thinking of using ARMA model for trading currency with the excess funds we had, we found that there was no need since we were almost always locked in with some position in pairs trading. As a result, ARMA model and currency trading has not been discussed in this paper.

5. Risks involved in the Strategy

Market Risk: the strategy of pairs trading is attractive since it is market neutral. This means that the trader does not bear any market risk and can expect to make profits irrespective of rising or falling prices. This is because the trader bets on the spread between the two stocks instead of betting on the absolute price levels.

Fundamental Risk: one of the main risks involved with pairs trading based only on technical analysis is that a fundamental change in the relationship between the two stocks can get masked and the trader can enter positions when the prices are not expected to revert to historical means. This can happen when for example, there is a fundamental change in the strategy of one of the companies as a result of which the price level changes permanently.

Industry risk: while fundamental analysis based pairs trading normally looks at stocks within the same industry, technical analysis based trading does not. This is evident from our pairs as well where only 4 out of 15 were one industry pairs. This means that the trader is somewhat protected against adverse movements affecting any particular industry since he is diversified. However, the diversification may not be large enough given only two stocks in the pair.

Noise Trader risk: like any other contrarian, mean reversion strategy, our strategy was subject to noise trader risk. This is the risk that the deviations which signal a trading opportunity may not converge in the short run and therefore, lead to higher losses, also resulting in larger margin requirements.

6. Limitations

Low priced stocks: since Stocktrak does not allow us to trade in stocks with a price of below $5, we had to exclude some stocks while choosing the lowest 50 on the S&P 500. We do not feel, however, that this limitation resulted in any significant losses although it might have reduced the potential number of pairs available for trading.

Price discrepancy: our trading signals were based on actual market prices at the end of each day. Since the prices in Stocktrak were somewhat different from these, there was a discrepancy in the price at which we wanted to place the trade and the price at which we could actually place it.

7. Mistakes

Opposite positions: one of the most obvious mistakes we made was that when taking positions based on our trade signals, we misunderstood the signal and took opposite positions. This happened since the signals were based on ranks and higher ranks are lower numbers! This mistake cost us $4401.25 as we ha to close one of the positions at a loss. For the other positions where we made this mistake we were able to close the position at a profit since the spread had widened instead of converging.

Delay in starting: we were also unable to start trading early. This was mainly due to time constraints. In order to select the pairs we had to individually download stock price data for one year for 150 stocks. Thereafter, run regressions for each one of them and compute residuals. This took quite a lot of time and given the exams at the end of last term, there was a delay before we started trading. Also, our strategy required us to compute ranks everyday. However, due to other classes and projects, there were some days when we were unable to do so. We feel that we did lose out on some opportunities due to the delay. However, missing out on some days did not cost us heavily since we were generally able to take positions or close the same the next day.

Use of Market orders: when placing orders, we placed market orders to be executed at the opening prices of the next day. This meant that the prices were not the same as the ones implied by the trading signals we received. This could have been averted by placing limit orders. It is difficult to estimate the impact of this mistake, however it could have been substantial.

Pure technical analysis strategy: as mentioned earlier, a pairs trading strategy based solely on technical analysis can be risky since fundamental relationship between stocks can change permanently. However, we followed the technical heuristics assuming them to be correct indicators of deviations which would mean revert.

8. Risk Control Measures

We did not implement any risk control measures for the strategy except monitor the positions daily. However, there are several ways in which one can control the risks. A common way is to use limit orders and to place stop-loss orders. The problem with using the stop-loss method for the pairs trading strategy is that we enter the position as soon as there is a deviation and it can be expected to widen before reverting back to the mean. A stop-loss in such a scenario would lead to pre-mature termination of positions which could lead to losses.

