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**Statistical Arbitrage:
Opportunity Spotting for Financial gain in
Financial Markets**

**Thesis submitted for the degree of
M.Phil.**

by
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Statistical Arbitrage: Opportunity Spotting for Financial gain in Financial Markets

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Abstract

The project sought to identify anomalies in the price-time relationship of historically highly correlated company stocks, and to exploit these anomalies by trading both sets of stocks in a manner so as to yield a profit independently from financial market movement.

The stock positions taken upon each opportunity are those of a zero investment strategy (i.e. the same value of one stock is bought as is sold in another stock – with a net of zero outlay). The idea being that the bought stock rises and/or the sold stock falls. Either way makes money.

The aim of the work was to engineer this Statistical Arbitrage system, which spots real-time opportunities, and capitalize upon the event for profit. The application has indeed been engineered, and to this end this aspect part of the work has been realized.

While significant annualised percentage gains of between 6.0% and 44.1% have been achieved in later simulations, this could have be due to factors present in the market at the time and/or as yet unconsidered influences. Poor or inconsistent performance in falling and level market conditions leave, at least myself, unwilling to invest in the strategy, without more work being undertaken.

While the overall outcome of this work does not bode well for a totally infallible alchemist dream, I still believe that somewhere in this method is a holy grail, and would urge other individuals to complement this work if at all possible.

Declaration of Originality

It is hereby certified that this thesis is the author's original work, except where otherwise stated. References are given stating sources where applicable. The thesis, wholly or partly, has not been submitted for any other degree either to the University of Leicester or any other Institution of Education.

John Holme

4th June 2010

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My children

Table of Contents

CHAPTER 1	FOREWARD: Big Bang	12
CHAPTER 2	BACKGROUND	14
2.1	Share trading in general and terms frequently used	14
2.2	Day trading, Strategies and Program Trading.....	19
2.3	Objectives.....	22
2.4	Financial Terminology	26
2.5	What Is Pairs Trading?	29
2.5.1	Evidence of Profitability	30
2.6	An Example Using Futures Contracts	32
2.7	An Example Using Options	32
2.7.1	SHORTING A STOCK	33
CHAPTER 3	RELATED WORK.....	38
3.1	Further Background.....	38
3.2	Market Neutral	39
3.3	Interesting for the reader	54
3.4	Technical Analysis.....	56
3.4.1	Hedge funds	62
3.5	When things go wrong	63
3.5.1	Long Term Cap	64
3.5.2	Tiger Management	64
3.5.3	A risky strategy.....	65
3.5.4	Bailey Coates Cromwell Fund	66
3.5.5	Marin Capital	67
3.5.6	Worldcom	68
3.5.7	The Credit Crunch: No quick end in sight	68
CHAPTER 4	TECHNOLOGY AND DESIGN	70
4.1	ANALYSIS.....	70
4.2	Requirements	70
4.3	Design Details based upon Requirements	72
4.3.1	Detailed List of Functional Requirements	73
4.3.2	Database Design.....	73
4.3.3	The Process (functional) matrix.....	77
4.3.4	Process diagram	77
4.3.5	Class diagram.....	83
4.4	Technology	84
4.5	Creation of a Simulation.....	86
4.5.1	A trading simulation	86
4.6	Data.....	86

CHAPTER 5	EXPERIMENTS & RESULTS	88
5.1	Introduction	88
5.2	Proof of the code and concept	89
5.2.1	Testing	90
5.2.2	Simulation Results	93
5.3	Parameters	94
5.4	Simulation over historical periods of time and search for the holy grail	101
5.4.1	List of experiments	102
5.4.2	RISING Market	103
5.4.3	FALLING Market	109
5.4.4	LEVEL Market	115
5.5	Performance in the real time market	121
5.6	Real Time	122
5.6.1	Data	122
5.6.2	Number of trades	123
5.6.3	Final values vs ValueOnDay	125
5.6.4	Breakdown	128
5.6.5	Profit per trade	128
5.6.6	Reports	129
5.7	Pseudo Real Time	137
5.7.1	Data	137
5.7.2	Number of trades	137
5.7.3	Pseudo Real Time Replay	138
5.7.4	Profit per trade	139
5.8	Live Pseudo Replay	141
5.8.1	Number of trades	142
5.8.2	Varying simulation start date and code trigger parameters	142
5.8.3	Per trade breakdown	145
5.8.4	Profit per trade	147
5.8.5	Annualised Profit	149
CHAPTER 6	FURTHER WORK	151
6.1	Rising, falling and level simulations	151
6.2	Real time trading	151
6.3	Parameter wrapping	152
6.4	Changing regression values	153
6.5	Profit and Loss	154
CHAPTER 7	CONCLUSIONS	156
7.1	Rising, Falling and Level Market Movement Simulations	156
7.2	Testing	156
7.3	Performance in a Real time scenario	157
7.4	Trading Reports	158
7.5	General feeling	158
APPENDIX 1.	Proof of code	160

Table of Tables

Table 1 Requirements of the opportunity spotting application	73
Table 2: The trading parameters table (TRD_Params)	95
Table 3: trading parameter field meanings.....	96
Table 4: Analysis periods	97
Table 5: Trading Parameters	100
Table 6: Simulation period summary.....	103
Table 7: Rising data excerpt	104
Table 8: Rising Period profit & loss.....	107
Table 9: Falling data extract.....	110
Table 10: Falling tabulated results	112
Table 11: Level Simulation Results.....	116
Table 12: Level Simulation Data.....	119
Table 13: Live data (first trades)	122
Table 14: Live data (final trades).....	122
Table 15: Live trade cumulative count.....	124
Table 16: Live profit per trade	126
Table 17: Live breakdown of pairs	128
Table 18: Live Pseudo cumulative number of trades	137
Table 19: Live Pseudo final values and value of day of positions	138
Table 20: Live Pseudo profit per trade	139
Table 21: Live pseudo replay simulation data extract	141
Table 22: Live Pseudo Replay number of trades.....	142
Table 23: Comprehensive assessment	143
Table 24: Profit per trade	147

Table of figures

Figure 1: Investor, broker, exchange relationship	16
Figure 2: Perfect Share Price Correlation	23
Figure 3: Highly correlated share prices	24
Figure 4: Main database tables	74
Figure 5: Database Design	76
Figure 6: Functional matrix	77
Figure 7: High level process flows.....	78
Figure 8: Low level process flows.....	79
Figure 9: Class Diagram.....	83
Figure 10: Market movements.....	102
Figure 11 : Meanings/Definition of the columns in the simulation results	103
Figure 12: RISING Market graphic.....	106
Figure 13: Meanings/Definition of the columns in the simulation results	109
Figure 14: FALLING Market graphic	111
Figure 15: Meanings/Definition of the columns in the simulation results	115
Figure 16: LEVEL Market graphic	118
Figure 17: Live Final amount and valueOnDay.....	127
Figure 18: Live breakdown of pairs.....	128
Figure 19: Live profit per trade.....	129
Figure 20: Live Open position suggestion GOOG-NTAP.....	130
Figure 21: Live on-going position GOOG-NTAP	131

Figure 22: Live Suggested closure GOOG-NTAP.....	132
Figure 23: A view of the relative performance of the stock and any unusual trading volumes in a 1 Year period	133
Figure 24: A view of the relative performance of the stock and any unusual trading volumes in a 3 Month period	133
Figure 25: A view of the relative performance of the stock and any unusual trading volumes in a 3 month period	134
Figure 26: 3 Months Stock Graph of first party in the pair to show unusual volume or price movement	134
Figure 27: 3 Months Stock Graph of second party in the pair to show unusual volume or price movement	135
Figure 28: News from each component of the pair	136
Figure 29: Live Pseudo final values and value of day of positions.....	139
Figure 30: Live Pseudo profit per trade	140
Figure 31: Comprehensive assessment.....	144
Figure 32: Per trade breakdown	146
Figure 33: Profit per trade	148
Figure 34: Annualised profit.....	149
Figure 35: Historical price graphs for simulated stocks	161
Figure 36: Simulation data regression values on the initial day	163
Figure 37: Simulation 1 - Continuation of trend data	165
Figure 38: Simulation 1 - Final day Report.....	166
Figure 39: Simulation 2 - Days price files	168
Figure 40: Simulation 2 - Final day report.....	170
Figure 41: Simulation 3 - Days price files	172

Figure 42: Simulation 3 - Final day report.....	174
Figure 43: Entity model.....	176

CHAPTER 1 FOREWARD: Big Bang

In the early eighties financial instruments were bought and sold by salesmen from other salesmen who worked for Financial Market Traders who came largely from the East End of London. They were known as Barrow boys, primarily because their fathers had sold fruit from barrows in the East End markets, and had inherited their fathers' instincts for sales within a market albeit a financial market.

The phrase Big Bang was used to describe the deregulation of financial markets. It included the abolition of the distinction between stockjobbers and stockbrokers on the London Stock Exchange by the United Kingdom government in 1986.

This change in the rules of the London Stock Exchange occurred on 27 October 1986, dubbed "Big Bang Day. Big Bang was so called because the abolition of fixed commission charges precipitated a complete alteration in the structure of the market. One of the biggest alterations to the market was the change from open-outcry to electronic, screen-based trading.

Following Big Bank the late eighties saw the major stock markets of the world become global. It became possible to buy and sell financial instruments (then typically equities and other derived products, known as derivatives) from global companies on many different (and new) financial markets (London, New York, Tokyo, Singapore and Hong Kong), and obviously in multiple currencies.

As the eighties headed toward the nineties the complexity of the financial instruments, especially their derivatives, began to increase.

This was basically due to a drive for more and 'better' products than competitors were selling.

In the earlier days a share in a company was basically calculated as being equal to the value of the company divided by the number of shares plus a premium the market deemed appropriate for owning the share. With more complex products (for example derivatives – products derived from other products), the pricing of these products became more complicated. The more complex products incorporated one or more optional cash flows in possibly one or more currencies. Valuing optional cash flows or those based on future market movements became more complex and with hindsight “error prone”, especially when these also can involve one or more foreign exchange rate conversions that occur in the future.

As a result of this Financial institutions began to recruit highly qualified staff to both perform valuations and also to sell these products. They were known as “Rocket Scientists” or “quants” (for quantitative analysts), as they generally came from the defence industry.

Having worked on guidance systems in the defence industry with algorithms that looked to find targets within a noisy environment it struck me very early on that there may be an opportunity to spot signals within the noise of financial markets stock price movements with a view to exploiting trends or anomalies for financial gain.

CHAPTER 2 BACKGROUND

2.1 Share trading in general and terms frequently used

Before concentrating upon the mission of this work it is probably a good idea to understand the process of share trading and covering a little of the background and terminology that this thesis will discuss.

To begin with then it is a must to discuss “stock”. This is also referred to as “equity” or “shares”. A share is literally a share in a company. When a small company is formed it has a certain amount of shares “issued” (typically 100 or 1000). These are merely pieces of paper with the company name and a notional value (typically £1, but it can be any amount) shown on the paper. A share is indeed what its name suggests. It is a share in the company. Each “shareholder” owns a proportion of the company equal to the shareholders “shareholding” equal to the proportion of the issued number of shares (the shares in issue). It is not the notional amount that is important but the number of shares as a proportion of the shares issued that is important.

A company may be private or public. A private company is one whose shares are not available to the general public and are not listed upon stock exchanges. A public company’s shares however, are available to be bought and sold upon stock exchanges. Their shares are said to be listed on one or more stock exchanges. Depending upon how many shares are bought and sold each day gives rise to the term liquidity. The more a stock is bought and sold the more liquid the stock is said to be. The more liquid a stock is the narrower the gap is between the buying price and selling price. This gap is termed the spread.

People who own shares, and these can be bought by everyone if it is a listed company, are likely to receive a “dividend” on the shares. A dividend is generally paid once or twice a year or in some special one-off event. A dividend represents that portion of the company’s profit (earnings less costs) that has been allocated to shareholders. It is typically quoted and paid as an amount per share owned (e.g. in the UK, 13p per share).

In a typical trading scenario one would deal with a broker. A broker has direct contact to the financial exchange that you wish to trade upon. He sends the financial market (generally a stock exchange) your order. The stock exchange matches your order to buy with part of, one or more other trade(s), resulting from an order placed by a counterparty with possibly a different broker. This communication path is shown in Figure 1. Arrows are bi-directional as once confirmation of the trade is obtained feedback regarding details is passed to the respective counterparties. You are the counterparty to the other side of the deal. As a rule individuals do not get to know the other counterparty as it is not necessary.

Nowadays it is possible for people (such as day traders, individuals trading from home) to have direct access to the exchanges.



Figure 1: Investor, broker, exchange relationship

A broker charges similar commissions and fees for this service as would be charged for opening or increasing a long position. However with a short position there is also an additional charge to cover “stock borrowing”.

When a stock is bought or sold it is bought or sold from someone else (called in financial terminology the counterparty). This counterparty expects to either send your broker the stock you bought or indeed receive the stock you sold.

In the simplest case a person will buy stock and then sell the stock through their broker. It is however possible to arrange with your broker to “short” stock – that is sell stock that you did not own. If you did not have the stock when you sold with your broker (i.e. you were shorting the stock) the counterparty still expects to receive the stock you sold. The physical delivery of the stock is arranged by the broker’s settlement instructions to the exchange (and passed on to the other broker).

In order to meet the settlement requirement (typically 3 days from the day of the trade) of a shorted stock the broker will arrange for you to

“borrow” the stock from him (although the mechanics can be more complex). Fees for this service vary, but are typically a percentage of the value borrowed. Typically a short position is only held for a small length of time.

For the interested reader equity comes in different forms. Most notably there can be preference shares, ordinary and golden shares. As I have said the shares are exactly what they say they are – a share of the company. A share allocates part of the company to the owner of the share. As a shareholder you do indeed own a part of the company i.e. its fixed assets such as factories and machines and so on as well as a claim to any profits deemed dividends. If a company goes bankrupt and the assets are sold the proportion of the money received (less creditor claims) are given to the shareholders in the proportion of their shares. In the event of such a liquidation of assets the holders of preference shares are first to receive payment (after creditors).

Creditors are people who are owed money by the company this can typically be banks whose loans are unpaid or bond holders.

Bonds are loans raised on behalf of the company by a financial institution (known as the issuer). They are obligations to pay a certain interest rate for a period of time on the notional amount of the bond. These obviously cost money to buy. The buyer can be viewed as making an investment while the company who had ultimately issued the bonds can be seen to be raising a loan. The buyer then receives the specified interest for the time specified just as interest in a bank account but the (fixed rate of) interest can vary from lower than that of the bank to

higher depending on the risk involved in effectively lending money to the company whose shares are issued. The higher the rate of interest offered the riskier the loan. In order to show investors how risky the bond (loan) is various agencies (Moodies^a, Bloomberg^b and others) are in the business of rating companies. This ranges on a scale which vary from company to company but the one thing they agree on is that the top rating is AAA (triple A). There are very few triple A rated companies left but government bonds carry triple A.

There are other products called derivatives. As their name suggests these are derived instruments. Various traded financial items have futures and options ranging from those on equities to pork bellies (made famous in the film trading places). The simplest are probably futures and equity options. These products are now so popular that they are traded on their own exchanges just as equity is. An option on equity is just that, it is an option to buy the underlying at some time in the future (usually fixed periods into the future) at an agreed price. A future is a commitment to buy the underlying at some time in the future at a fixed price.

Typically an option on an equity will be the right to buy that equity at a specified time in the future at a certain price. As it is an option you have the right to decide whether you wish to go ahead with the

^a <http://www.moodys.com/cust/default.asp>

^b <http://www.bloomberg.com/?b=0&Intro=intro3>

transaction at the expiry date of the option. Clearly this makes sense if the price that the option allows you to buy the equity (known as the underlying) is less than the market value of the equity (less the original cost of the option).

A future on the other hand is not an option, it is a fixed agreement to take delivery of the underlying at the agreed price at the agreed time in the future. This of course may be what the buyer wants however there is a difference between receiving a bond paper and several hundred pork bellies. As with all financial instruments buying and selling them come with a health warning. It is advised to only trade financial instrument that the person is aware of – if doing so alone.

The diverse range of items being traded are now often lumped into the term “financial instruments”. Some of the more complex instruments (beyond the scope of this thesis have specialist departments in banks working on the pricing of these instrument). These instruments are currently CDO’s (Collateralized Debt Obligation) and CDO²’s (a CDO based on a reference portfolio of other CDO tranches). The groups/departments typically pricing these financial instrument are called Financial Engineering and the people working in the group are called Financial Engineers.

2.2 Day trading, Strategies and Program Trading

When people use the term "day trading" [1], they mean the act of buying and selling a stock within the same day. Day traders seek to make profits by leveraging large amounts of capital to take advantage of small

price movements in stocks or indexes that have a high volume of trading.

There are various day trading strategies that can be used: Scalping, Fading, Daily Pivots and Momentum to name but a few. Computers and Computer programs have enhanced and mimicked these strategies, doing so at very high speed and in some instances cutting out the human element. Program trading takes this a whole step further, with trades being based upon many (and in some cases complex) calculations and which could not have been performed by a human in a timeframe that would have allowed successful trades to be performed.

Program Trading is very prolific. For example, during July 5-8 14/07/05 program trading averaged 55.8 Percent of the NYSE^c daily volume of 1,501.2 million shares [2], that is 837.1 million shares a day!

Of the five member firms reporting the most program trading activity on the NYSE, UBS Securities, LLC. and Lehman Brothers^d, Inc. executed most of their program trading as principal for their own accounts. Morgan Stanley & Co. Inc., Goldman, Sachs & Co. and Deutsche Bank Securities executed most of their program trading activity for customers, as agent. Although Lehman's was arguably the catalyst for the credit crunch program trading was unlikely to have led to the demise of the company [3].

^c New York Stock Exchange (NYSE).

^d It should be noted what happened to Lehman Brothers.

Program trading generally relates to baskets of securities or index arbitrage: With regard to security baskets it is accepted that this means buys and sells of baskets of fifteen stocks or more and usually with a combined value of at least \$1 million; while index arbitrage is the purchase or sale of a basket of stocks in conjunction with the sale or purchase of a derivative product such as stock-index futures (with similar value to the former), both aiming to profit from the price difference between the buys and sells.

In addition to index arbitrage, other strategies exist [31] and include customer facilitations, liquidation of facilitations, index substitutions, liquidation of error accounts, risk modifications, and liquidation of exchange-for-physicals stock positions. Other strategies exist of course using time and events as triggers for trading, as people always seek to have an edge, Thompson [4] discusses some of these.

Program trading came about as technological advances facilitated the growth of electronic communication networks, which allowed electronic exchanges to match thousands of buy and sell orders in milliseconds without any human intervention, Connolly [5] gives some good insight into the background and methods. The proliferation of hedge funds with all their sophisticated trading strategies also ramped up program-trading volume.

Statistical arbitrage was chosen for my research as it has always been of interest. Especially after earlier work in the field in the Department of Engineering at Leicester University left many questions unanswered [6].

2.3 Objectives

This project aims to concentrate in spotting anomalies in highly correlated stocks within a market. Again work has been performed in this area but the aim here is to make the opportunity spotting real-time (to exploit opportunities as they happen) and to do so using automated procedures.

In brief, my research seeks to identify real-time anomalies in the price-time relationship of historically highly correlated stocks and to exploit these anomalies by trading both sets of stocks in a manner so as to yield profit independently from the market as a whole. The stock positions taken upon each opportunity are those of a zero investment strategy (the same value of one stock is bought as is sold in another stock). The idea is that the bought stock rises and/or the sold stock falls. Either way makes money. This is explained more fully by the example to follow:

Suppose we have two companies Company 1 and Company 2 whose share prices are perfectly correlated (Figure 2), a movement in one or

other of the companies' share price has a corresponding change in the others' share price.



Figure 2: Perfect Share Price Correlation

With the relationship shown in Figure 2 it is possible to predict the exact change in the other share price given a known change in one share price. There is however another dimension to this graph, and that is time. It may be that the time taken to achieve the price in the other company's share price may take between a millisecond or possibly several days. With a perfect relationship like this, knowing that the relationship will maintain the highest correlation possible the time taken between the change in one price until the corresponding change

in the other price allows for a time arbitrage opportunity. This is in the realm of program trading. I am going to concentrate my efforts on relationships which are highly correlated (i.e. not perfect) but which still have a high probability of returning to the norm. In this case a price fluctuation in one share may take several days to be reflected in the other share.

A non perfect, but highly correlated, relationship may be seen in Figure 3. The fluctuations in share price can be seen as the saw shaped line. A regression line can be seen showing the assumed perfect relationship. The trading strategy of this thesis assumes any fluctuations in price will probably return to the regression line.

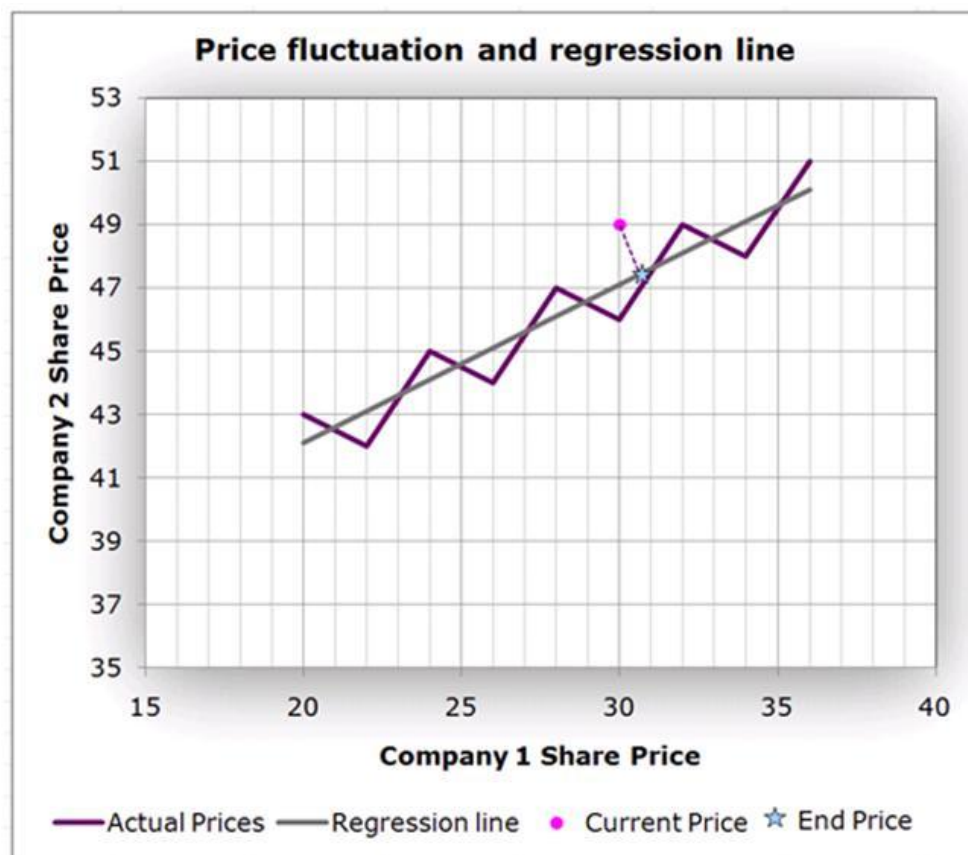


Figure 3: Highly correlated share prices

This research seeks to identify these highly related stocks prior to any attempt at real time opportunity spotting. The calculation time required for the full cross section of company versus company coefficients would take too long for a typical PC. Instead it is proposed that the analysis of highly related stocks would take place, say weekly or fortnightly and the results be used for one or two weeks. It is proposed that some time is dedicated to seeking the optimal recalculation time required.

Opportunities will be spotted using a second tool which will be designed to read “real-time” or at least “near real-time” prices. Using the correlation matrix of high r^2 's it will identify opportunities. Take for example the scenario of high correlation shown in Figure 3 and imagine the opportunity spotting tool spots that the current prices of the Company 1 stock and Company 2 stock are at one of the high points on the saw.

The first part of the analysis gives a strong indication that the stocks are highly correlated. The second part has shown that the prices of both stocks have moved such that at the saw point they find themselves at they are a considerable distance from the regression line to which they normally adhere. The “considerable” distance needs to be such that any trades resulting from the analysis are profitable (as remember there are brokerage charges to take into consideration).

Assuming that the stocks will revert back to their normal relationship (that of the regression line) it is possible to sell stock from Company 2 and buy stock from company 1.

If (and this is a big if) the trend reverts to the mean of the regression line Company 2's stock price will fall and Company 1's will rise. Company 2's stock can be bought back at this point and Company 1's stock can be sold. Hopefully this yields a profit.

At this point it is worth a digression into some financial facts and scenarios.

2.4 Financial Terminology

In a financial market it is obviously possible to buy a stock you do not own. This is usually done through a broker who will levy a fee for the transaction, known as commission. It is also possible a fee may be charged for the order to buy. When a stock is bought (say you bought 1000 of stock "A") you are said to have a position in "A" (of a 1000). If you purchase an additional 500 of stock "A" your position has increased to 1500. Similarly once you own a stock it is possible to sell it.

With the right sort of trading account it is possible to sell stock that you do not own. For example if you do not own any of stock "B" but have a trading account that lets you "short stock" you can, for example sell 1000 of "B" without owning "B" in the first case. If you sell 1000 "B" when you didn't own it you are said to be shorting the stock. You have a position of -1000 "B" which is more commonly termed a short position in "B" of 1000. Similarly a positive position such as the scenario just covered would be known as a long position.

Assuming the current prices of the stocks in Figure 3 (the point [30, 49] and shown as a luminous purple blob) return to the nearest point on the regression line (labelled the end price and shown as a blue star) a zero investment opportunity to open an arbitrage position can be seen.

By buying an amount of stock X and selling a similar value of stock Y the amount required for the purchase of X is equal to the value received for the sale of stock Y. A positive position or long position in X has been taken and a negative or short position in Y has been taken. If all goes as is historically predicted and the stocks return to the blue cross position it can be seen that stock X has gained in value so the original amount purchased can be sold at a profit. Similarly the amount of Y sold has decreased in value so the same quantity can now be bought back again cheaper than when it was sold. This also yields a profit.

Clearly the amount to be gained needs to be in excess of the commissions and stock borrow costs. This all needs to be taken into consideration in the analysis and research. But conceptually there are large profits to be made.

The aim of my work is to engineer a Statistical Arbitrage system, which spots real-time opportunities capitalising upon the event for profit.

The idea is to identify stocks whose price-time relationships are highly correlated within a Market and then to exploit anomalies in this relationship for financial gain.

The term “The Market” refers to the environment in which financial instruments are being traded. This is typically for example the stock exchange in London trading company equity or the London International Financial Futures exchange trading commodities. When people refer to the Market they are referring to the level of the market. The level of “The Market” is generally accepted to be that figure represented by an index. This is a measure of how the market is rising or falling relative to itself at a previous time. A typical index for stocks trading on the London Stock Exchange is the FTSE 100. This represents an average of the top 100 stocks in the UK (weighted by market capitalization – so the largest companies have the largest impact, where market capitalisation is the value of the company). Market movement is a phrase that is used to summarise the overall movement of the stocks in the index for example the FTSE 100 has risen 60 points (or 1.2%) today implies that the basket of stocks in the index has, on average, risen 1.2% on the day.

It is normal practise for a single non institutional investor to amass a portfolio of (usually) stock, and turn this into safe cash at some point. Another approach is to amass wealth gained from trading strategies. In this thesis I am concerned with a particular trading strategy known as the market neutral strategy. The type of trading described above, where one instrument is bought and another similar amount is sold and where the relationship between the instruments is firm is sometimes referred to as Market Neutral. A Market Neutral Strategy is, as the name suggests, Market Neutral, i.e. it is independent of whether the

market moves up or down or even stays at the same level. There are various Market neutral strategies available. The Market Neutral strategy that this thesis is concerned with is typically termed Pairs Trading.

There are two good arguments for using a market neutral strategy: The first is to eliminate the “market risk” of owning stocks and instead carry only the risk associated with owning particular companies; the second is that since markets or sectors tend to move as a group regardless of individual company merits, there is a risk that even a good company’s stock price will fall when a sector or the entire market declines.

2.5 What Is Pairs Trading?

In his article dated September 8th, 2004 Chris Stone [7] details how pairs trading came about and how profits are to be made from trading in pairs. He describes "Quants" as a Wall Street name for market researchers who use quantitative analysis to develop profitable trading strategies. He tells us that a quant combs through price ratios and mathematical relationships between companies or trading vehicles in order to divine profitable trading opportunities.

He says that it was during the 1980s, a group of quants working for Morgan Stanley struck gold with a strategy called the 'pairs trade'. Institutional investors and proprietary trading desks at major investment banks have been using the technique ever since, and many have made a tidy profit with the strategy. This is the same basic technique being exploited in my work, only this work seeks to enhance the decision making process putting more emphasis upon automated

detection and triggering of buy and sells. Trigger points are very important, not only in program trading, and are discussed by Lukeman [8] in length.

He points out that it is rarely in the best interest of investment bankers and mutual fund managers to share profitable trading strategies with the public, so the pairs trade remained a secret of the professionals (and a few deft individuals) until the advent of the Internet. Online trading opened the lid on real-time financial information and gave the novice access to all types of investment strategies. It didn't take long for the pairs trade to attract individual investors and small-time traders looking to hedge their risk exposure to the movements of the broader market.

2.5.1 Evidence of Profitability

In June of 1998, Yale School of Management released a paper written by Even G. Gatev, William Goetzmann, and K. Geert Rouwenhorst [11] who attempted to prove that pairs trading is profitable. Using data from 1967 to 1997, the trio found that over a six-month trading period, the pairs trade averaged a 12% return. To distinguish profitable results from plain luck, their test included conservative estimates of transaction costs and randomly selected pairs.

Ganapathy Vidyamurthy's [9] book Pairs Trading: Quantitative Methods and Analysis, looks at the performance of pairs trading over a period

from 1962 to 2002. Collating data over 6 month periods in this time period they claim they had a 12% rate of return in this time slice.

He concludes that the broad market is full of ups and downs that force out weak players and confound even the smartest prognosticators. The theory is that using market-neutral strategies like the pairs trade, investors and traders can find profits in all market conditions. The beauty of the pairs trade is its simplicity, a pairs trade has the potential to achieve profits through simple and relatively low-risk positions. The pairs trade is market-neutral, (as previously mentioned) meaning the direction of the overall market does not affect its win or loss [7].

When selecting a pairs trade the goal is to match two trading vehicles that are highly correlated, trading one long and the other short when the pair's price ratio diverges "x" number of standard deviations - "x" is optimized using historical data. If the pair reverts to its mean trend, a profit is made on one or both of the positions. The correlation can be on Profit/Earnings (P/E) ratios and other factors but my work concentrates purely on the statistical correlation of prices.

It is also possible to trade pairs in different ways. Rather than a simple buy of one stock and sell of another stock (albeit using some prearranged stock borrow arrangement. It is possible to trade using futures and options contracts.

2.6 An Example Using Futures Contracts

The pairs trading strategy works not only with stocks but also with currencies, commodities, and even options. In the futures market, "mini" contracts--smaller-sized contracts that represent a fraction of the value of the full-size position--enable smaller investors to trade in futures.

A pairs trade in the futures market might involve an arbitrage between the futures contract and the cash position of a given index. When the futures contract gets ahead of the cash position, a trader might try to profit by shorting the future and going long in the index tracking stock, expecting them to come together at some point. Often the moves between an index or commodity and its futures contract are so tight that profits are left only for the fastest of traders – as Stone [7] says, often using computers to automatically execute enormous positions at the blink of an eye.

2.7 An Example Using Options

An option is just that. The option contract is the right to buy (or sell) an item at a fixed price at a designated time in the future, for which a price (called a premium) is paid up front. The contract itself is drawn up (or written) by an issuer of the contract. A call is a commitment by the writer to sell shares of a stock at a given price sometime in the future. A put is a commitment by the writer to buy shares at a given price sometime in the future.

Option traders use calls and puts to hedge risks and exploit volatility (or the lack thereof). A pairs trade in the options market might involve writing a call for a security that is outperforming its pair (another highly correlated security), and matching the position by writing a put for the pair (the underperforming security). As the two underlying positions revert to their mean again, the options become worthless allowing the trader to pocket the proceeds from one or both of the positions.

2.7.1 SHORTING A STOCK

Having found a good pairs trade to open that matches all the criteria wished there is a buy side of the deal and a sell side. This is all very well if the orchestrator of the trade is an institution with the stock to be sold already on its books. For the smaller investor, who does not own the stock he wishes to sell, all is not lost. He is able to “borrow” the stock, which is then available to be sold, with a view to returning it to the lender in the future. This is called “stock borrow”. It is a very popular technique and most settlement systems have this in built capability. This obviously comes at a cost to the borrower but the cost is not astronomically high, typically 3-6% p.a. for an institution, with pro-rata costs applicable until the stock is returned.

Buying the same amount of shorted stock after the price of the stock has declined allows for the stock to be returned. The investor who shorted the stock keeps any profit (and yes, bears any loss!). For example borrowing 50 shares and selling them at \$20 and then buying

them back when the price is at \$15 yields a \$250 profit, minus commissions.

However, different brokerage firms have different policies on shorting. Some firms will only allow a customer to short a stock if the shares are in inventory, meaning some other customer at the same firm holds the shares. If a small brokerage firm has this policy then shorting opportunities may be limited. Larger brokers however, allow the setting up of an account that will allow this type of trade, knowing they are large enough to cover liquid stocks. Other brokerages will borrow the shares from outside their own firm in order to allow their customer to short a particular stock.

As a practical matter it is often difficult, if not impossible, to sell short shares in small companies. There usually isn't enough liquidity in small-cap companies to borrow the shares, even though small-cap companies sometimes represent the most overvalued stocks. This work uses liquid stocks from very active markets. Finding pairs in illiquid stocks is difficult and dangerous (illiquid is a term used to identify financial instruments which do not trade easily and whose prices therefore remain static for long periods of time).

There are many ways of implementing a market neutral strategy, but the basic premise is the same: at any given time some securities are overvalued and others are undervalued. An investor takes advantage of

this temporary disequilibrium by buying undervalued securities and taking an equal, short position in a different and overvalued security.

Some papers and literature refer to terms as if we had been brought up with them in primary school and they can cause confusion. A summary of terms worth noting when surveying the literature are as follows:

Mean reversion

Reversion to mean is the tendency of a number that changes over time to return to its long term average value after a period above or below that.

While reversion to mean can be a reasonable indicator or likely long term returns, it is not often useful as a predictive tool. While one may expect a period of exceptional (high or low) returns to end, this does not tell one when to expect it to end.

Technical analysis

Technical analysis is the rather solid sounding name given to what is also called chartism: the attempt to predict financial markets purely by looking at past financial data (securities prices, indices and other trading data). Its practitioners are sometimes called chartists.

Back-testing

To test a financial model that makes any kind of predictions, it is clearly impractical to enter the currently available data and then wait to see how well forecasts are met - particularly as it will be necessary to do this many times in order to obtain a statistically meaningful measure of the accuracy of forecasts.

The solution is to test the model by using it on only the data available at some past date, and then comparing the predictions to what happened subsequently. This is back testing.

Econometrics

Econometrics is a branch of statistics that is applied to economics and financial economics. The key distinguishing feature of econometrics is that it deals specifically with time series data.

The problem with time series data is that it introduces many spurious correlations. If two data series both show a consistent trend over time they may appear correlated when they are not. They may have a positive correlation coefficient although there is no causal link between them. This makes it harder to find true correlations.

Correlation coefficient

A coefficient of correlation is a mathematical measure of how much one number (such as a share price) can expected to be influenced by changes in another (such as an index). It is closely related to covariance (see below).

A correlation coefficient of 1 means that the two numbers are perfectly correlated: if one grows so does the other, and the change in one is a multiple of the change in the other.

A correlation coefficient of -1 means that the numbers are perfectly but inversely correlated. If one grows the other falls. The growth in one is a negative multiple of the growth in the other.

A correlation coefficient of zero means that the two numbers are not related.

A non-zero correlation coefficient means that the numbers are related, but unless the coefficient is either 1 or -1 there are other influences and the relationship between the two numbers is not fixed. So if you know one number you can estimate the other, but not with certainty. The closer the correlation coefficient is to zero the greater the uncertainty, and low correlation coefficients means that the relationship is not certain enough to be useful.

CHAPTER 3 RELATED WORK

Survey and critical assessment. Relation to own work

3.1 Further Background

This chapter aims to cover and review the world of statistical arbitrage outside of this thesis. Statistical arbitrage is not new it has been around since the quants at Morgan Stanley opened up the opportunities (as mentioned in the previous chapter).

Particular interesting websites/books that relate to this thesis have been split into 2 sections: Background & Definition and Actual/Prospective Trading. Some of the background shows other people have tried simulation and suggested strategies, all of which my work has attempted to do.

The buying and selling of stock as suggested in the chapters prior to this one put the investor in a market neutral position. Done properly this means that the direction of the market is largely irrelevant to the investment made as this depends purely now on the movement of two share prices relative to each other. This independence from the market in this way is termed “market neutral”. Being market neutral avoids Market Risk – the movements of prices upon the stock exchange.

Despite a position being market neutral there are other risks involved in such a holding, in particular Company Risk: "Company risk" refers to the likelihood that any one firm's stock price will rise or fall. As investors or money managers, there's not much we can do to control

company risk except to do our homework as best we can. There is no substitute for having a thorough understanding of a company's valuation and its growth prospects. While careful research is important, it's not infallible and those who invest in the market must be prepared to accept some level of company risk.

3.2 Market Neutral

"Market risk" refers to the likelihood that the entire market will go up or down. The collective movement of stocks, as measured by a variety of different indices, will inevitably go up or down in any given month. Unfortunately, we don't know in advance what the overall market will do in a particular month. There is, however, a way to insulate ourselves from this market risk and that is Market Neutral Strategy's *raison d'être*.

The stock market still intrigues people, but shell-shocked individual investors have learned to be more savvy and realistic with their investments. There is no way to eliminate risk when stocks fluctuate, but risk can be reduced and even controlled. Eric Stokes ^[10] attempts to unravel the mysteries behind using market neutral investing principles, he says that stocks go up and down, but investors shouldn't have to limit themselves to only one-half of the equation and that investors can take advantage of movement in both directions—long and short investing. Pairs trading is an attempt at attaining a market neutral status. Theoretically then pairs trading should be able to take advantage of movements in both directions.

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A search on “Pairs Trading: performance of a relative value arbitrage rule” yielded an interesting paper from 1998 by Gatev, Goetzmann and Rouwenhorst [11]. They examined the risk and return characteristics of pairs trading with daily data over the period 1962 through December 2002. This work has many of the ideas that I have had while pursuing my work and presented here.

Their results seem to be based upon back-testing only, and do not present real-time actual on-the-day trades as I do in my results section. Trading purely at the end of day prices is rather like eating the cake without having to have had to mix the ingredients. Using a simple algorithm for choosing pairs, they tested the profitability of several straightforward, self-financing trading rules. They found average annualized excess returns of about 11% for top pairs portfolios.

They take into consideration transaction costs but as they say these are conservative.

From the findings in this work 11% per annum is significantly better than I have been able to generate and I suspect it is possible to optimise trading strategy based on a known set of data as in repeated back testing. Trading real time is the goal of such a strategy and there is no evidence that they managed to achieve this.

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Statistical arbitrage can be described as being synonymous with pairs trading. It is probably more accurate to say that the terms overlap. Statistical arbitrage is a strategy where mean-reversion is expected to

take place based on historical patterns. Chartism is a field of financial analysis based on graphical trends and bandings. Statistical arbitrage has a certain similarity to Chartism [12], but statistical arbitrage is more sophisticated (as it uses the methods of econometrics) and therefore more credible, rather than rely on the art and eye of the chartist. What they do share is a reliance on the existence of anomalies (violations of weak form market efficiency).

Most violations of market efficiency, especially weak form efficiency, are likely to be small and transient. It is therefore unsurprising that statistical arbitrage strategies tend to be short term and involve taking positions that are very sensitive to the movement in price of individual securities. High frequency trading has also been investigated by Gori [13] after discussing the basics.

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It has been said that Statistical arbitrage, sometimes called StatArb, relates to the statistical mispricing of one or more assets based on the expected value of these assets. For example, consider a game in which one flips a coin and collects £1 on heads or pays £0.50 on tails. In any single flip it is uncertain if one will win or lose money. However, in the statistical sense, there is an expected value of $£1 \times 50\% - £0.50 \times 50\% = £0.25$ for each flip. According to the law of large numbers, the mean return on actual flips will approach this expected value as the number of flips increases. This is precisely the way in which a gambling casino makes a profit. Statistical arbitrage merely attempts to find statistical

mis-pricings or price relationships that are out of line with the long term expectation.