Diversification is another common way of decreasing the risks involved. From the point of view of pairs trading, it could mean two things. Firstly, it might mean investing only a portion of total capital in the pairs trading strategy so that there is adequate diversification through other investments. Secondly, it could mean holding positions in several pairs and limiting the amount invested in any pair like we did. However, this may not be easy to implement since it is reasonable to assume that trading opportunities would not arise in many pairs at the same time.
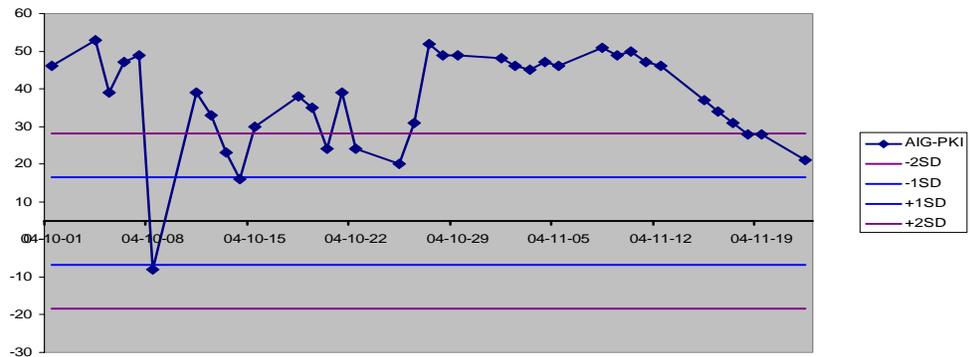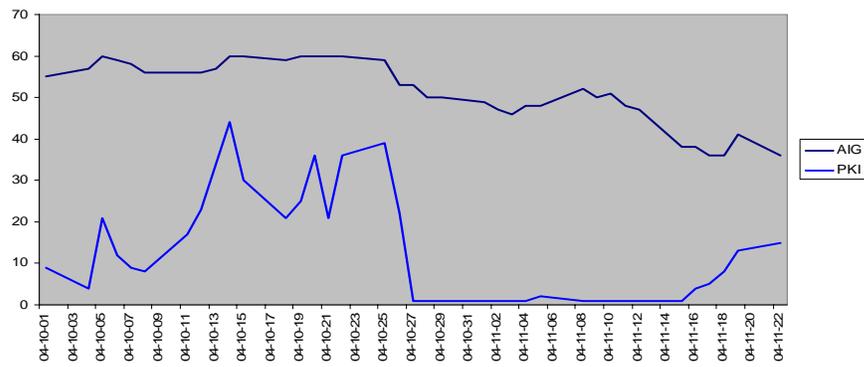
9. Conclusion

In the end, we feel that pairs trading is an attractive strategy since it does not require very high levels of skills from the traders. However, as a stand alone strategy, it is faced with some risks which can be diversified away. Thus, we believe that a pairs trading strategy makes sense as part of a larger portfolio. It is, however, trade intensive and thus, entails high transaction costs. In real life these costs might be higher than those in Stocktrak which could make this strategy unprofitable.
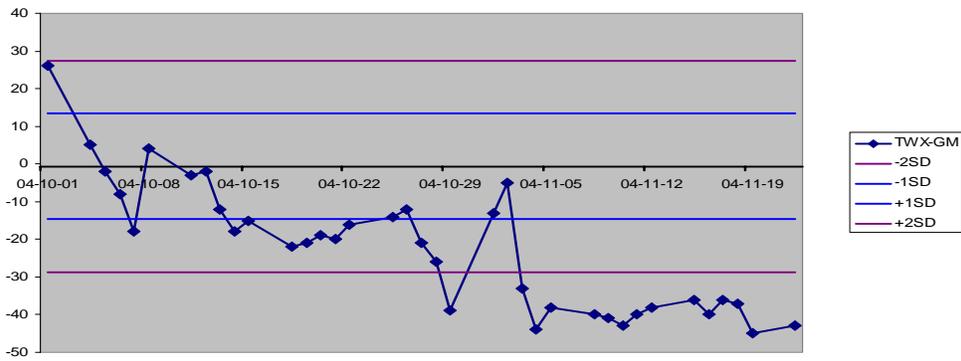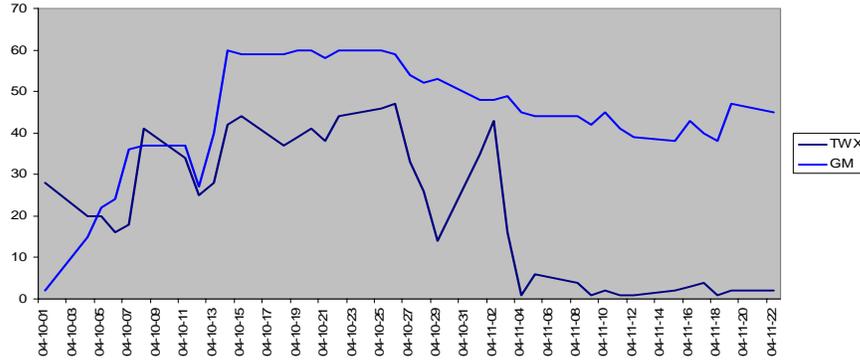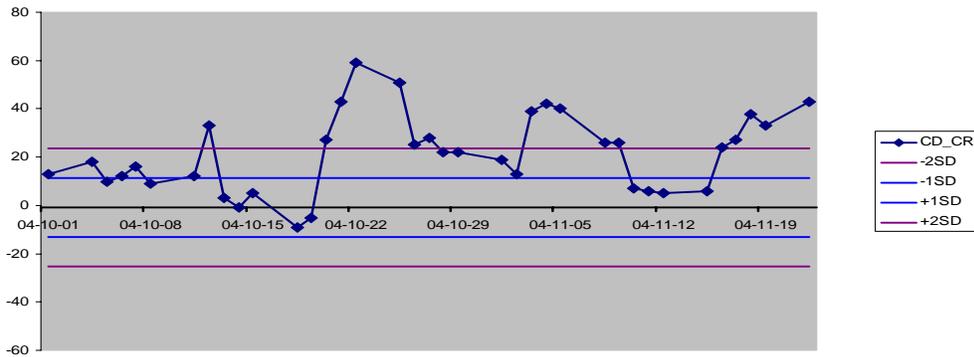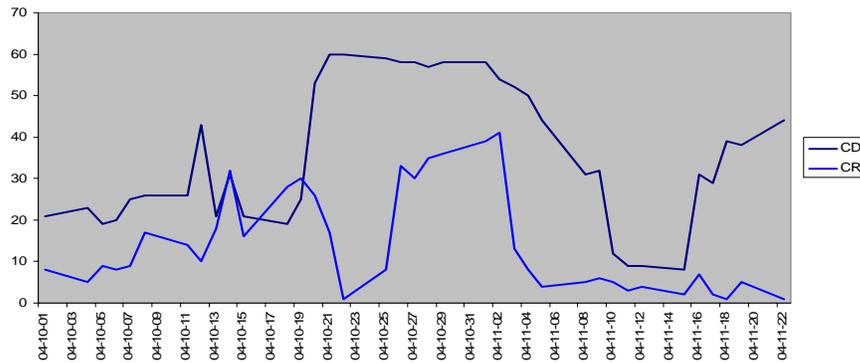
Appendix