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Sudbury's [14] Pairs trading strategy seeks to profit from the out-performance of one stock over another by trading two highly correlated companies (usually from the same industrial sector) and going long in one and short in the other.

A widening in the historical spread between the two share prices represents a trading opportunity to buy the loser and short sell the winner, the presumption being that history will reassert itself, and the spread will revert to its mean value. If this does, in fact, happen, the net position will yield a profit.

He bothers to point out the difficulty of identifying a pairs trade involves monitoring and analysing potentially suitable shares and having identified a possible pair, the trader has to establish a sufficient point of divergence to trigger the trade. Essentially, a pairs trader is looking for an instance of short-term momentum pulling two stocks out of line before the fundamentals reassert themselves. Sudbury states that "A graph of the historical price ratio of the two shares is extremely helpful in this respect". I concur with this statement and have endeavoured to back up the statistics behind the buy and sell suggestions I make, with as many indicative graphs and charts as possible.

He argues that "the perfect historical price ratio plot for a pairs trade looks like a sine curve with the ratio oscillating around its mean value". However I would argue that the perfect relationship is constant with

momentary glitches of such a time period as to allow the pairs trade to be setup and subsequently closed, thus avoiding stock borrow and associated funding costs of a position.

He states that some brokers will accept orders in the form of a packaged pairs trade, while others insist that the long and short trades each be made separately. Either way, it is vital to place stop orders on the combined position using either the ratio of prices or the spread. A stop order is an order that reverses the original position in order to cut losses. This is a must, and my simulations make a stop trade based on a notional 'accepted loss' percentage.

I agree with the notion of keeping it simple by sticking with pairs of big stocks in the same industry and pairs with similar long-term trading histories, and trading them when they diverge. He suggests unwinding the trades if the divergence persists and your losses reach 3% or after the stocks are back in synch and suggests that you then have a gain — typically of about 7%.

And it offers this as a winning strategy: Disregard any stock movement on the heels of bell-ringer news like fraud charges or a new asbestos liability. However, modest earnings surprises that cause a stock pair to decouple often present opportunity — a rare commodity in a market that may be going nowhere.

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Market neutral strategies are defined on [15] as trading strategies that are widely used by hedge funds or proprietary traders. A trader goes long certain instruments while shorting others in such a way that his

portfolio has no net exposure to broad market moves. The goal is to profit from relative mispricings between related instruments—going long those that are perceived to be under priced while going short those that are perceived to be overpriced—while avoiding systematic risk. Market neutral strategies are sometimes called relative value strategies. In equity markets, market neutral strategies take two forms.

- Equity market neutral, and
- Statistical arbitrage.

The former is a strategy that emphasizes fundamental stock picking. A portfolio of long and short positions is maintained to be beta neutral [16]. If the portfolio holds foreign equities, foreign exchange risk will generally also be hedged away. Long and short positions are also managed to eliminate net industry, market capitalization, regional or other exposures [17].

Individual pairs will generally not be market neutral, but the overall portfolio of pairs can be managed to be market neutral. However, the focus is more short-term than equity market neutral. Exposures to factors such as industry or market capitalization may not be as tightly controlled. Pairs trading can be extended in various ways, for example, by identifying and trading larger baskets of correlated stocks.

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As a trading strategy, it has been said that statistical arbitrage is a heavily quantitative and computational approach to equity trading. It describes a variety of automated trading systems which commonly

make use of data mining, statistical methods and artificial intelligence techniques. Pairs trading is a popular strategy as it hedges risk from whole-market movements.

In recent years, there has been a trend away from simple pair-trading, and now it is more common for portfolios of stocks to be 'clustered' by sector and region in offsetting any beta exposure. After the portfolio is constructed in this manner, it is usually optimized using risk models like Barra/APT/EMA/Northfield to constrain or eliminate various risk factors [18].

Statistical Arbitrage is actually any strategy that is beta-neutral in approach and uses statistical/econometric techniques in order to provide signals for execution. Signals are often generated through a contrarian mean-reversion principle, but can also be formed by extreme psychological barriers, corporate activity, as well as short-term momentum. Clearly, this technique only is demonstrably correct as the amount of trading time approaches infinity, or alternately, it does not take into consideration what is typically called "gambler's ruin." [19].

Statistical arbitrage has become a major force at both hedge funds and investment banks. Many bank proprietary operations now centre to varying degrees around statistical arbitrage trading.

Volatility arbitrage is a form of statistical arbitrage in which options, rather than equities, are the primary vehicle of the strategy, and considered out of the scope of this thesis [20].

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TRADING

Anyone who operates in the fast-paced, highly competitive world of pairs and long/short trading will tell you that monitoring relationships among stocks while simultaneously submitting and maintaining orders is a formidable challenge. Market conditions change rapidly and competition among participants for available liquidity is intense.

A company called the Investment Technology Group (ITG) claimed to have found the holy grail. They claimed, rather obviously, that the key to the Pairs strategy is QuantEX's built-in notion of a related pair of assets, and to have produced a product with the underlying software language that can "think in pairs". This is a concept first used in a product called fame at the start of the 90's (still available from SUNGUARD FINANCIAL SYSTEMS [21]).

They have a fully fledged application and marketed it as a product. They say it has a Pairs User Interface that displays the relevant information for the stocks being traded, as well as aggregate measures of portfolio performance. On the Pairs execution page, the user could monitor the trades that have occurred for each of the specified pairs as well as the spread conditions that triggered the trades.

They say the QuantEX language has the ability to think in pairs. The user begins by loading lists of pairs and related execution triggers, which typically take the form of a price ratio and/or price spreads. From there, the strategy will continuously monitor asset prices and other market conditions, automatically alerting users to opportunities.

The Pairs strategy can also provide varying degrees of automated execution. Many traders prefer to confirm signals before initiating a trade but don't want to manage execution details once the opportunity has been confirmed.

Running an ITG Pairs Strategy on QuantEX, it is claimed that a user can:

- Monitor and analyze up to 4,000 pairs of stocks at once, in real time.
- Instantly act upon trade alerts whenever pair prices reach predefined levels.
- Automatically set orders, route them to multiple markets, and electronically execute trades.
- Use the autotrading option to automate the entire process.
- Minimize implicit trading costs with built-in cost-management tools.

It mentions many of the items I have independently created/used in my models: Trader confirmation and so on. Their claim to have the ability to monitor 4000 stocks is envious. The processing power for this must be significant. However there were no results shown on their website and there remains no mention of the product at present [22].

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Companies have been formed to trade pairs and trade using market neutral strategies. One such company was MarketNeutralStrategy. They stated three basic rules of market neutrality trading (all of which I agree with):

The first was to eliminate the “market risk” of owning stocks and instead carry only the risk associated with owning particular companies. Since markets or sectors tend to move as a group regardless of individual company merits, there is a risk that even a good company’s stock price will fall when a sector or the entire market declines.

Their second argument for a market neutral strategy was what they call the “reversion to the mean” theory. This theory suggests that all other things being equal (and admittedly they usually aren’t) stocks will trade at similar valuations. If two companies are in the same business with similar growth prospects, their valuations will converge over time.

A third argument was more subtle but undeniably logical. One certainty of the market is that stocks go up and stocks go down. Why should any investor limit himself or herself to only one half of the equation? It makes sense to take advantage of movement in both directions if at all possible.

They mentioned the potential downside of shorting stock; it is a common and correct criticism that the losses associated with shorting stocks are potentially infinite. When you own a stock (you’re long) the most you can lose is your initial investment. When you short a stock there’s no upper limit to how high it can go, thus the losses can be limitless.

They say that a market neutral strategy is commonly used but not necessarily by individuals (as I am advocating here) but certainly by large institutions (such as hedge funds that require a large buy-in).

They also answered the obvious question: “Does a market neutral approach always work?”. They answer it very honestly by saying “No, certainly not. Any investment strategy, no matter how well conceived and researched can perform poorly.”

They mentioned that one of the critical factors here is that of time and for how long a period disequilibrium in two stocks’ valuations will continue. One stock’s premium over another stock’s discount might continue for quite a long time.

In addition, any time a stock is trading at a premium or a discount to its peers, the first question to be asked is “why?” There may be a very good reason and thorough research is required. A stock that appears overvalued may have some unique competitive advantage that is hidden from casual observation. Conversely, a stock trading at a substantial discount may have diminished prospects that are not easily discerned.

While I agree with much of what they said (this circa. 2002) time has seen the company ceased trading and their website domain is currently on offer!

They present some performance guides which have been useful and indeed adopted in the back testing in this thesis:

- Dividends received from the long portfolio, or paid from the short portfolio, are not accounted for.
- Transaction costs are not accounted for.
- Positions are rebalanced each month.
- Portfolios reflect an equal investment in each position.

No results were presented and the latest articles that could be seen are from 2002. This suggests that this winning strategy perhaps had its faults.

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A rather interesting company called PairsTrading appeared some 15 years ago. The background on the company (on the internet at the time) stated that PairsTrading.com was designed to help investors and traders of all levels of skill and experience to consistently make profitable trading decisions that have significant protection against losses. It was the first company to offer drastically different market neutral services to individual traders and investors.

While many individual stocks tend to trade within a static range, they are susceptible to movements in the general market. PairsTrading claimed to remove that risk and protect the trade from the whims of the market. The trade itself had risk in that history may not always be reverted to, and extraordinary events may occur such as bankruptcy.

In the manner of a classic money making scheme it provides a Subscription Services a newsletter containing trading ideas, economic outlook and market commentary to assist you during the following trading session. It also provided books [23] and seminars. It tries to hook you by using questions like: Would you like to know how the best hedge fund managers make millions of dollars without predicting the direction of a stock or an index, without complicated options strategies and without comprehensive technical or fundamental analysis? Would

you like to obtain a unique edge and level of comfort when implementing a trade, which has an extremely high probability of making money regardless of whether the stock market crashes, goes nowhere or explodes to the upside? Would you like to find out what is arguably the most intelligent way to make money on Wall Street?

Interestingly it offers a Pairs Generator - software allowing traders to find appropriate pairs for both stocks they currently own or completely new pairs that will allow them to build their own comprehensive portfolio. Their system is designed for traders who have a long equity position for which they need a long-term, intermediate, or short-term hedge. It allows you to weight the importance of 3 month, 6 month, and 2 year correlation and customize the exact time horizon for which the hedge is planned.

Generally speaking, arbitrage seeks to exploit inefficiency in the market. While such a situation would seem somewhat fantastic in today's era of information technology, it was once possible for a limited number of individuals with superior information and communication capabilities to exploit these types of situations. With the advent of real-time data on every desktop, for even the smallest market participant, the days of simple arbitrage are long gone.

While certain market inefficiencies do still exist, the majority of arbitrage activity today is based on perceived or implied pricing flaws rather than on real ones. These pricing flaws are not born of bad or slow information, but rather may be designated "out-of-whack" from the

historical or statistical perspective. In simple terms, relative value arbitrage is the activity of taking offsetting positions in securities that are historically or mathematically related, but where the relationship is temporarily distorted. Thus, the most important feature of arbitrage, particularly in terms of how it relates to pairs trading, is the convergence of these flaws back to their expected values.

Understanding statistical arbitrage is important to understanding pairs trading because it is essentially the same thing, or should at least be considered a form of pairs trading. Where pairs trading may be driven by either fundamental or technical information and may have almost any time horizon, statistical arbitrage is based purely on historical, statistical data that is utilized in the very short term for numerous small positions. The most significant point of differentiation is that statistical arbitrage is almost purely model and computer driven, with very little human analysis affecting any single trade. Once a statistical arbitrage model is constructed and accepted, it is fed into a computer that makes all trading decisions based on the pre-screened criteria. This often involves hundreds of trades a day, each trying to capture a very small positive price movement. This kind of trading obviously requires both very sophisticated modelling capabilities and a fairly extensive technology infrastructure. What drives relative value arbitrage decisions is careful analysis, rather than corporate news.

Pairs trading has elements of both relative value and statistical arbitrage. Pairs traders select their stocks via a method that is based on mean reversion, which is a statistical anomaly. Traders utilizing mean reversion strategies work under the assumption that anomalies among stock valuations may occur in the short term, but, in the long term, these anomalies will correct themselves as the market processes information. Thus, within a group of stocks that historically trade similarly, short-term events and the tendency of investors to overreact to unexpected news can create pricing disparities (stocks are over- and undervalued relative to the group) that should not hold in the long term. When one stock's statistical price anomaly reverts back to the mean price of its group of stocks, the move is known as mean reversion. The strategy tries to take advantage of related securities whose prices have diverged from their historical norms. Traders search for groups of stocks for which the values, over the long term, are positively correlated. Usually, a common theme within each group links the individual equities together. A sector, an industry, a commodity, or a particular risk factor may define a group. The long-term trend line for the group is relatively smooth, but the short-term individual stock lines are full of peaks and valleys. Mean reversion traders try to sell short the stocks in the group that are their peaks and buy those that have bottomed out.

The pairs system is essentially an arbitrage system where the trader is able to capture profits from the divergence of two correlated stocks. In a sector based pairs strategy the market as a whole is broken into

indexes, which are divided into sectors, which are made up of individual equities (examples can be found in the quality newspapers as share prices are listed within such sectors). The retail stocks make up the retail sector, and the trucking stocks make up the trucking sector... Obviously, the retail stocks must then follow one another in price movement. Can these stocks trade in perfect tandem with one another? The answer is no, there has to be divergence, as no two equities can trade with a perfect correlation co-efficient of 1. They cannot be identical twins. They can trade very close though, veering away occasionally to come back together once again. This divergence and convergence produces opportunity of which pairs trading may take advantage.

Pairs trading often uses a statistical model as the initial screen for creating a relative value trade. A careful pairs trader will perform several layers of analysis on top of the model output before any pairs are actually executed. Clearly arbitrage theory plays a fairly central role in understanding pairs trading; it will therefore receive very careful consideration.

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3.3 Interesting for the reader

In his book *Trading Chaos*, Williams [24] aims to teach the reader how to spot trading opportunities from seemingly random market events (one of which can be glitches in the price-time ratio in a pair of stocks as is the subject of this thesis) by giving you a five step process starting with

a clear non-technical explanation of chaos theory and taking you all the way to chart analysis techniques, fractals, Elliot Wave and non-linear dynamics.

The book claims that Chaos theory now stands at the cutting edge of financial decision-making methods. The book was written in 1995, and having spent more years than I would like to in the industry I would refute this claim, tending to lean towards the take-over of the market by quants and financial engineers having introduced more complex products. The mathematics of more recent activity in the market has been advanced to say the least with impressive analysis and highly adapted financial models. However it is my opinion that while these leaps in financial mathematics have been great and the results of the mathematics proven beyond question, the fundamental basis of these relays on unsound and downright wrong assumptions then was only a matter of time before a financial crisis (credit crunch) began to unfold. As I write this section of my thesis this is starting to happen. It will get worse.

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The book “Pairs Trading: Quantitative Methods and Analysis” by Ganapathy Vidyamurthy [25] comes up in many literature searches of the subject area of this thesis. The book covers some interesting areas of background to statistical arbitrage which I leave for the reader to peruse at his/her leisure, some of the topics to grip you are:

- The CAPM Model.
- Market Neutral Strategy.

- Arbitrage Pricing Theory.
- The Covariance Matrix.
- The Kalman Filter.

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3.4 Technical Analysis

It should be fairly clear by this point that technical analysis plays a very central role in pairs trading. While it is certainly possible to create fundamentally driven pairs trades, the methodology suggested throughout this text uses such analysis (performed by computer programs) to perform the majority of the analysis required before trading; fundamentals are used simply as an overlay to ensure that there is no glaringly obvious reason (such as the death of a young founder and CEO of a company that has no obvious successor) to avoid a trade not captured in the technical indicators examined.

While a fundamental analyst considers a huge amount of very subjective data, the technical analyst deals with only three pieces of data: price, trading volume, and sentiment. From a pairs trading stand point, and especially short-term statistical arbitrage stand point, technical analysis plays a much more important role, and, in the majority of cases, is the driving force behind some trades.

Technical analysts use computers to reconstruct past market activity and test trading theories. The underlying assumption is that a trading system that worked well in the past will work well in the future. System traders analyse their findings, which are based on technical analysis,

by studying trading methods that have worked well in the past (over recent months and years) and try to determine a set of rules in order to project future trading results. This process, which is called “optimising”, seeks the optimum balance between the values that produce the greatest profit and the values that produce the smallest loss. The problem is, of course, that today’s price behaviour may not resemble yesterday’s price behaviour at all.

Factors that affect prices are almost countless and constantly change. This is one of the most significant risks facing a pairs trader and is called “model risk”. If there is a major flaw in the trading model, the entire system is likely to break down and not produce a profit. The pairs trading approach, however, has a great advantage over any other methods, because it allows the trader to incorporate different studies (correlation, technical tools, fundamentals, risk management) in order to achieve high probability without sacrificing the statistical relevance. Again interestingly enough this site is no longer available.

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Investment Week announced that Omam [26] launched its Global Statistical Arbitrage fund in May 2007 and Old Mutual Asset Managers launched it’s Global Statistical Arbitrage fund [27] on 1 June 2007, with further hedge funds to follow in 2007. The fund was to be managed by the group’s current European Statistical Arbitrage managers Paul Simpson and John Dow. Advertising said that Simpson and Dow would use systematic techniques that exploit short term pricing anomalies, with the portfolio typically containing approximately

850 stocks selected from the S&P Global 1200 Index of developed global markets.

During the credit crunch (late 2008) the fund was reluctant to divulge the recent performance of the fund and I believe had started to lose money.

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As I have said "Market-neutral" investing refers to a group of investment strategies that seek to neutralise certain market risks by offsetting long and short positions in instruments...". Nicholas [28] states that the market neutral strategy encompasses eight different sub-strategies that deal with financial instruments ranging from equities, to convertible bonds, and mortgage backed securities. Mortgage backed securities being one of the instruments blamed for the credit crunch.

He notes that the investor bets that the spread between the values of securities he is long and the one he is short will narrow. Thus, the values of the long undervalued positions and the values of the short overvalued positions should converge over time. Nicholas, however, is a realist and acknowledges (one of the few in my opinion) that this is the ideal and it does not always work out that way. Often, the long and short positions respective values do not converge, but diverge. Reservations regarding market neutral investing are supported by well publicized failures of some of the biggest funds within this investment

style. These include the failure of Long Term Capital Management (section 3.5.1) and the liquidation of the Tiger Funds [section 3.5.2].

Nicholas airs scepticism about the superior risk adjusted return of market neutral strategies having invested in three such market neutral funds, saying that they tend to have had alluring past performance that deteriorated the minute we invested in such funds.

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“Pairs Trading” by Ganapathy Vidyamurthy [25] arguably shows the tools investors need to successfully implement and profit from this proven trading methodology. Pairs Trading contains specific and tested formulas for identifying and investing in pairs, and answers important questions such as what ratio should be used to construct the pairs properly. My method uses several ratios and tries to adopt an optimised strategy. He does say that 'Statistical arbitrage', the risk free returns and mean reverting versions of these techniques were largely invented by Nunzio Tartaglia [29] and company at Morgan Stanley in the 1980s. Many of his underlings went on to found their own hedge funds, and the secret eventually became relatively common knowledge. The question has been asked however: Why should Vidyamurthy give away the keys to the kingdom for the price of his book? The fact that the specific details of hedge trades are kept secret is also stated in the work by Richards [30].

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In his book “The Handbook of Pairs Trading : Strategies Using Equities, Options, & Futures” Douglas Ehrman [31] covers pairs trading involving stocks, options on stocks, and futures contracts, and explains how this type of trading allows you to profit from the changing price relationship of securities. Douglas S. Ehrman also served as the chief executive officer of AlphAmerica Financial, Inc., the company that operated PairsTrading.com prior to its merger with PairTrader.com. The company is still present in the form of www.tradewex.com [32].

Pairs can be traded as a spread. Rather than a buy and sell of stocks some brokers put up instruments based upon their spreads (i.e. difference in price). This is perfect for a pairs trader and the contracts can be seen to be called Contracts for Difference (CFD's). Pryor [33] provides a good background to these (in the context of spread betting) while “The Complete Guide to Spread Trading” by Keith Schap [34] explains Spread trading as a low-risk, high-profit technique, involves buying a contract in one market while selling a different contract in another market to profit from the imbalance between those markets. Trading spreads can also be seen to be trading contracts for differences (CFDs) any serious trader of pairs should look at these – currently offered by brokers such as E*Trade [35].

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"Over time, anything that creates an edge for a particular group of gamblers - including the most astute observers of horse flesh - gets factored into the odds and becomes unreliable as a system. There is arguably, however, a lot of money to be made before that factoring is

complete. “Statistical Arbitrage: Algorithmic Trading Insights and Techniques” by Andrew Pole [36] is a contribution to that never-ending debate."

While statistical arbitrage has faced some tough times as markets experienced dramatic changes in dynamics beginning in 2000 new developments in algorithmic trading have allowed it to rise from the ashes of that fire. There were market warnings that after 2004, the spreads began exhibiting much sharper reversions to the mean ("catastrophe process") which complicated the trading. Even so I believe there is still something left in the technique.

“The Complete Arbitrage Deskbook” by Stephane Reverre [37] states that arbitrage is "the simultaneous purchase and sale of the same, or essentially similar, securities in two different markets for advantageously different prices...". Clearly this is not the case as it can be in the same markets. For the private trader, the book does provide some food for thought. However, unless a private trader has access to cutting edge technology and the appropriate price feeds, he will not be able to effectively execute too many of the posited strategies

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In his book “Evidence-Based Technical Analysis” Aronson [38] examines how you can apply the scientific method, and recently

developed statistical tests, to determine the true effectiveness of technical trading signals.

Aronson tests more than 6,400 technical analysis rules and finds that none of them offer statistically significant returns when applied to trading the S&P 500. He offers insight into evaluating the performance of rules/signals that are discovered by data mining.

With recent advances in computing power and analysis software, it is now possible for virtually anyone to search through years of data and identify seemingly profitable trading rules. He points out that many of the dangers of data mining and curve fitting are grounded in psychology.

3.4.1 Hedge funds

Hedge fund investors are looking for downside protection while maintaining good returns--and market-neutral investing has become one of the hottest methods to meet that need. In his book, Joseph G. Nicholas [39] explores new approaches to return enhancement and risk reduction through market-neutral strategies.

Nicholas explains clearly that market neutral investing derives its return not from market movements, but from changes in the

relationship or spread between its long positions and its short positions within a certain type of securities.

In my opinion Nicholas assertion that these strategies provide superior risk adjusted return is less convincing. I would not be surprised if his data is victim of survivor bias. If you select only the funds that survived during your research period, you ignore all the funds that failed during this same period. As a result, you overstate the performance of this investment style by selecting only the strong survivors.

3.5 When things go wrong

Pairs trading does not deliver a guaranteed profit - in fact many statistical arbitrageurs have made large losses. Statistical arbitrage is subject to model weakness as well as stock-specific risk.

The statistical relationship upon which the model is based may be spurious, or may break down due to changes in the distribution of returns on the underlying assets. Factors which the model may not be aware of having exposure to could become the significant drivers of price action in the markets, and the inverse applies also.

On a stock-specific level, there is risk of Merger & Acquisition activity or even default for an individual name. Such an event would immediately end any historical relationship assumed from empirical statistical analysis.

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Statistical arbitrage is not without risk; it depends heavily on the ability of market prices to return to a historical or predicted normal.

3.5.1 Long Term Cap

Long-Term Capital Management (LTCM) [40] was a U.S. hedge fund which used trading strategies such as fixed income arbitrage, statistical arbitrage, and pairs trading, combined with high leverage. It failed spectacularly in the late 1990s, leading to a massive bailout by other major banks and investment houses, which were supervised by the Federal Reserve.

LTCM was founded in 1994 by John Meriwether, the former vice-chairman and head of bond trading at Salomon Brothers. Board of directors members included Myron Scholes and Robert C. Merton, who shared the 1997 Nobel Memorial Prize in Economic Sciences [2]. Initially enormously successful with annualized returns of over 40% (after fees) in its first years, in 1998 it lost \$4.6 billion in less than four months following the Russian financial crisis and became a prominent example of the risk potential in the hedge fund industry. The fund folded in early 2000.

3.5.2 Tiger Management

When Julian Robertson, once regarded as one of Wall Street's highest rollers, announced plans to liquidate all six of his Tiger Management

funds [41], it was the latest in a series of setbacks for the highly volatile hedge fund market.

The move marks the downfall of a veteran hedge fund manager, whose bets on value stocks backfired as investors turned their attention to high-octane technology shares.

In a letter to investors, Robertson, Tiger's 67-year-old chief, blamed the fund's problems on the rush to cash in on the Internet craze. "As you have heard me say on many occasions, the key to Tiger's success over the years has been a steady commitment to buying the best stocks and shorting the worst," he wrote. "In a rational environment, this strategy functions well. But in an irrational market, where earnings and price considerations take a back seat to mouse clicks and momentum, such logic, as we have learned, does not count for much."

3.5.3 A risky strategy

Hedge funds are unregulated pools of money that use riskier strategies like derivatives and short-selling to boost returns. By leveraging their investments, hedge funds can boast substantial returns. However, when the bets go against the fund, the losses can be huge.

In 1998, Long-Term Capital Management roiled markets when the fund made a bad bet on interest rates. The Federal Reserve stepped in to negotiate a \$3.6 billion bail-out plan. The fund ultimately paid back \$1.3 billion to investors, but many on Wall Street regarded the fund's near-collapse as a warning sign for high-flying hedge funds.

Unlike most mutual funds, hedge funds require substantial minimum investments of \$500,000 to \$1 million. The typical shareholders are foundations, pension funds, university endowments and wealthy investors. But even though most individual investors can't get into hedge funds, the funds can have a dramatic effect on Wall Street.

In Tiger Management's case, the Jaguar Fund had suffered sharp losses for more than a year, tumbling 7.8 percent in February and 13.8 percent year-to-date as of Feb. 29th, 2000. Meanwhile, the fund's assets plunged from roughly \$20 billion in 1998 to about \$6.5 billion, analysts said.

For Tiger, the beginning of the end occurred when the fund lost \$2 billion on a bad bet against the Japanese yen. To make matters worse, the fund continued to stick to its diet of so-called "old economy" stocks last year even though investors were pumping billions of dollars into technology issues.

3.5.4 Bailey Coates Cromwell Fund

In 2004, this event-driven, multi-strategy fund based in London was honored by Eurohedge as Best New Equity Fund. In 2005, the fund was laid low by a series of bad bets on the movements of U.S. stocks, supposedly involving the shares of Morgan Stanley, Cablevision Systems, Gateway computers and LaBranche (a trader on the New York Stock Exchange). Poor decision making involving leveraged trades

chopped 20% off of a \$1.3-billion portfolio in a matter of months. Investors bolted for the doors and on June 20, 2005, the fund dissolved.

3.5.5 Marin Capital

This high-flying California-based hedge fund attracted \$1.7 billion in capital and put it to work using credit arbitrage and convertible arbitrage to make a large bet on General Motors. Credit arbitrage managers invest in debt. When a company is concerned that one of its customers may not be able to repay a loan, the company can protect itself against loss by transferring the credit risk to another party. In many cases, the other party is a hedge fund.

With convertible arbitrage, the fund manager purchases convertible bonds, which can be redeemed for shares of common stock, and shorts the underlying stock in the hope of making a profit on the price difference between the securities. Since the two securities normally trade at similar prices, convertible arbitrage is generally considered a relatively low-risk strategy. The exception occurs when the share price goes down substantially, which is exactly what happened at Marin Capital. When General Motors' bonds were downgraded to junk status, the fund was crushed. On June 16, 2005, the fund's management sent a letter to shareholders informing them that the fund would close due to a "lack of suitable investment opportunities".

3.5.6 Worldcom

Even the technique used in this thesis has failed dramatically within the application produced. The positions opened up position after position as WorldCom shares collapsed in 2002, and this generated greater losses [42]. This is the reason the stop-loss was introduced into my code.

3.5.7 The Credit Crunch: No quick end in sight

The credit crunch [43] dominated the market for much of 2008 and 2009 and is still in evidence now. The credit crunch came about following a reluctance of banks to make inter-bank loans following credit events: Notably the failure of Lehmans [44].

It isn't yet clear how far-reaching the problems of the credit crunch are. MarketWatch [45] reported that event-driven funds as a whole lost roughly 1% to 2% in July (not surprising given the recent turmoil in the deal market. But it remains to be seen how the losses were distributed (i.e., whether there are some funds that really got it wrong and will face investor redemptions) and whether, given the sea change in the credit markets, there is now too much capital committed to credit arbitrage.

At the start of the crisis DealBreaker was breaking the news in "Blood Bath for the Quants?" [46] it said readers are reporting that some funds are in distress and there was the following quote pertinent to Statistical Arbitrage:

A number of DealBreaker readers have written in to say that the StatArbs are in trouble.

Many (most or indeed all) statistical arbitrage players rely heavily on computers not simply to identify possible trades, but also to execute them automatically. Speed is of the essence, since the anomalies are often fleeting. Needless to say, just like program trading of the 1980s, a computer-driven trading process is impossible to override when markets behave in unanticipated ways. In a credit crunch environment systems can go AWOL! Administrators have to halt the trading entirely or let it run. There is no way to apply human judgement except via modifying the models. So when using my own money I must make the decisions!

CHAPTER 4 TECHNOLOGY AND DESIGN

4.1 ANALYSIS

In order to prove the hypothesis that profit could still be made from statistical arbitrage (pairs trading) a set of requirements needed to be drawn up that would allow this hypothesis to be tested.

4.2 Requirements

The requirement is for the system to be able to read current stock prices in near real time. Then based upon previously identified pairs stocks, to identify pairs trades based on previously identified rules and suggest these trades be done. The system holds the trades in a position base, and for all positions still open, values them based upon the current prices just taken in. If any of the positions have reached preset profit or loss values they are closed. Reporting on the positions is available to see the exact state of play and to be able to assist in the “do I perform the trade for real” decision making.

The following was deemed appropriate as a high level set of requirements for this task for the user to be able to sit in front of the computer screen and:

- View a list of statistical arbitrage suggested trades based on computed historic data from which to make a decision upon which trades to actually do using additional market data graphs and stochastic data.

- To have the resultant trades held in the system as a portfolio valued as often as possible and to be told by the system when the required level of profit has been achieved or that the position should be closed and profits realised.
- Have a P&L profit report on the portfolio history should be available. In order for the process to work it is necessary for prices to be loaded for the companies who are taking part in the project.

To break this down further a method for providing the price history regression calculations must be present. Ideally this will be run overnight as real-time would take too long (certainly on single PCs). It was decided that Company price data will be scraped from NASDAQ internet web pages disseminated and loaded into properly normalised [47] database tables in a relational database for better handling of data.

In order to maintain a correct history of prices facilities to cope with any corporate actions must be present to identify them and adjust price histories. Adjusting prices keeps prices in line with corporate actions, used in models by Mudchanatongsuk [48], who models pairs as a closed control problem. Very early into the project I decided to use NASDAQ as the basis for my stock data. NASDAQ stocks are very liquid and as such the spread between buy and sell value is negligible when taken into the context of the pairs being traded. These can also be

scraped from NASDAQ pages and also for safety SQL run into the database.

4.3 Design Details based upon Requirements

To get from requirements to code the following were undertaken

- Detailed List of Functional Requirements – a statement of what units of work are actually needed
- Database design – a database implemented in Microsoft SQL Server, designed to hold the data for the entities in the project
- The Process (functional) matrix – mapping from the list of functional requirements to the database entities
- Process diagram – Dataflow from the entities in the database directed by the processes derived from the functional requirements
- Class diagram – top layer of the architecture. The code that actually does the work.

4.3.1 Detailed List of Functional Requirements

This list would be derived from a brief statement of the requirements of this project.

The set of functional requirements (what needs to be done) from the above is as follows:

Required function
Historic Data Load
Calculate regression measures (r^2) and ratio data from HISTORY
Copy data from work table to main DB table
Scrape Prices
Identify Corporate actions priory to load company prices
Load company name and ticker data
Load company price
Value Positions
Identify What-To-Buy (WTB)
Store Positions
Identify What-To-Close (WTC)
Identify & correct Corporate actions in HISTORY
Financials report of suggested trades to aid ID of trades to expedite
Identify which trades to expedite
Report Positions
Save EOD prices to HISTORY

Table 1 Requirements of the opportunity spotting application

4.3.2 Database Design

The database design comes from analysis of the entities and relationships of the above requirements. These can be seen in

Figure 4.

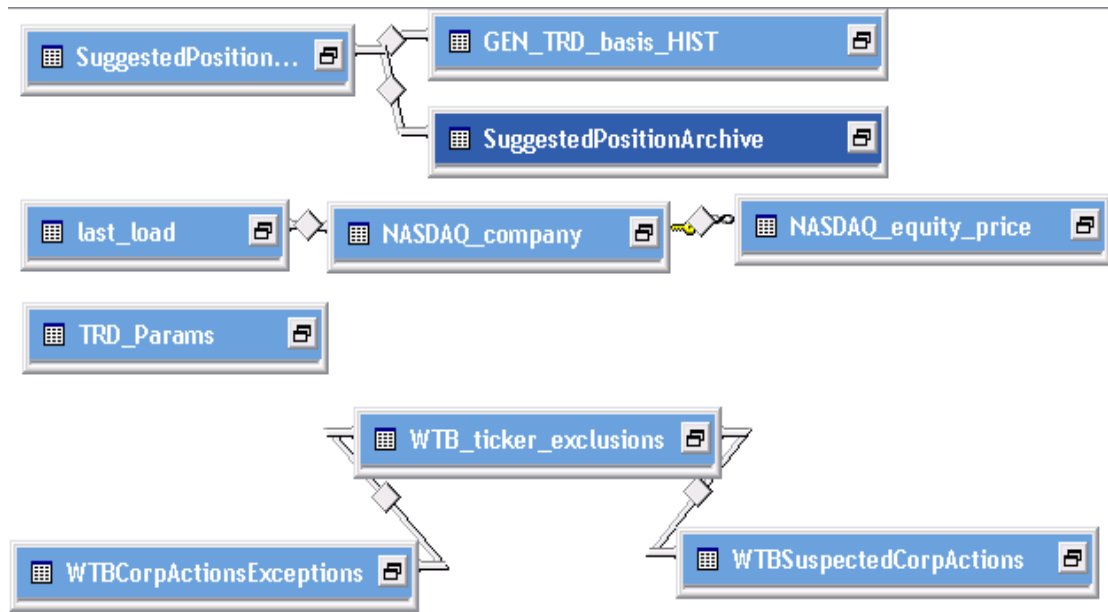


Figure 4: Main database tables

The main entities and off if left half if tough relationships are as follows:

- A NASDAQ_company has a current stock price (last_load).
- A NASDAQ_company stock has one or more NASDAQ_equity_prices (i.e. history of prices)
- A NASDAQ_company stock has one or more regression and associated values (GEN_TRD_basis_HIST)
- A Suggested Position (SuggestedPositionArchive) is for a NASDAQ_company and based upon TRD_Params has the parameter rules for trading when regression and associated parameters (GEN_TRD_basis_HIST) meet these rules

Other additions used to fine tune real time trading are:

- WTBSuspectedCorpActions are suspected corporate actions which may need to be looked at prior to trading.
- WTBSuspectedCorpExceptions are noted exceptions which should be allowed to trade. WTB_ticker_exclusions are manual exclusions to trading which can be added.

The detailed database table and relationship design can be seen in Figure 5.

Database design

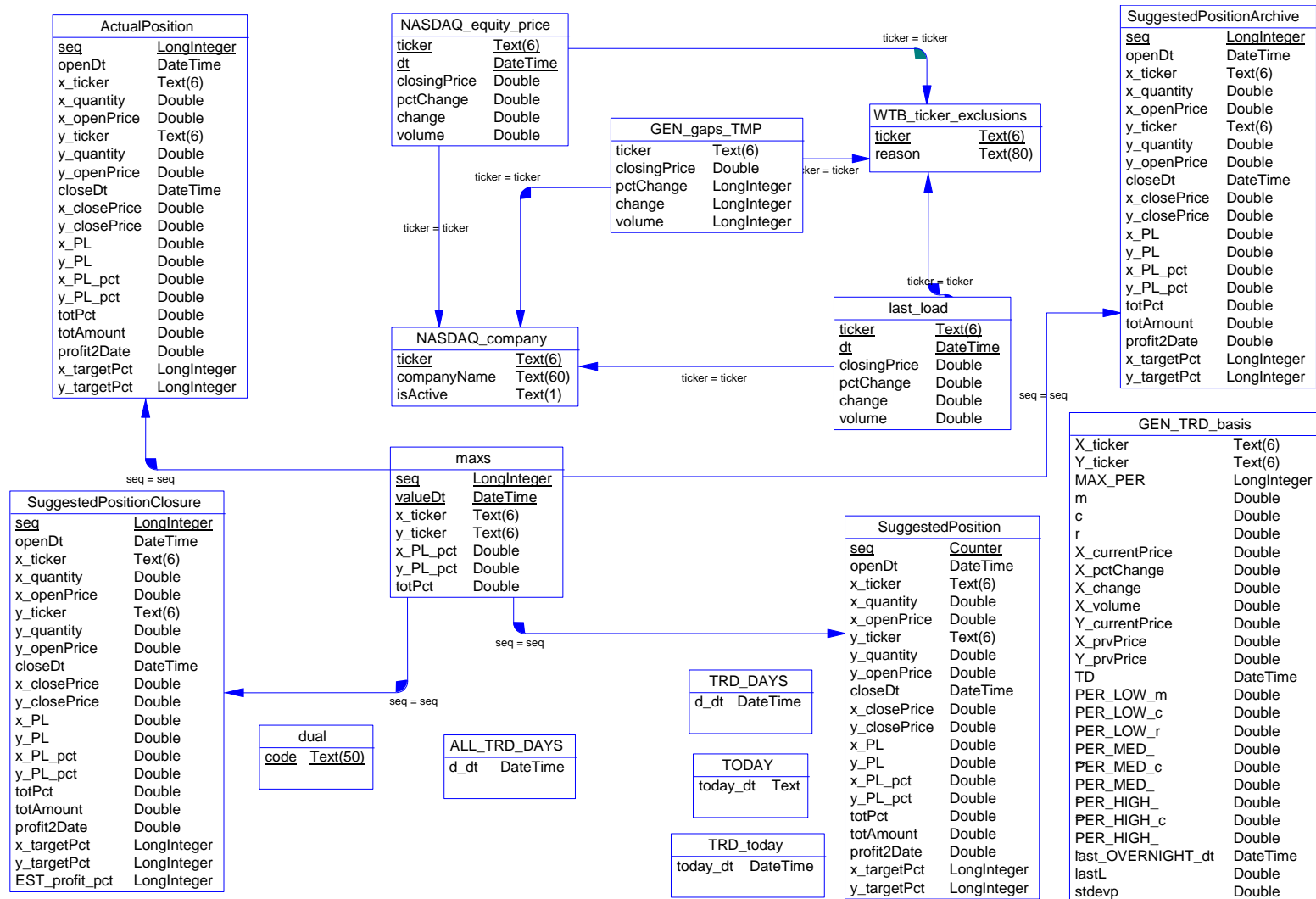


Figure 5: Database Design

4.3.3 The Process (functional) matrix

Figure 6 shows mapping and usage of the database tables to the requirements

				test_suite	MAX_ALLOWED_cycles_per_sec	MIN_TIME_per_sec_MINIT	MIN_TIME_per_sec_MAXIT	SuggestedThreshold	SuggestedThresholdPerSec	CycleThreshold	UNIT
Minutely to measure Configuration solution for MINITTIME	ConfigurationQuery			0	0						
Maximum expected suggested cycles in sec. 10 off cycles in response	getConfigData			0	0			0			
Maximal Data Cycle	Maximal				0						0
Minutely refresh cycles in response	Maximal										
ConfigRefresh	getConfig										
Duration of Config cycle from MINITTIME	MINITTIME	max(MINITTIME)		0	0	10					
ConfigRefreshes	refreshData			0				0			
Configuration refresh interval in sec. 100 times	1 A ₀ ConfigRefreshes					0	100				
Save EOD (cycles in MINITTIME)	1 A ₀ EOD			0	100						
Each sample cycle in sec. 100 times	1 A ₀ sample_X AS2DAS ₀ per AS ₀ per sec	1 A ₀ sample_X AS2DAS ₀ per AS ₀ per sec		0 100	0 100 00		0 10				
Each sample cycle	1 A ₀ sample_X AS2DAS ₀ per AS ₀ per sec	1 A ₀ sample_X AS2DAS ₀ per AS ₀ per sec		0 100	0 100 00		0 10				
Maximal Threshold	1 A ₀ sample_X AS2DAS ₀ per AS ₀ per sec	1 A ₀ sample_X AS2DAS ₀ per AS ₀ per sec						10	10		
Minutely 1000	1 A ₀ min			0	0		0				
Minutely Configuration solution query in each sample cycle	cycle									0 10	
Minutely 1000	10000			0	0		0				
Save Threshold	10000			0					0 1		

Figure 6: Functional matrix

4.3.4 Process diagram

Figure 7 shows the high level functions and interaction with the database.