CSCO-HPQ
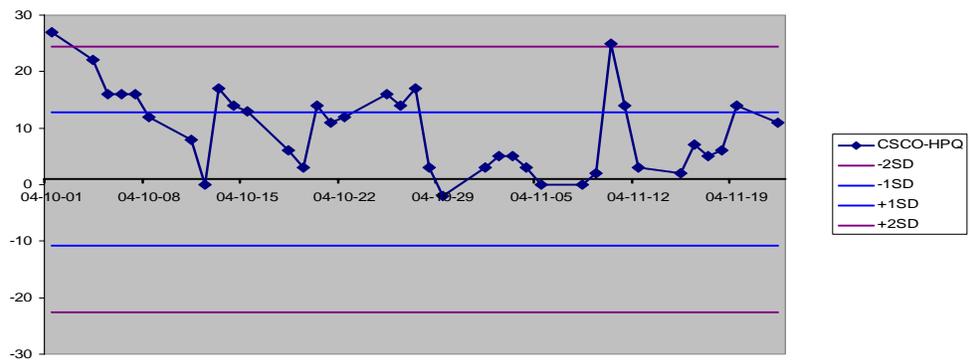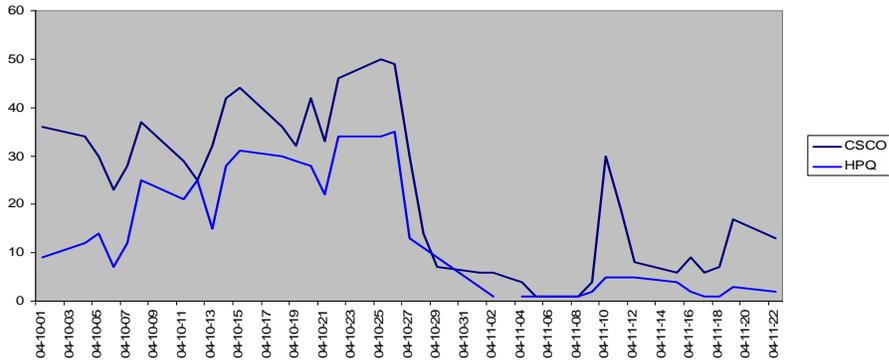
AIG-PKI

TWX-GM

CD-CR

CSCO.TWX