DESIGN

Regression

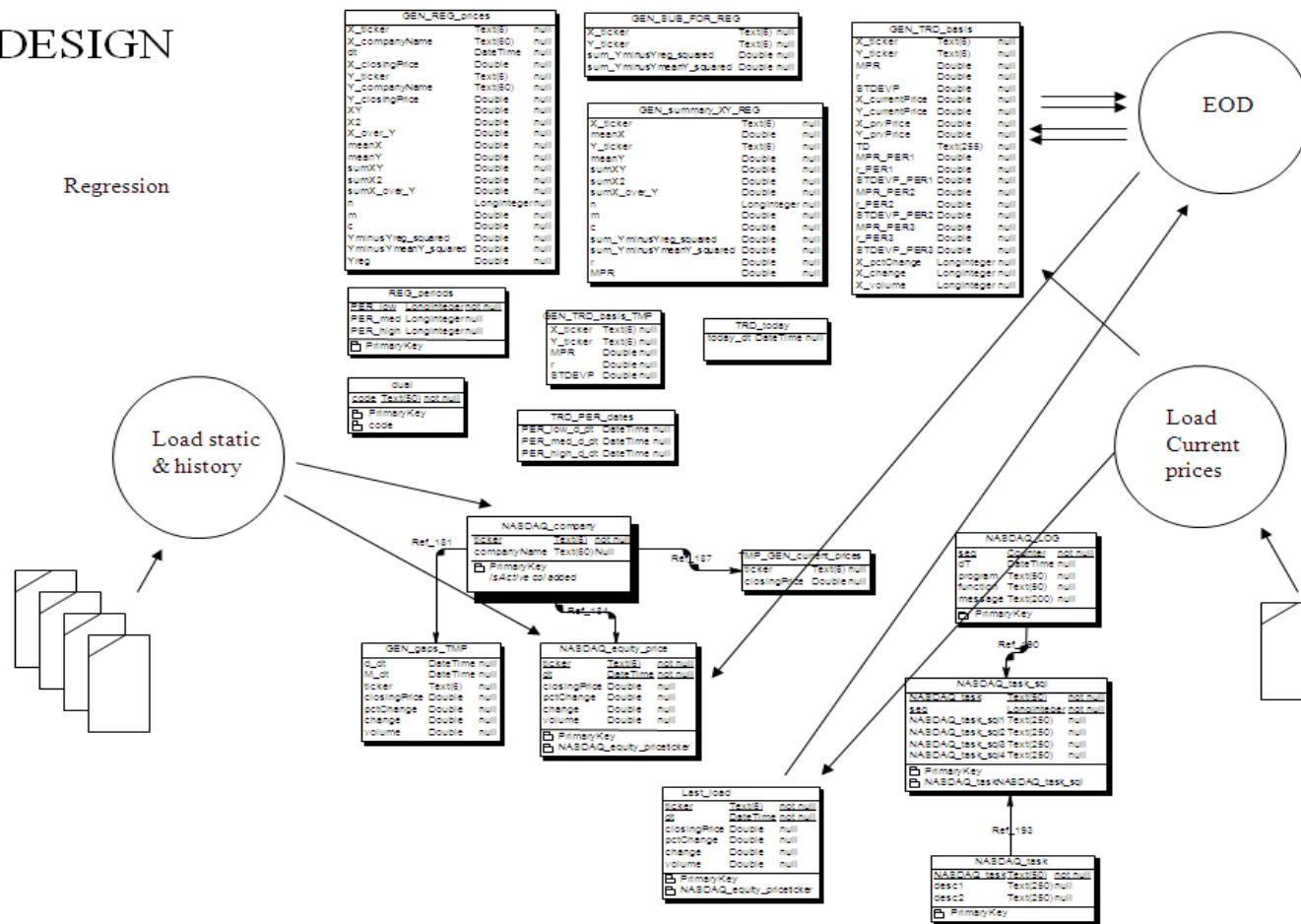


Figure 7: High level process flows

The lower level flow of information can be seen in Figure 8 - the process diagram

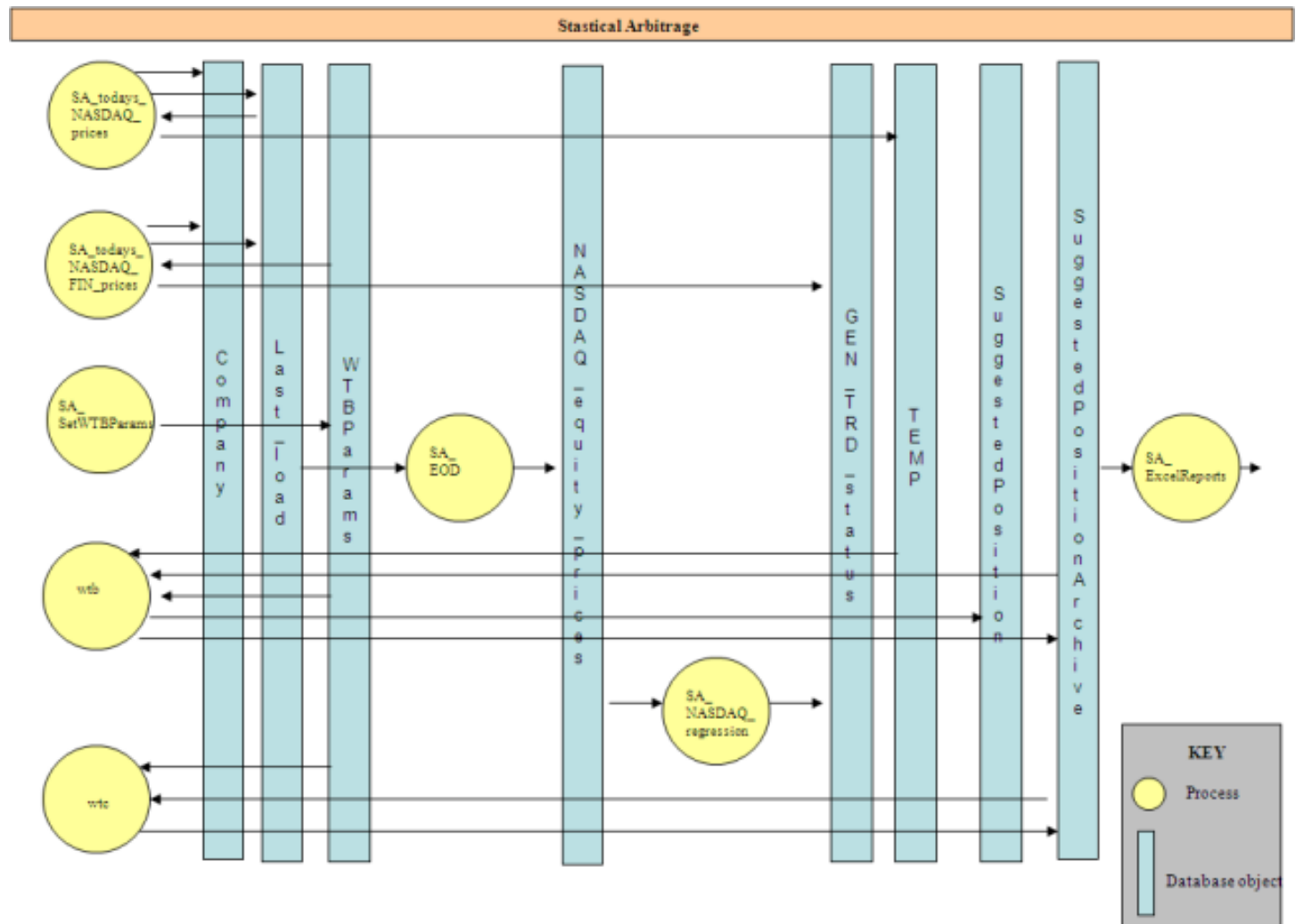


Figure 8: Low level process flows

4.3.4.1 The application

The application database contains a rolling 2 year history for the NASDAQ 100 tech stocks and NASDAQ 100 financial stocks. The regression values are calculated in a batch for a range of periods (which takes approximately 3hrs on a quad dual core PC). This period basis is referred to as the “training period” by Nath [49]. The code performing this operation is called REGRESSIONSS and can be seen on the attached CD in the Csharp\REGRESSIONSS folder. It takes as a parameter the pathname of the excel spreadsheet used to calculate values used in the application (using the LINEST function in Microsoft Excel [50]).

The application then scrapes the data it needs for position taking from NASDAQ web pages. It produces 3 files:

- NASDAQ 100 tech
- NASDAQ 100 financials
- Up and coming splits

Any splits (corporate actions) for the day are parsed and loaded into the database. Trades in the real-time environment will not take place in these stocks until historical prices have been adjusted. The code for this can be seen on the attached CD in splits.java the Java\Code folder.

The NASDAQ price files are loaded into the last_load database table and trading ratios and prices are placed upon on the GEN_TRD_basis_HIST database table made using embedded SQL. Using the values loaded into this table with the trading parameters loaded by SetWTBParams in the TRDParams database table the decision making code ss_param_based_wtb3 decides what to buy.

TRDParams contains the parameter values for the number of standard deviations from the regression line of stock prices between pairs of companies at which stock will be bought and/or sold for each of the periods regression values have been computed. The module wtc_param_based then makes a decision upon whether to close any positions. This has in build a stop-loss of 5%, i.e. A 5% loss will trigger a closing of a position. The prices are then archived onto the NASDAQ_equity_price database table by a program called SA_EOD.

It is not enough to have just code running without being able to see what is happening. For this reason two reports were written in order to be sure what is happening within the application. justgetdataSS and reportSPASS which are shown in on the attached CD in the Csharp\JustGetDataSS folder. They show the pictorial representation on the status of the trading price ratios in two different fashions (polar and line graphs) and a straight Profit and Loss excel report. Examples of their output can be seen in the proof of code runs in APPENDIX 1 and the real-time runs reports shown in section 5.6.6. The idea of the

reports is to pictorially see the divergence in relationships causing the trading opportunity and the current position of any profit or loss.

4.3.5 Class diagram

The Class diagram for the Java code used within the application can be seen in Figure 9. The code listings can be seen on the attached CD in the Java\Code folder.

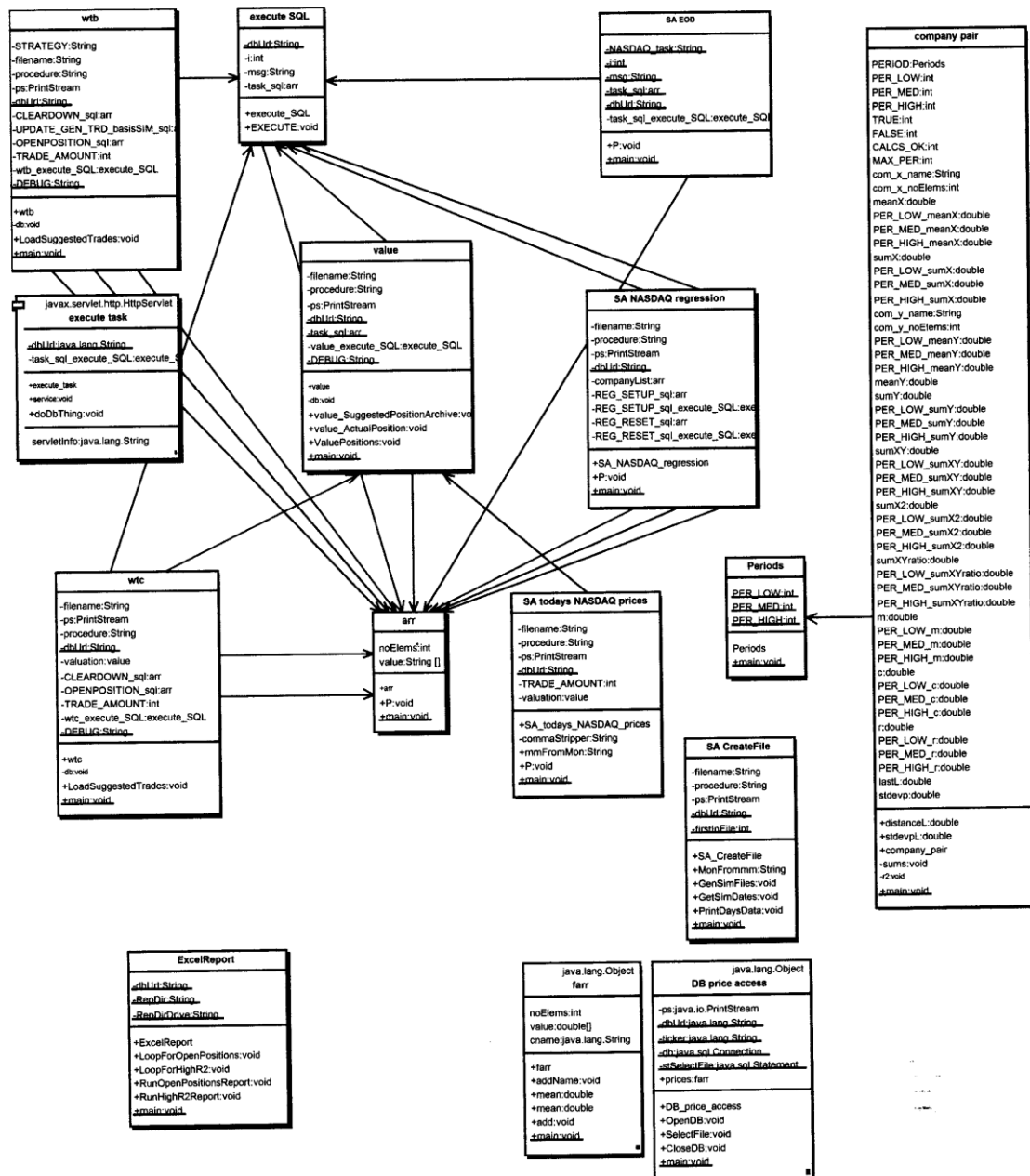


Figure 9: Class Diagram

In fulfilling the requirements there were two other issues to be taken into consideration:

Technology: What technology would enable to work to progress and achieve the requirement of the project?

Data: Where would the data be obtained from for the real-life simulations and live trials?

The remainder of this chapter details the initial choices and thinking of the above and the subsequent shift in thinking and technology, as, with shifts in IT development techniques, the project evolved into the current model set.

4.4 Technology

Commercial decisions ranked highly in the food chain of decision making, free or cheap being the main watch words! Initially the programming language Java (from Sun Microsystems) was used for coding as it offered (and still offers) object oriented programming closely linked to web technology. It was originally hoped that a system based around a web site would be provided. If it proved successful it could then have been made commercial!

Apache was originally chosen as the web server as that would provide a portal to the application. Apache software is available free and in conjunction with Java (also free) provided a state of the art interface from the outside world to the STAB (STastical ArBitrage) application. Initially this was a good decision and the Java based components were

able to be linked up to VB widgets. However, as will be seen the web aspect of the project faded and a more realistic engine was developed that concentrated on the decision making rather than the presentation.

A significant proportion of the code was migrated from Java to Microsoft's C# (C sharp). This was driven by the fact that Microsoft decided to provide the Visual Studio development platform with the C# (and other languages) for free, to compete with Sun Microsystems^e. The great benefit that this offered me was INTEROperability. Code could be written in C# while easily using Microsoft excel as the calculation engine. This meant the complexity of writing large amounts of code for calculations and display in the Java and Web based application could be replaced with a minimal code based C# application using excel as a calculation engine which could then also be used to display and present results, negating the need for a web server in the pre-commercial stage!

Togethersoft's case tool was chosen as the object orientated design tool. This was kindly provided free on an academic licence to Leicester University. This provides an integrated package allowing ease of editing of code while providing class diagram (maintained by the tool as changes to code are made). Changes to code can be made via the diagram. It is the most powerful tool I have seen, if a little slow on a

^e Now owned by Oracle corporation - <http://www.oracle.com/us/sun/index.html>

standard PC. However the license was provided without charge so this puts this powerful tool at the top of the list.

Microsoft's access database was chosen (again because it is free) as the repository to house the historical price data and results of analysis. Access wins over other products as it has integrated forms and reporting requiring minimal effort to code.

4.5 Creation of a Simulation

4.5.1 A trading simulation

This enables testing of different strategies over the same period of time to be compared. A start date is first chosen and the trading simulator rolls forward the days. Each day based on a pre-defined but flexible set of rules, taking advantage of perceived trading opportunities similar to those that would have been highlighted to the trader by the system at the time.

The buy and sell amounts, and therefore profit/loss, can be increased and decreased as the strategist wishes. The simulation does not currently take into consideration the stock borrow costs of the shorted stock (but if positions are large enough this is negligible as positions unfold quickly). If required the simulation can be modified to take such costs into consideration.

4.6 Data

The market for the research project has been chosen as NASDAQ as these were easy and free to obtain. I believe much larger trading profits

would result from adapting the technique to perform real-time in the Japanese stock market, since the cross holdings in Japanese companies are an ideal basis for highly correlated stock prices upon which the technique is based. NASDAQ does yield some, or at least enough, companies with the required relations to use in this work. Spreads are close enough together on NASDAQ to render the gap between buy and sell negligible.

Data is scraped from the following NASDAQ web pages

<http://quotes.nasdaq.com/quote.dll?page=nasdaq100>"

<http://quotes.nasdaq.com/quote.dll?page=nasdaqf100>

<http://stockplits.nasdaq.com/UpcomingSplits.asp?pageName=Upcoming%20Splits>

CHAPTER 5 EXPERIMENTS & RESULTS

There are three aspects to be covered in testing. The first is to prove the concept and code, the second is to investigate the potentially winning ways over historical periods of time and thirdly to prove the idea in real time with the market.

5.1 Introduction

This chapter details the following proof of concept and real time running results:

Proof of code

Proof the code is working.

Parameters

A discussion of the parameters involved in running the application.

Simulation and search for the holy grail

Back simulation over a chosen period of operation. Analysing the results of many different starting dates within the range with a view to finding optimal – always winning parameters.

Real time

Real time results – intra day running.

5.2 Proof of the code and concept

In order to test the code synthetic price histories for pretend companies were setup. These were inserted into the data model and relevant regression values put in place. Day to day synthetic prices were loaded, with deliberate glitches in the trends, were put in place to trigger the processes put in place to detect real price anomalies to result in trades and the taking of a pairs position.

The test data simulations had test data has been created for simulation runs between arbitrary dates 20050915 (my date follow the YYYYMMDD convention) and 20050920. The file of prices for the synthetic (made up) stocks are run into the application as if they were the real files on the day, using the processes already described. At the end of each day an excel report of the suggested position archive (REPORT_SPA.xls) is shown. If any trades have been done other reports will be shown. These show 3 sets of graphs: a 40 day period, 130 day period and a 220 day period. Each period shows 3 graphs: A ratio plot of the prices over the period; a scatter diagram of the stock prices over the period and a polar plot of the ratios over the period to visually show trends.

The ratio plot of the prices (if the stocks are highly correlated) should be constant. The man-made anomaly upon which any trade is performed should be evident as a larger than normal rise or fall in the ratio. The

scatter diagram of stocks is shown so that a visual idea of the correlation between stocks can be seen for the different periods.

For both the ratio and scatter plots there are lines showing the ± 1 standard deviation standard deviation lines. This enables the current stock values to be viewed with respect to the standard deviation.

The polar plot shows the ratio of stocks again but obviously in a polar plot. The reason for this view is that if the stocks are highly correlated then the resulting plot will be pretty much circular (barring the movement of stock price resulting in a position having been taken).

Another reason for such plots is to be able to spot moves in stocks caused by corporate actions such as those mentioned in CHAPTER 4. Any trigger to take a position (buy of one stock and sell of another should be checked against corporate action events). The reason for this is that the application stores historical data of stock prices and if such a corporate action has taken place historical stock prices need adjusting or positions will be taken with very incorrect data and result in potential losses.

5.2.1 Testing

Three sets of test data are presented here as proof of code and concept. The historical test data for several synthetic stocks (made up stocks with tickers STK_1, STK_2, STK_3, STK_4, STK_5, STK_6) was

formulated using Microsoft excel based on simple liner trends with a slight random adjustment. This allowed slightly less than perfect correlations between the stocks allowing the concept of the project to be shown. For simulation purposes data for the days following the historical data was derived in a manner for 3 simulations as follows:

Simulation 1: The following day's data is based on the same trend and same random element. If the trading strategy works properly there will have been no change in average ratios and no anomalies upon which to trade. The resulting report showing archived positions will have no position data.

Simulation 2: The following day's data is based on the same trend and same random element. On day 20050916, STK_5's price is reduced. This is the only stock price which has been manipulated and so should cause a buy of the stock and sell of other stock which have the stipulated level of correlation and movement from the average. On the subsequent day the stock price for STK_5 is returned to the trend of simulation 1, and as such an unwinding of the position should occur^f. On the 20050918 STK_5's price is inflated from the trend and should result in a sell of stock 5 against the same related as for the previous trigger. On the subsequent day the position is unwound resulting in no positions at the end of the simulation run.

^f i.e. the bought stock is sold and the sold stock is bought. This results in a flattening of the position with no stock owned and no exposure to the market.

The code that implements the detection required is as follows:

```
+ " and      GTBS.PER_MED_r      > 0.87 \n"
+ " and      GTBS.PER_LOW_r      > 0.87 \n"
+      "      and      ABS(avg40ratio*GTBS.Y_currentPrice-
GTBS.X_currentPrice) > 1.0*GTBS.stdevp40*GTBS.Y_currentPrice
"

+ " and      GTBS.PER_MED_m > 0 \n"
+ " and      GTBS.PER_LOW_m > 0 \n"
```

Where

```
+ " and      GTBS.PER_MED_r      > 0.87 \n"
+ " and      GTBS.PER_LOW_r      > 0.87 \n"
```

State that the regression value should be greater than 0.87 and

```
+      "      and      ABS(avg40ratio*GTBS.Y_currentPrice-
GTBS.X_currentPrice) > 1.0*GTBS.stdevp40*GTBS.Y_currentPrice
"
```

States that the absolute values^g of the difference between the 40 day average daily ratios of the stock and the simulation days average ratio must be greater than one standard deviation from the current ratio^h.

```
+ " and      GTBS.PER_MED_m > 0 \n"
```

^g Absolute value as it doesn't matter if the ratio movement is higher or lower. The important thing is the movement is of a magnitude required in this case 1 standard deviation.

^h Clearer if both sides are divided by the current y price

+ " and GTBS.PER_LOW_m > 0 \n"

Specifies that the slope of the regression lines for the MEDium and LOWest periods are positive. This eases the amount of code required for this project but should the project prove what is believed at the onset then is a very worthwhile extension for extra work to be performed.

Simulation 3: Similar to Simulation 2 except multiple stocks are used. Several triggers are used the first is a single stock (STK_5 to be sold), this is then subsequently unwound. Next the same stock is made into a buy along with a buy of another stock STK_6.

5.2.2 Simulation Results

Simulation Data and results can be seen in APPENDIX 1, which also shows the details the results of the simulations are as we expect the code to be. For the 3 simulations presented using synthetic test data the results show the values of regression are being calculated and stored correctly in the database. It shows that the trigger mechanism for opening and closing trading posiotions works as expected. It also shows the reporting of results is correct (REPORT_SPA.xls).

It shows the ratio graphs and end of day reports mentioned and makes us ready to get set for the quest for the simulation parameters to be used in real trading.

5.3 Parameters

Integral to the quest for the holy grail of pairs trading are what parameters to use and what the decision process is going to be. Prior to testing real-time the search for these parameters must be done by iteration.

The application has been constructed such that the decisions which form the taking up of a position (the “What To Buy” or WTB you may see in the code listings) and closing a position (the “What To Close” or WTC when you see the code listings) are parameterised such that control is given to allow a position. The soft coded parameters available to be changed are as follows:

WTB

- The number of standard deviations away from the norm the LOWest period ration has to exceed if this period is used for trading
- The number of standard deviations away from the norm the MEDium period ration has to exceed if this period is used for trading
- The number of standard deviations away from the norm the HIGHest period ration has to exceed if this period is used for trading
- The value of regression that the LOWest period regression value has to exceed

- The value of regression that the MEDium period regression value has to exceed
- The value of regression that the HIGHest period regression value has to exceed
- Multiplicative buy factor (threshold for how many standard deviations from the norm for a buy)
- Multiplicative sell factor (threshold for how many standard deviations from the norm for a sell)

WTC

- The number of standard deviations away from the norm the LOWest period ration has to have reverted back to if this period is used for trading
- The number of standard deviations away from the norm the MEDium period ration has to have reverted back to if this period is used for trading
- The number of standard deviations away from the norm the HIGHest period ration has to have reverted back to if this period is used for trading

These are held in the TRD_Param table shown in Table 2.

period	r2medNhigh	r2low	r2vlow	stdevp10buyfactor	sellfactor	stdevp40buyfactor	stdevp40sellfactor	periodfrom	periodto
rising	0.89	0.89	0.6	0	999	1.2	0.9	20100204	date

Table 2: The trading parameters table (TRD_Params)

Where the fields have the meanings shown in the following table, where field name is the name of the field in the TRD_params table, area of use

is where in the program trading suite the field is typically used and the description is what the field is (green cells being used in the work presented here - Table 3)

field name	area of use	description
period	simulation	name of simulation
r2medNhigh	WTB & WTC	limit of HIGHest and MEDium period regression
r2low	WTB & WTC	limit of LOWest period regresstion
r2vlow	WTB & WTC	limit of a VeryLOW period regresstion
stdevp10buyfactor	WTB & WTC	no of STDEVP in VeryLOW buy
stdevp10sellfactor	WTB & WTC	no of STDEVP in VeryLOW Sell
stdevp40buyfactor	WTB & WTC	no of STDEVP in LOW buy
stdevp40sellfactor	WTB & WTC	no of STDEVP in LOW sell
periodfrom	simulation	start of trading period
periodto	simulation	end of trading period

Table 3: trading parameter field meanings

The program at the heart of the trading decision making program (when WTB program `ss_param_based_wtb3`) has to make decisions based upon the stock pairs that have already been found via regression computations that have already been stored in the database. When plotted upon a scatter diagram stocks showing high correlation will typically show a linear relationship. This linear relationship means that there is a constant gradient (the m in $y=mx+c$, y , m and c are also held for the different periods on the `GEN_TRD_basis_HIST` table). The constant gradient shows, as does the correlation value, that the ratio of the two stocks is the same over time.

The decision making process (`ss_param_based_wtb3.java`) suggests appropriate trades when there appears a glitch in the ratio being used

for trading. It is hoped that the ratio of the stocks returns to the norm after which the trading position is unwound hopefully yielding profit. The likelihood of the return to the norm is held in the regression values. Regression values are calculated for 4 the following periods: very low, low, medium and high (length of times).

The parameters experiment attempts to identify the choice of which regression period or periods to best use and the best setting for these values in the period, or combination of periods in an attempt to find the holy grail! The periods used in this work are shown in Table 4.

Period	No of trading days
Very short	10
Short	40
Medium	130
Long	220

Table 4: Analysis periods

The decision making program then has to decide (based upon whatever period or indeed combination of periods regression values) when the glitch is enough of a glitch to perform a trade that will yield sufficient profit (this needs to be able to cover the cost of doing the trade – in this case brokerage costs typically \$7 to \$15). Regression threshold values are held in the database and can be changed without having to recompile any code.

The glitch is identified as such when the ratio of the prices has moved away from the norm for the period or periods of regression being used

by a multiplicative factor applied to the standard deviation, again for a particular period or periods being used. The standard deviation is the simplest measure as it takes into consideration in one simple figure the distribution of the price ratio about the average price ratio.

Historically the decision upon what to buy used to base its trading on the decision making program working out the profit from the current point on the scatter diagram if the point moved to the closest point on the line of best fit. It involved calculations performed inside the code (then java) but then Microsoft C#'s interoperability and the ability to use excel using a relatively simple set of calls came along, which could calculate standard deviation without code. Common sense made me switch to the method using standard deviation using excel with a view to keeping code as simple as possible.

In simulation mode the automated process has to make the decision of what positions have made enough profit or which positions are losing money or have lost too much money. In other words which open positions need to be closed (due to sufficient gain or stop-loss). With the historical model this was done by simply looking at the profit generated and if larger than or lower than certain thresholds the position was closed. In the current/final model positions are closed out when the price ratio of the stock returns to within a multiplicative factor of the standard deviation or standard deviations of the period used to open (or as it is possible to do) periods of time used for the other standard

deviations (held in the TRD_Params table). In the buy decision we are left with the following available parameters:

1. The regression R2 variables (for 4 time periods and with permutations and combinations therein)
2. The multiplicative factors in play therefore for the decision making of what positions to open are therefore:
3. The Standard deviation STDEVP variables (for 4 time periods and with permutations and combinations therein). The HIGH and MED period regression values are inseparable in my work as it was found that the use of either period was similar in the outcome.

5.3.1.1 The strategy of the simulation (ratio/scatter)

In simulation mode there is also another additional factor involved, that being the period over which the simulation is run.

- Buy level STDEVP
- Multiplicative factor for the BUY level STDEVP
- Sell level STDEVP
- Multiplicative factor for the SELL level STDEVP
- Ratio period from which the norm price ratios are taken

Variable	Start value	End value	Step	Number of Iterations
HIGH, MED & LOW combined regression parameter	0.85	0.89	0.03	3
BUY multiplicative factor	1.00	1.40	0.20	4
SELL multiplicative factor	0.80	0.90	0.10	2
Price ratio period (this could be 40, 120 or 220 or indeed combinations thereof). I use the 40 day period [i].				1
Total permutations and combinations 3x4x2				24

Table 5: Trading Parameters

Table 5 shows that there are 24 permutations and combinations for each simulation. The purpose of the simulation is to find the set of parameters that produces the best set of results (i.e. the most profit).

Remember that each of the 24 runs with a parameter set is run for over the period of the simulation (typically an average of 3 weeks (15 working days)). To ensure the parameters work, regardless of the start date

ⁱ The 40 day period was chosen as previous simulations found larger periods failed due to lesser movements

chosen (which, if only one were chosen may be a lucky date or an unlucky one from a profit prospective), all dates in the period are used as a start date and a profit (or loss calculated) as the simulation then works towards the end date in the period.

Total start date its over is therefore 15 day period. Which, given the parameter permutations and combinations above is a total of 360 (15x24) simulation runs. Note that time taken is long as a 15 day run is 15 times that of a 1 day. Some simulations have taken a week to run on a windows PC.

5.4 Simulation over historical periods of time and search for the holy grail

When doing experimental back testing previous periods GEN_TRD_basis_HIST retains the r2 and associated period data, and therefore long periods of recalculating regression do not need to be performed. This was a change made when it became obvious how important back testing is to this method of trading and how time consuming it can be to perform the calculations over the 200 stocks the simulation uses. Using previously stored r2 values and amending the code so it uses the r2 and associated values for the active simulation date reduced simulation periods from 48 hrs to 30-40 minutes for some experiments.

In the simulation each trading pair is done for a nominal \$100,000.

5.4.1 List of experiments

The permutations and combinations of parameter that should be used to establish the best parameters to use in real-time ideally have to produce consistent profit in all conditions. The range of parameters was therefore run over the periods when the market was:

- RISING
- FALLING
- LEVEL

Looking at the market movements (see Figure 10) it can be seen that there are period that match the conditions required.



Figure 10: Market movements

Analysing the market for periods that test the parameters for the above market movements the periods chosen for the above testing can be seen in Table 6.

	falling		rising		level	
date start	06/02/2009	1,591.71	09/03/2009	1268.64	12/06/2009	1858.8
date end	09/03/2009	1,268.64	26/03/2009	1587	15/07/2009	1862.9

Table 6: Simulation period summary

5.4.2 RISING Market

5.4.2.1 Data

The simulation data table can be seen in the database backup file on the attached THESIS CD in the RISING.bak Microsoft SQL Server backup file^j.

5.4.2.2 Simulation results Data

A brief extract of the data from the simulation can be seen here. It shows the results of the simulation where the column headings are as shown in Figure 11.

column	description
db_name	the database name
this_view	the database view showing the data
MH_L_VL_10B_10S_40B_40S	compact shorthand for the values of the high, med, low, 10 day buy and selle factors, 40 day buy and sell factors
periodfrom	start of the simulation period (yyyymmdd)
dt	status date of positions within period
seq	unique sequence number of a stock position pair
x_ticker	x ticker in the position
y_ticker	y ticker in the position
finalAmount	the final amount (profit or loss) on the final date of the simulation period
valueOnDay	the value on the simulation date (dt) amount (profit or loss) of the simulation period

Figure 11 : Meanings/Definition of the columns in the simulation results

^j This would need to be loaded into SQL Server first.

Partial results from this simulation can be seen in Table 7, and in full on the attached THESIS CD in the **RISING** tab of the excel file called **20100109 THESIS SIM DATA.xlsx** .

db_name	this view	MH L VL 10B 10S 40B 40S	periodfrom	dt	seq	x ticker	y ticker	finalAmount	valueOnDay
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12527	ANAT	PAYX	8639.150077	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12528	HCBK	IBOC	-6220.015043	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12529	MICC	NWSA	5501.431615	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12530	NIHD	XRAY	7454.212454	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12531	SEIC	WRLD	8891.443682	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12532	CA	PCAR	10773.2301	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12533	ADSK	SEIC	6893.547584	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12534	CMCSA	LBTYA	11357.50182	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12535	EBAY	PCAR	-7968.600655	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12536	BOKF	WFSL	-9358.600226	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12537	EBAY	MSFT	6153.349952	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12538	WRLD	XRAY	11785.32244	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12539	TROW	WYNN	-6555.475871	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12540	SCHW	TROW	-6958.657102	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12541	SHLD	WYNN	-7477.540733	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12542	OXPS	WYNN	-6048.951049	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12543	PCAR	SEIC	-8075.696882	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12544	PCAR	SIAL	5164.588735	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12545	NIHD	PICO	-5234.780687	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12546	LBTYA	WYNN	-5963.483987	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12547	LRCX	NWSA	-5792.736193	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12548	CME	NWSA	6885.199952	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12549	CTXS	NWSA	7353.783877	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12550	BBBY	SHLD	5544.03035	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	10/03/2009 00:00	12551	CMCSA	WYNN	-2754.362754	0
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12527	ANAT	PAYX	8639.150077	2580.941265
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12528	HCBK	IBOC	-6220.015043	1233.517355
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12529	MICC	NWSA	5501.431615	3629.764065
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12530	NIHD	XRAY	7454.212454	3233.849484
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12531	SEIC	WRLD	8891.443682	717.7340308
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12532	CA	PCAR	10773.2301	1979.748312
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12533	ADSK	SEIC	6893.547584	-2701.182805
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12534	CMCSA	LBTYA	11357.50182	2191.544215
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12535	EBAY	PCAR	-7968.600655	1885.384256
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12536	BOKF	WFSL	-9358.600226	333.7494696
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12537	EBAY	MSFT	6153.349952	951.9592408
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12538	WRLD	XRAY	11785.32244	2327.793047
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12539	TROW	WYNN	-6555.475871	-3961.335786
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12540	SCHW	TROW	-6958.657102	-2035.15947
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12541	SHLD	WYNN	-7477.540733	-3973.825796
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12542	OXPS	WYNN	-6048.951049	-3184.678957
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12543	PCAR	SEIC	-8075.696882	-2022.338496
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12544	PCAR	SIAL	5164.588735	2142.899029
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12545	NIHD	PICO	-5234.780687	2026.805368
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12546	LBTYA	WYNN	-5963.483987	-5963.483987
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12547	LRCX	NWSA	-5792.736193	486.3455978
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12548	CME	NWSA	6885.199952	4170.304606
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12549	CTXS	NWSA	7353.783877	155.7095359
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12550	BBBY	SHLD	5544.03035	-2621.108626
RISING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090309	11/03/2009 00:00	12551	CMCSA	WYNN	-2754.362754	-3771.939772

Table 7: Rising data excerpt

5.4.2.3 Graphic

The graphic shown in Figure 12 shows the results (i.e. final profit or loss), in the rising period, for each of the possible starting dates in the

period and for a range of regression factors and buy and sell multiplicative factors shown along on one of the axes (which corresponds to the column in the MH_L_VL_10B_10S_40B_40S column in Table 7, the table of results).

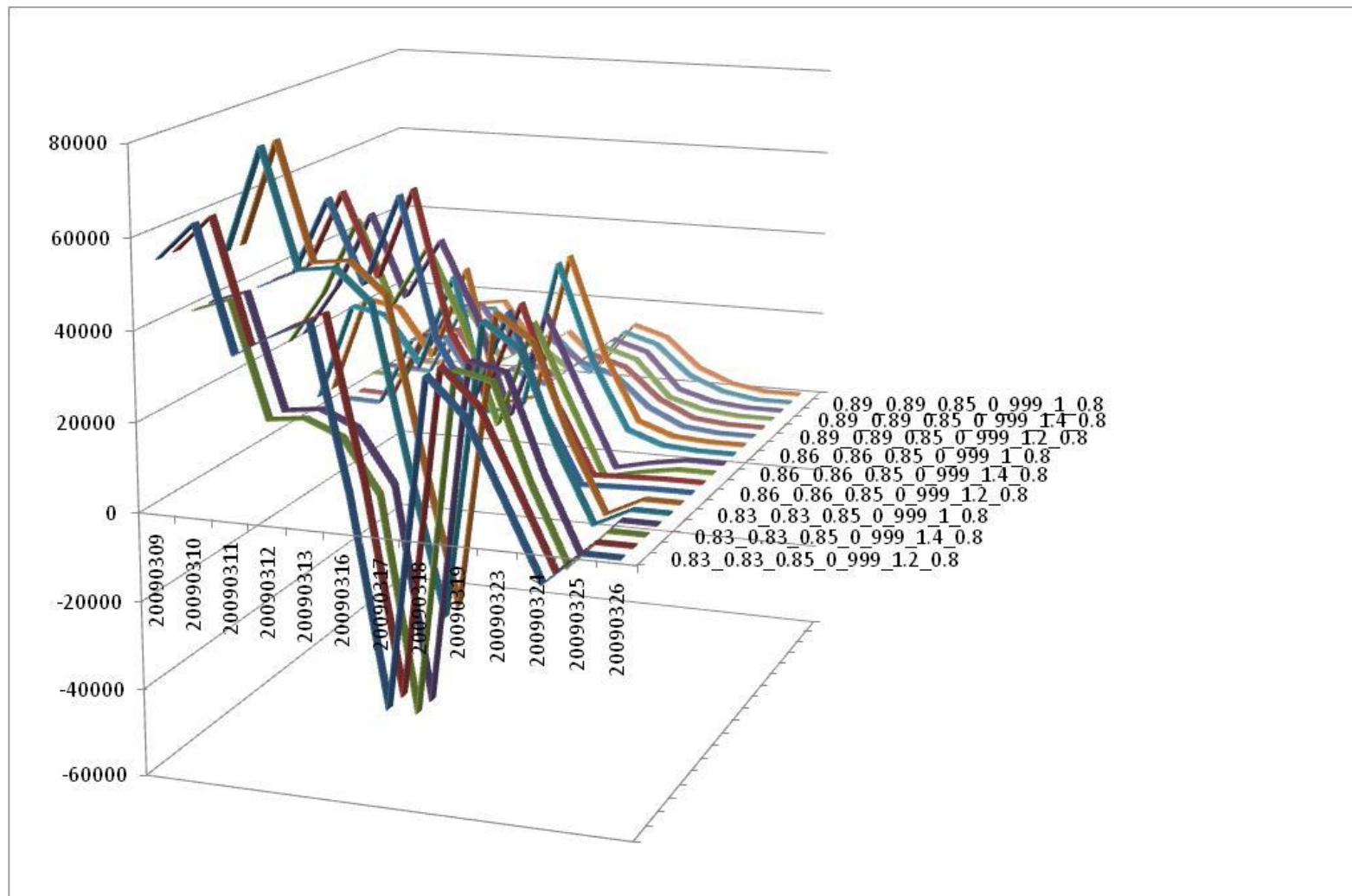


Figure 12: RISING Market graphic

The tabulated data for Figure 12 can be seen in Table 8.

dt	26/03/2009																			
Sum of finalAmount	Column Labels																			
Row Labels	0.83_0.83_0.85_0.999_1.2_0.0	0.83_0.83_0.85_0.999_1.2_0.0	0.83_0.83_0.85_0.999_1.4_0.0	0.83_0.83_0.85_0.999_1.4_0.0	0.83_0.83_0.85_0.999_1.4_0.0	0.83_0.83_0.85_0.999_1.0.8	0.86_0.86_0.85_0.999_1.0.9	0.86_0.86_0.85_0.999_1.2_0.0	0.86_0.86_0.85_0.999_1.2_0.0	0.86_0.86_0.85_0.999_1.4_0.0	0.86_0.86_0.85_0.999_1.4_0.0	0.86_0.86_0.85_0.999_1.0.8	0.89_0.89_0.85_0.999_1.0.9	0.89_0.89_0.85_0.999_1.2_0.0	0.89_0.89_0.85_0.999_1.2_0.0	0.89_0.89_0.85_0.999_1.4_0.0	0.89_0.89_0.85_0.999_1.4_0.0	0.89_0.89_0.85_0.999_1.0.8	0.89_0.89_0.85_0.999_1.0.8	Grand Total
20090309	55,127	55,127	40,519	40,519	50,124	50,124	38,743	38,743	22,379	22,379	5,033	5,033	419	419	3,037	3,037	419	419	431,600	
20090310	63,334	63,334	43,399	43,399	74,252	74,252	42,503	42,503	34,417	34,417	27,764	27,764	100	100	2,718	2,718	100	100	577,175	
20090311	35,642	35,642	17,408	17,408	47,152	47,152	60,236	60,236	52,150	52,150	26,205	26,205	16,633	16,633	19,251	19,251	16,633	16,633	582,619	
20090312	40,380	40,380	18,432	18,432	48,272	48,272	41,049	41,049	32,963	32,963	14,997	14,997	17,825	17,825	20,443	20,443	17,825	17,825	504,373	
20090313	44,183	44,183	15,045	15,045	41,026	41,026	61,996	61,996	47,010	47,010	36,899	36,899	6,212	6,212	8,830	8,830	6,212	6,212	534,826	
20090316	7,497	7,497	2,954	2,954	4,340	4,340	29,935	29,935	30,122	30,122	4,838	4,838	11,269	11,269	13,887	13,887	11,269	11,269	232,221	
20090317	-38,912	-38,912	-45,715	-45,715	-29,128	-29,128	15,829	15,829	6,721	6,721	7,173	7,173	8,201	8,201	8,201	8,201	3,412	3,412	-128,435	
20090318	34,893	34,893	32,149	32,149	39,052	39,052	37,638	37,638	31,387	31,387	41,798	41,798	14,405	14,405	14,405	14,405	14,405	14,405	520,264	
20090319	26,768	26,768	30,235	30,235	33,274	33,274	14,898	14,898	13,800	13,800	19,058	19,058	11,911	11,911	11,911	11,911	11,911	11,911	347,535	
20090323	9,875	9,875	8,692	8,692	12,384	12,384	-606	-606	-3,285	-3,285	3,554	3,554	4,741	4,741	3,160	3,160	4,741	4,741	86,512	
20090324	-7,404	-7,404	-8,900	-8,900	-4,193	-4,193	-291	-291	-1,389	-1,389	573	573	815	815	815	815	1,353	1,353	-37,242	
20090325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
20090326	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Grand Total	271,383	271,383	154,216	154,216	316,556	316,556	341,931	341,931	266,277	266,277	187,894	187,894	92,530	92,530	106,658	106,658	88,278	88,278	3,651,449	

Table 8: Rising Period profit & loss

5.4.2.4 Analysis

The top 10 and bottom 10 results (top ten shown in green and bottom ten shown in red) occur on the bands with looser trading parameter. Moderate, but positive (i.e. profitable) results are to be seen in the areas where tighter trading parameters are involved.

For the bulk of the start dates in the rising period a positive profit can be seen. For the strategy and parameters to be perfect however there would always be a profit.

It can be seen that as the regression parameters are tighter (i.e. have higher regression thresholds and trading parameter values) a more consistent profit is seen - but \$1353 is not a large profit for 3 weeks of trading.

While there are a larger percentage of profit peaks seen in the rising simulation there are some peaks of losses. The larger losses and gains occur in the areas where the looser trading parameters are in use. Profit, while not as large, can be seen for the majority of cases in the rising simulations with tighter trading parameters in control.

5.4.3 FALLING Market

5.4.3.1 Data

The simulation data table can be seen in the database backup file on the attached THESIS CD in the FALLING.bak Microsoft SQL Server backup file.

5.4.3.2 Simulation results Data

A brief extract of the data from the simulation can be seen in Table 9. It shows the results of the simulation where the column headings are described in Figure 13: Meanings/Definition of the columns in the simulation resultsFigure 13.

column	description
db_name	the database name
this_view	the database view showing the data
MH_L_VL_10B_10S_40B_40S	compact shorthand for the values of the high, med, low, 10 day buy and selle factors, 40 day buy and sell factors
periodfrom	start of the simulation period (yyyymmdd)
dt	status date of positions within period
seq	unique sequence number of a stock position pair
x_ticker	x ticker in the position
y_ticker	y ticker in the position
finalAmount	the final amount (profit or loss) on the final date of the simulation period
valueOnDay	the value on the simulation date (dt) amount (profit or loss) of the simulation period

Figure 13: Meanings/Definition of the columns in the simulation results

Partial results from this simulation can be seen in Table 9, and in full on the attached THESIS CD attached to this thesis in the **FALLING** tab of the excel file called **20100109 THESIS SIM DATA.xlsx** .

db_name	this view	MH_L_VL_10B_10S_40B_40S	periodfrom	dt	seq	x ticker	y ticker	finalAmount	valueOnDay
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	09/02/2009 00:00	32140	ASBC	ZION	-8498.044228	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	09/02/2009 00:00	32142	MBFI	WTNY	5804.826514	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	10/02/2009 00:00	32142	MBFI	WTNY	5804.826514	3078.098429
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	11/02/2009 00:00	32140	ASBC	ZION	-8498.044228	-8498.044228
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	12/02/2009 00:00	32142	MBFI	WTNY	5804.826514	1634.246811
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	17/02/2009 00:00	32141	FMBI	WTNY	-5332.653476	-5332.653476
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	17/02/2009 00:00	32151	ASBC	ZION	-9223.61642	-9223.61642
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	18/02/2009 00:00	32140	ASBC	ZION	-8498.044228	-8498.044228
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	18/02/2009 00:00	32145	ASBC	ZION	-7766.744036	-7766.744036
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	18/02/2009 00:00	32149	FMBI	WTNY	-6616.510367	-2714.916385
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	19/02/2009 00:00	32142	MBFI	WTNY	5804.826514	5804.826514
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32141	FMBI	WTNY	-5332.653476	-5332.653476
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32151	ASBC	ZION	-9223.61642	-9223.61642
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32163	WTFC	ZION	-9204.460518	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32166	WTFC	FMBI	-6969.43227	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32170	NPBC	UFCS	5637.365108	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32174	NWSB	SIGI	-5197.887508	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32176	PCBC	ZION	-8207.317073	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32177	WTNY	FMBI	5239.653134	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32178	NWSA	LRCX	-8196.589691	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32179	PCBC	ASBC	5240.748528	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32183	SUSQ	WFSL	8925.88291	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32186	DISH	LOGI	-6303.278381	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32188	WYNN	LBTYA	-13763.61263	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32193	EXPE	MSFT	5660.206718	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	20/02/2009 00:00	32198	NIHD	ADBE	-14833.65089	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32159	ASBC	ZION	-6743.765457	-6743.765457
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32163	WTFC	ZION	-9204.460518	-1253.76733
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32168	PCAR	LOGI	5445.303725	-2977.910002
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32179	PCBC	ASBC	5240.748528	754.6531612
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32181	WTNY	MBFI	202.0337219	327.1801164
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32191	SHLD	WTNY	-5641.812767	-5641.812767
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32197	WFSL	ZION	11467.37213	-335.0970018
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32198	NIHD	ADBE	-14833.65089	-1622.030501
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32203	ADSK	LOGI	7418.483195	-2870.310047
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	23/02/2009 00:00	32207	SHLD	MBFI	-5882.405034	0
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32140	ASBC	ZION	-8498.044228	-8498.044228
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32145	ASBC	ZION	-7766.744036	-7766.744036
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32163	WTFC	ZION	-9204.460518	4683.946152
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32167	ERTS	KLAC	6280.872506	4475.23338
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32168	PCAR	LOGI	5445.303725	-2074.772648
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32170	NPBC	UFCS	5637.365108	5637.365108
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32184	SUSQ	WTFC	5477.88118	5477.88118
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32187	URBN	HCBK	5326.648204	5326.648204
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32191	SHLD	WTNY	-5641.812767	-5641.812767
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32193	EXPE	MSFT	5660.206718	5660.206718
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32195	FMBI	MBFI	9227.194516	3718.042515
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32197	WFSL	ZION	11467.37213	11467.37213
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32199	KLAC	LOGI	-627.094705	-2359.388472
FALLING	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090206	24/02/2009 00:00	32204	WCRX	EBAY	7598.877009	-1536.625479

Table 9: Falling data extract

5.4.3.3 Graphic

The graphic shown in Figure 14 shows the results (i.e. final profit or loss) in the rising period for each of the possible starting dates in the period along one axis against a range of regression factors and buy and sell multiplicative factors shown on the other axis (which corresponds to the column in the MH_L_VL_10B_10S_40B_40S column in Table 9).

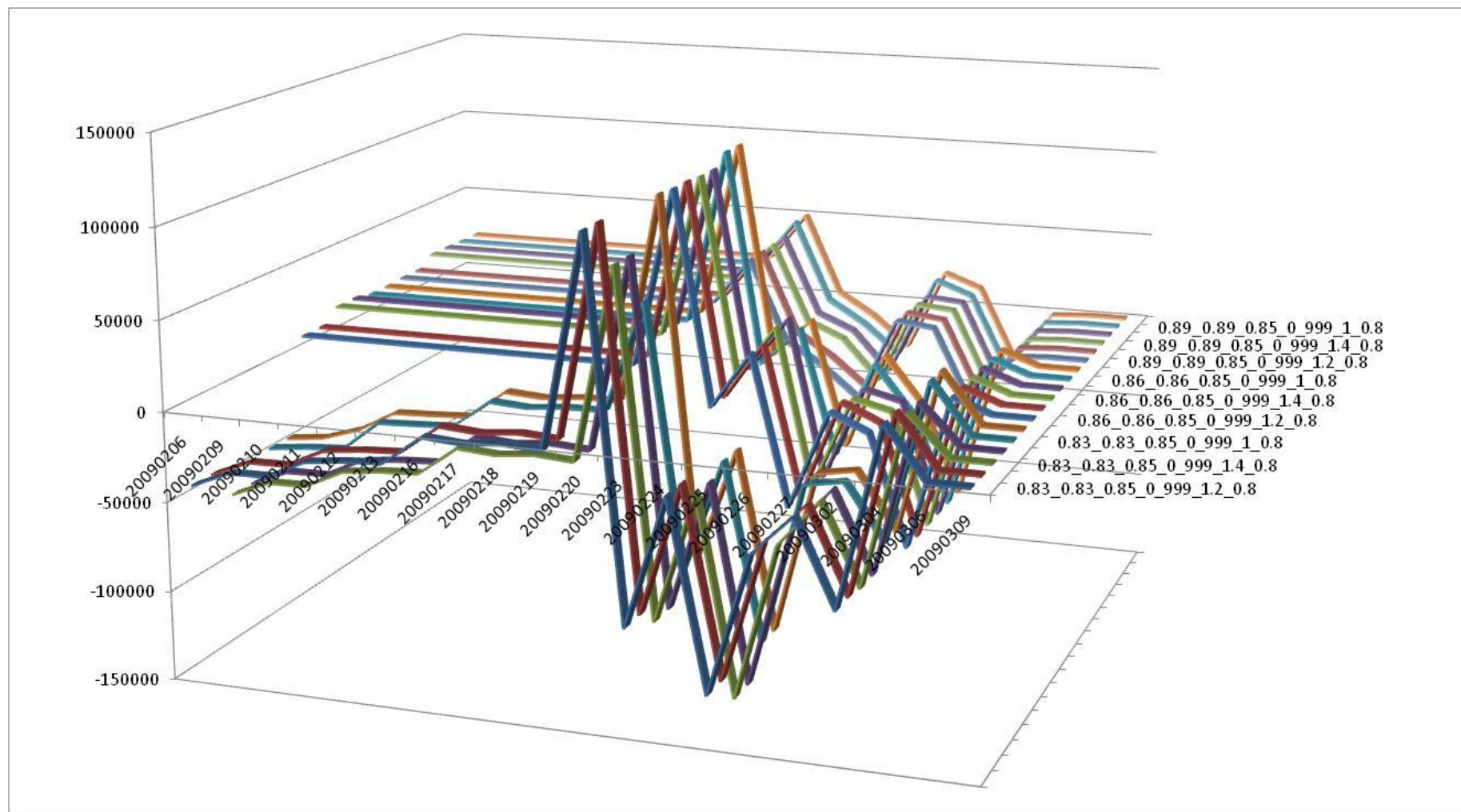


Figure 14: FALLING Market graphic

The tabulated data corresponding to the graphic in Figure 14 (or 12?) can be seen in Table 10.

dt	09/03/2009																			
Sum of finalAmount	Column Labels																			
Row Labels	0.83_0.83_0.85_0.999_1.2_0.0	0.83_0.83_0.85_0.999_1.2_0.0	0.83_0.83_0.85_0.999_1.4_0.0	0.83_0.83_0.85_0.999_1.4_0.0	0.83_0.83_0.85_0.999_1.4_0.0	0.83_0.83_0.85_0.999_1.0_0.8	0.86_0.86_0.85_0.999_1.0_0.9	0.86_0.86_0.85_0.999_1.2_0.0	0.86_0.86_0.85_0.999_1.2_0.0	0.86_0.86_0.85_0.999_1.4_0.0	0.86_0.86_0.85_0.999_1.4_0.0	0.86_0.86_0.85_0.999_1.0_0.8	0.89_0.89_0.85_0.999_1.0_0.9	0.89_0.89_0.85_0.999_1.2_0.0	0.89_0.89_0.85_0.999_1.2_0.0	0.89_0.89_0.85_0.999_1.4_0.0	0.89_0.89_0.85_0.999_1.4_0.0	0.89_0.89_0.85_0.999_1.0_0.8	Grand Total	
20090206	-41,569	-41,569	-59,237	-59,237	-44,765	-44,765	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	-83,788	
20090209	-32,795	-32,795	-50,464	-50,464	-42,382	-42,382	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	-43,926	
20090210	-32,394	-32,394	-50,063	-50,063	-40,992	-35,591	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	-34,144	
20090211	-22,136	-22,136	-39,805	-39,805	-23,775	-23,775	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	35,921	
20090212	-19,702	-19,702	-37,371	-37,371	-22,899	-22,899	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	47,412	
20090213	-18,554	-18,554	-36,222	-36,222	-21,750	-21,750	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	54,302	
20090216	-2,177	-2,177	-19,846	-19,846	-5,553	-5,553	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	152,202	
20090217	-3,842	-3,842	-21,510	-21,510	-7,038	-7,038	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	142,575	
20090218	-1,735	-1,735	-19,403	-19,403	-4,931	-4,931	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	155,217	
20090219	-3,192	-3,192	-20,861	-20,861	-4,831	-4,831	10,230	10,230	17,721	17,721	15,550	15,550	16,312	16,312	22,124	22,124	21,741	21,741	149,587	
20090220	112,927	112,927	86,553	86,553	57,569	111,288	110,178	110,178	108,993	108,993	115,497	115,497	44,139	44,139	44,139	44,139	49,568	49,568	1,512,846	
20090223	-92,960	-92,960	-104,102	-104,102	-89,540	-89,540	-9,701	-9,701	-3,929	-3,929	-6,461	-6,461	-2,934	-2,934	-1,218	-1,218	2,495	2,495	-616,699	
20090224	-19,933	-19,933	-31,539	-31,539	-26,134	-26,134	22,164	22,164	26,792	26,792	15,819	15,819	-16,096	-16,096	-10,283	-10,283	-10,667	-10,667	-99,756	
20090225	-123,830	-123,830	-141,250	-141,250	-125,828	-125,828	-62,202	-62,202	-63,387	-63,387	-56,883	-56,883	-33,727	-33,727	-33,727	-33,727	-28,298	-28,298	-1,338,267	
20090226	-46,052	-46,052	-54,556	-54,556	-34,604	-34,604	-6,596	-6,596	-10,225	-10,225	-1,277	-1,277	14,271	14,271	14,271	14,271	19,701	19,701	-210,135	
20090227	-24,241	-24,241	-28,741	-28,741	-30,844	-30,844	-16,203	-16,203	-15,440	-15,440	-27,977	-27,977	11,633	11,633	12,396	12,396	11,633	11,633	-215,567	
20090302	-70,532	-70,532	-72,871	-72,871	-62,135	-62,135	-78,036	-78,036	-78,036	-78,036	-78,146	-78,146	-31,181	-31,181	-31,181	-31,181	-31,181	-31,181	-1,066,604	
20090304	28,045	28,045	22,075	22,075	27,935	27,935	7,859	7,859	7,859	7,859	7,750	7,750	-1,388	-1,388	-1,388	-1,388	-1,388	-1,388	194,722	
20090306	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
20090309	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Grand Total	-414,673	-414,673	-679,214	-679,214	-502,498	-443,378	69,761	69,761	149,840	149,840	123,817	123,817	147,832	147,832	214,252	214,252	229,271	229,271	-1,264,102	

Table 10: Falling tabulated results

5.4.3.4 Analysis

The largest losses occur with less tight trading parameter values. It is interesting to note that the top 10 results (shown in green) are for the same start date in the simulations, predictably however these do occur at the looser trading parameter values where I would have expected greater profits and loss to have shown as the movements that are allowed in price ratios are larger.

There are appreciable gains from the majority of the simulation start dates only 3/18 of the start dates yield losses, and the last date may even be discounted as several days need to pass for a position to work its way into profit.

Generally with looser trading parameters the greater the gain and larger the losses that can be expected.

The tighter trading parameter result in profits of \$21,741 for 78% \$ (i.e. 14 out of the 18) start dates with a max profit of \$115,498 and maximum loss of \$141,250.

\$21,740 in one month is a fair profit. It could be that the losses that occur with the simulation start dates toward the end of period may have worked themselves into a profit as time when on further than the simulation.

The majority of parameters and start periods yield a profit.

Once again although there are significant profits no fixed set of parameters yield a profit in all scenarios. For the parameters and strategy and parameters to be perfect however there would always be a profit. As the regression parameters are tighter losses are not as large as the profit made.

Lower trading parameters yield unpredictable and fairly consistent losses in the falling simulation. Higher values of trading parameters yield a larger percentage of profit but a questionable level of stability (i.e. it is not possible to guarantee a level of profit).

5.4.4 LEVEL Market

5.4.4.1 Data

The simulation data table can be seen in the database backup file on the attached THESIS CD in the LEVEL.bak Microsoft SQL Server backup file.

5.4.4.2 Simulation results Data

A brief extract of the data from the simulation can be seen in Table 11. It shows the results of the simulation where the column headings can be seen in .

column	description
db_name	the database name
this_view	the database view showing the data
MH_L_VL_10B_10S_40B_40S	compact shorthand for the values of the high, med, low, 10 day buy and selle factors, 40 day buy and sell factors
periodfrom	start of the simulation period (yyyymmdd)
dt	status date of positions within period
seq	unique sequence number of a stock position pair
x_ticker	x ticker in the position
y_ticker	y ticker in the position
finalAmount	the final amount (profit or loss) on the final date of the simulation period
valueOnDay	the value on the simulation date (dt) amount (profit or loss) of the simulation period

Figure 15: Meanings/Definition of the columns in the simulation results

Partial results from this simulation can be seen in Table 11, and in full on the attached THESIS CD The data can be seen on the attached THESIS CD in the **LEVEL** tab of the excel file called **20100109 THESIS SIM DATA.xlsx** .

db_name	this view	MH L VL 108 105 408 405	periodfrom	dt	seq	x ticker	y ticker	finalAmount	valueOnDay
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	15/06/2009 00:00	12558	HBHC	IBOC	5657.15323	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	17/06/2009 00:00	12558	HBHC	IBOC	5657.15323	-26.73174798
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	18/06/2009 00:00	12558	HBHC	IBOC	5657.15323	1207.930777
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	19/06/2009 00:00	12558	HBHC	IBOC	5657.15323	1650.429954
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	22/06/2009 00:00	12558	HBHC	IBOC	5657.15323	1120.824005
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	22/06/2009 00:00	12562	CTBI	HBHC	701.6172761	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	23/06/2009 00:00	12558	HBHC	IBOC	5657.15323	-502.2556593
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	23/06/2009 00:00	12562	CTBI	HBHC	701.6172761	-1484.500981
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	24/06/2009 00:00	12558	HBHC	IBOC	5657.15323	-60.93977961
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	24/06/2009 00:00	12562	CTBI	HBHC	701.6172761	1016.406352
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12558	HBHC	IBOC	5657.15323	-2456.550825
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12562	CTBI	HBHC	701.6172761	2475.860164
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12568	CBSH	CVBF	-5450.40037	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12569	WFSL	ZION	-8900.042195	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12570	WTFC	ZION	-1586.506527	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12571	MBFI	WTNY	5373.959898	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12572	KLAC	LOGI	-7154.471545	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12573	IBOC	STBA	-7074.124903	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12574	FWLT	MICC	-6709.246828	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12575	FWLT	VRSN	-5610.625047	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12576	FMBI	WTNY	8402.644701	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12577	FNFG	HBHC	6827.133966	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12578	FITB	NDAQ	6647.990548	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12579	FMBI	MBFI	10541.2614	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12580	FAST	URBN	5204.415224	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12581	CINF	FITB	1286.731634	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	25/06/2009 00:00	12582	ADSK	LOGI	7398.284292	0
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12558	HBHC	IBOC	5657.15323	-1541.459085
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12562	CTBI	HBHC	701.6172761	1411.372601
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12568	CBSH	CVBF	-5450.40037	367.476607
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12569	WFSL	ZION	-8900.042195	-3406.566562
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12570	WTFC	ZION	-1586.506527	-3130.747544
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12571	MBFI	WTNY	5373.959898	-3860.000477
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12572	KLAC	LOGI	-7154.471545	4657.297021
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12573	IBOC	STBA	-7074.124903	-1259.523922
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12574	FWLT	MICC	-6709.246828	-3474.148191
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12575	FWLT	VRSN	-5610.625047	-3254.483895
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12576	FMBI	WTNY	8402.644701	-620.0399314
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12577	FNFG	HBHC	6827.133966	2851.081824
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12578	FITB	NDAQ	6647.990548	-1192.099947
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12579	FMBI	MBFI	10541.2614	3239.960545
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12580	FAST	URBN	5204.415224	-578.0724649
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12581	CINF	FITB	1286.731634	-1171.289355
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	26/06/2009 00:00	12582	ADSK	LOGI	7398.284292	7398.284292
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12558	HBHC	IBOC	5657.15323	2102.583755
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12562	CTBI	HBHC	701.6172761	-1196.94899
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12568	CBSH	CVBF	-5450.40037	-2659.080976
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12569	WFSL	ZION	-8900.042195	-4838.08847
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12570	WTFC	ZION	-1586.506527	-1749.516579
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12571	MBFI	WTNY	5373.959898	-2138.616694
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12572	KLAC	LOGI	-7154.471545	1957.417332
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12573	IBOC	STBA	-7074.124903	-3677.92974
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12574	FWLT	MICC	-6709.246828	-3508.507602
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12575	FWLT	VRSN	-5610.625047	-204.6638816
LEVEL	RESULTS_dayONday_cube	0.83_0.83_0.85_0_999_1.2_0.8	20090612	30/06/2009 00:00	12576	FMBI	WTNY	8402.644701	8402.644701

Table 11: Level Simulation Results

5.4.4.3 Graphic

The graphic shown in Figure 16 shows the results of the full set of results (partially shown in) Table 11 (i.e. final profit or loss) in the level period for each of the possible starting dates in the period, for a range of regression factors and buy and sell multiplicative factors shown

along on one of the axes (which corresponds to the column in the MH_L_VL_10B_10S_40B_40S column table of results).

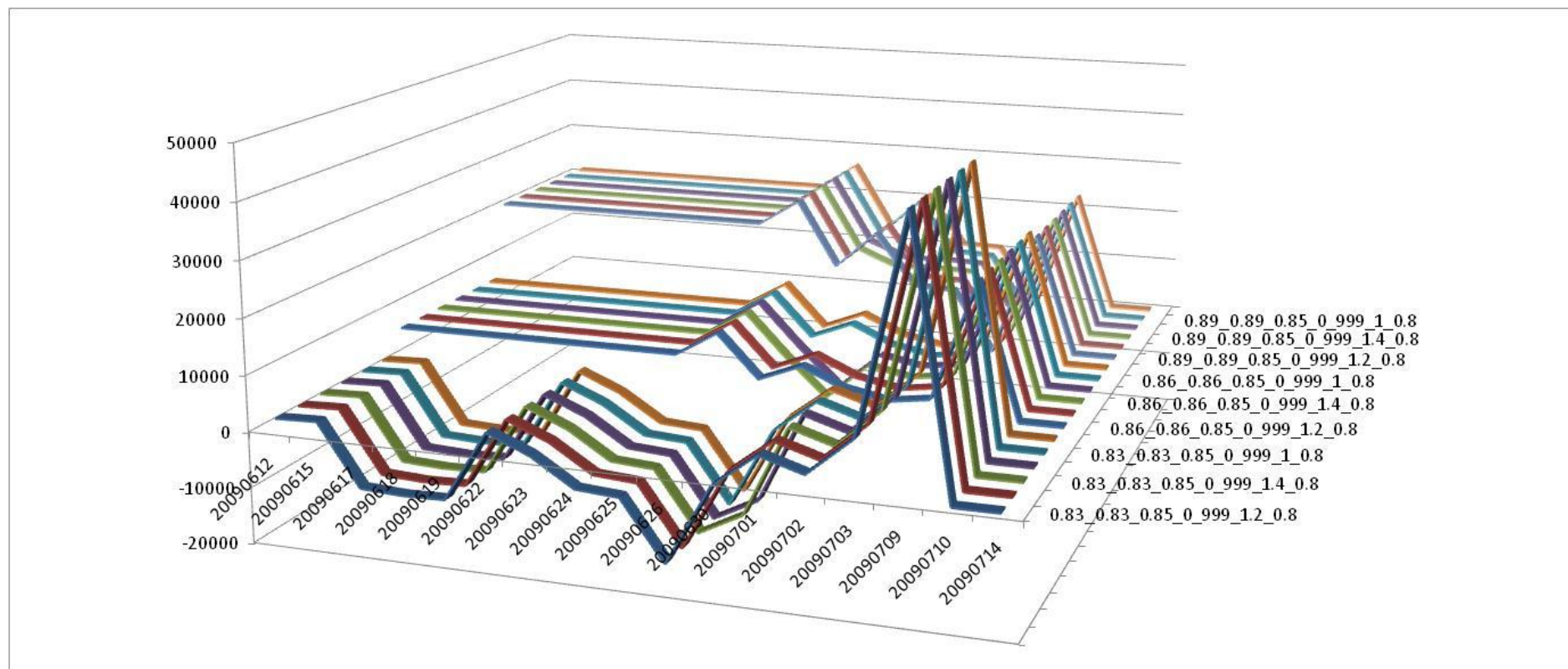


Figure 16: LEVEL Market graphic

The tabulated data forming the graphic in Figure 16 can be seen in Table 12.

dt	40,008																		
Sum of finalAmount	Column Labels																		
Row Labels																			
20090612	2,081	2,081	2,081	2,081	2,081	2,081	6,388	6,388	6,388	6,388	6,388	6,388	20,933	20,933	20,933	20,933	20,933	20,933	176,415
20090615	2,331	2,331	2,331	2,331	2,331	2,331	6,388	6,388	6,388	6,388	6,388	6,388	20,933	20,933	20,933	20,933	20,933	20,933	177,916
20090617	-8,688	-8,688	-8,688	-8,688	-8,688	-8,688	6,388	6,388	6,388	6,388	6,388	6,388	20,933	20,933	20,933	20,933	20,933	20,933	111,800
20090618	-9,069	-9,069	-9,069	-9,069	-9,069	-9,069	6,388	6,388	6,388	6,388	6,388	6,388	20,933	20,933	20,933	20,933	20,933	20,933	109,513
20090619	-8,881	-8,881	-8,881	-8,881	-8,881	-8,881	6,388	6,388	6,388	6,388	6,388	6,388	20,933	20,933	20,933	20,933	20,933	20,933	110,647
20090622	3,745	3,745	3,745	3,745	3,745	3,745	6,388	6,388	6,388	6,388	6,388	6,388	20,933	20,933	20,933	20,933	20,933	20,933	186,402
20090623	558	558	558	558	558	558	6,388	6,388	6,388	6,388	6,388	6,388	20,933	20,933	20,933	20,933	20,933	20,933	167,280
20090624	-4,278	-4,278	-4,278	-4,278	-4,278	-4,278	6,388	6,388	6,388	6,388	6,388	6,388	20,933	20,933	20,933	20,933	20,933	20,933	138,263
20090625	-4,806	-4,806	-4,806	-4,806	-4,806	-4,806	11,032	11,032	11,032	11,032	11,032	11,032	25,904	25,904	25,904	25,904	25,904	25,904	192,786
20090626	-15,292	-15,292	-15,292	-15,292	-15,292	-15,292	3,244	3,244	3,244	3,244	3,244	3,244	13,618	13,618	13,618	13,618	13,618	13,618	9,421
20090630	-1,056	-1,056	-11,225	-11,225	-1,056	-1,056	6,370	6,370	-3,799	-3,799	6,370	6,370	20,707	20,707	10,538	10,538	20,707	20,707	95,109
20090701	5,004	5,004	5,004	5,004	5,004	5,004	2,996	2,996	2,996	2,996	2,996	2,996	10,845	10,845	10,845	10,845	10,845	10,845	113,071
20090702	2,657	2,657	2,657	2,657	2,657	2,657	1,508	1,508	1,508	1,508	1,508	1,508	10,603	10,603	10,603	10,603	10,603	10,603	88,607
20090703	9,380	9,380	9,380	9,380	9,380	9,380	2,617	2,617	2,617	2,617	2,617	2,617	-926	-926	-926	-926	-926	-926	66,433
20090709	46,586	46,586	46,586	46,586	46,586	46,586	24,668	24,668	24,668	24,668	24,668	24,668	22,544	22,544	22,544	22,544	22,544	22,544	562,786
20090710	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20090714	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	20,273	20,273	10,104	10,104	20,273	20,273	103,544	103,544	93,375	93,375	103,544	103,544	270,760	270,760	260,591	260,591	270,760	270,760	2,306,450

Table 12: Level Simulation Data

5.4.4.4 Analysis

The greatest losses are all in the loser trading parameters band. The greatest gains are split evenly between the lower (less tight) parameters and the higher (tighter) trading parameters.

Interestingly all the many of the results occur for the same start dates in the simulation, irrespective of trading parameter values. This may suggest there is yet another factor involved with the method not yet contemplated!

Low regression value trading produce losses. For higher and indeed all the regression values used, trading activity is fairly static (as you would expect as stable markets have a used trading scenario).

The level simulation shows level profit for the higher parameter trading values and fluctuating profit (with some losses) for the loser trading parameter values. Higher trading parameters produce more consistent profits.

5.5 Performance in the real time market

Real Time

This is the actual realtime run and the other the control simulation of the realtime run. The start of this period is the 12th of February 2010. The end of the period is the 12th May 2010. The realtime intra day runs as the name suggests several times during the day. Real time^k means a trade opening a pairs position as it occurs. Subsequent runs may add another position in the same if the application computes that the stock price ratio has moved further from the norm than the previously opened position (i.e. there is more profit to be made by doing so”.

Pseudo Real Time

This is a replay of the real time data from the above. This mimics the simulations already used of falling, level and rising markets based purely upon end of day (and not intra day data) for comparison with the above real time.

Pseudo Real Time Replay

This is a full replay of the real time data (as per end of day data) but with several start dates chosen and a range of trading parameters used to try to show any surface that may be appearing from which maxima and optimal parameters may be chosen.

^k Albeit 20 minute delayed NASDAQ prices and any processing time

5.6 Real Time

5.6.1 Data

The data showing the results of live running this can be seen on the reference CD in the excel file LIVE.xlsx in tab called LIVE data. A short extract of the start and end of this data can be seen in Table 13 and Table 14. The data shows the database used, view the database is extracted from, period start date (periodFrom), date in the simulation (dt) of the value of the position, identifier of the position in the position table (seq), x and y tickers identifying the stocks, the final amount made or lost in the position at the end of the period and the value on the date (dt).

db_name	this view	MH L VL 10B 10S 40B 40S	periodfrom	dt	seq	x ticker	y ticker	finalAmount	valueOnDay	noTrades
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/02/2010 00:00	8784	CTSH	INFY	2981.114473	47.7429875	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/02/2010 00:00	8785	GOOG	NTAP	3094.81624	-299.2220227	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/02/2010 00:00	8793	GOOG	NTAP	3400.026969	0	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	15/02/2010 00:00	8784	CTSH	INFY	2981.114473	47.7429875	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	15/02/2010 00:00	8785	GOOG	NTAP	3094.81624	-299.2220227	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	15/02/2010 00:00	8793	GOOG	NTAP	3400.026969	0	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	15/02/2010 00:00	8794	DTV	ANAT	3954.121441	0	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	16/02/2010 00:00	8784	CTSH	INFY	2981.114473	2176.911679	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	16/02/2010 00:00	8785	GOOG	NTAP	3094.81624	-1439.506647	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	16/02/2010 00:00	8793	GOOG	NTAP	3400.026969	-1135.69347	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	16/02/2010 00:00	8794	DTV	ANAT	3954.121441	-2830.201394	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	16/02/2010 00:00	8799	DTV	ANAT	2744.951127	-3977.155632	1

Table 13: Live data (first trades)

... some 1500+ records

ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/05/2010 00:00	8881	BIDU	ISBC	3101.26874	3101.26874	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/05/2010 00:00	8885	BIDU	ISBC	3101.26874	3101.26874	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/05/2010 00:00	8893	CTSH	ESRX	1155.313429	1155.313429	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/05/2010 00:00	8894	CTSH	ESRX	2370.814178	2370.814178	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/05/2010 00:00	8895	ALTR	XLNX	-1241.756513	-1241.756513	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/05/2010 00:00	8902	CTSH	INFY	510.7738728	510.7738728	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/05/2010 00:00	8914	CTSH	INFY	2622.739041	2622.739041	1
ratio_SS_LIVE	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1.2_0.9	20100204	12/05/2010 00:00	8927	CTSH	INFY	5526.344655	4952.082201	1

Table 14: Live data (final trades)

5.6.2 Number of trades

The number of trades performed in this period was 50. The cumulative number (count) of all trades performed to the date shown can be seen per day in Table 15.¹

¹ Note: The number of trades performed does not commence at 1 as at the end of simulation day 1, in this case 3 trades had been performed. Subsequent days may have added 0, 1 or more increments to this tally.

db_name	ratio_SS_LIVE	
this_view	RESULTS_dayONday_cube	
MH_L_VL_10B_10S_40B_40S	0.89_0.89_0.6_0_999_1.2_0.9	
periodfrom	20100204	
Row Labels	Sum of noTrades	
12/02/2010 00:00		3
15/02/2010 00:00		4
16/02/2010 00:00		6
19/02/2010 00:00		12
23/02/2010 00:00		12
24/02/2010 00:00		14
25/02/2010 00:00		16
26/02/2010 00:00		19
02/03/2010 00:00		24
03/03/2010 00:00		26
04/03/2010 00:00		30
05/03/2010 00:00		31
08/03/2010 00:00		31
09/03/2010 00:00		31
11/03/2010 00:00		32
12/03/2010 00:00		32
15/03/2010 00:00		32
17/03/2010 00:00		32
18/03/2010 00:00		32
19/03/2010 00:00		32
22/03/2010 00:00		32
23/03/2010 00:00		32
25/03/2010 00:00		32
26/03/2010 00:00		32
29/03/2010 00:00		33
30/03/2010 00:00		33
31/03/2010 00:00		33
05/04/2010 00:00		37
06/04/2010 00:00		38
08/04/2010 00:00		44
09/04/2010 00:00		44
12/04/2010 00:00		44
13/04/2010 00:00		44
14/04/2010 00:00		45
15/04/2010 00:00		46
19/04/2010 00:00		47
20/04/2010 00:00		47
21/04/2010 00:00		47
22/04/2010 00:00		48
23/04/2010 00:00		48
26/04/2010 00:00		48
27/04/2010 00:00		48
04/05/2010 00:00		49
05/05/2010 00:00		49
06/05/2010 00:00		49
11/05/2010 00:00		49

Table 15: Live trade cumulative count

5.6.3 Final values vs ValueOnDay

The final amounts of each position and their value on the day can be seen in Table 16 and graphically in Figure 17.

db_name	(All)	
this_view	(All)	
MH_L_VL_10B_10S_40B_40S	(All)	
Values		
Row Labels	Sum of finalAmount	Sum of valueOnDay
12/02/2010 00:00	9475.957682	-251.4790352
15/02/2010 00:00	13430.07912	-251.4790352
16/02/2010 00:00	19419.64375	-10695.97801
19/02/2010 00:00	-6397.628237	7777.465159
23/02/2010 00:00	-6397.628237	5237.108472
24/02/2010 00:00	-3011.447505	2815.251599
25/02/2010 00:00	2315.85193	-2589.855606
26/02/2010 00:00	11262.06968	-8662.7395
02/03/2010 00:00	22260.82371	32554.08406
03/03/2010 00:00	24983.10927	20430.23086
04/03/2010 00:00	29895.48299	21719.35716
05/03/2010 00:00	30760.7986	23729.43319
08/03/2010 00:00	30760.7986	30760.7986
09/03/2010 00:00	30760.7986	30760.7986
11/03/2010 00:00	31361.4949	30554.55521
12/03/2010 00:00	31361.4949	30729.13998
15/03/2010 00:00	31361.4949	30309.14927
17/03/2010 00:00	31361.4949	31000.18307
18/03/2010 00:00	31361.4949	30819.80607
19/03/2010 00:00	31361.4949	32022.71166
22/03/2010 00:00	31361.4949	31361.4949
23/03/2010 00:00	31361.4949	31361.4949
25/03/2010 00:00	31361.4949	31361.4949
26/03/2010 00:00	31361.4949	31361.4949
29/03/2010 00:00	31950.51028	31930.54554
30/03/2010 00:00	31950.51028	31191.7389
31/03/2010 00:00	31950.51028	30834.99478
05/04/2010 00:00	43455.38412	31324.0916
06/04/2010 00:00	47001.84049	31958.39147
08/04/2010 00:00	56398.67894	25181.29648
09/04/2010 00:00	56398.67894	13490.70184
12/04/2010 00:00	56398.67894	1576.961424
13/04/2010 00:00	56398.67894	11027.33927
14/04/2010 00:00	57553.99237	20626.62813
15/04/2010 00:00	59924.80655	16558.96155
19/04/2010 00:00	58683.05004	49538.63509
20/04/2010 00:00	58683.05004	58505.70742
21/04/2010 00:00	58683.05004	59340.39407
22/04/2010 00:00	59193.82391	58186.61394
23/04/2010 00:00	59193.82391	58593.50771
26/04/2010 00:00	59193.82391	58077.12568
27/04/2010 00:00	59193.82391	59025.68013
04/05/2010 00:00	61816.56295	59019.67378
05/05/2010 00:00	61816.56295	61072.14723
06/05/2010 00:00	61816.56295	61701.06334
11/05/2010 00:00	61816.56295	61816.56295

Table 16: Live profit per trade

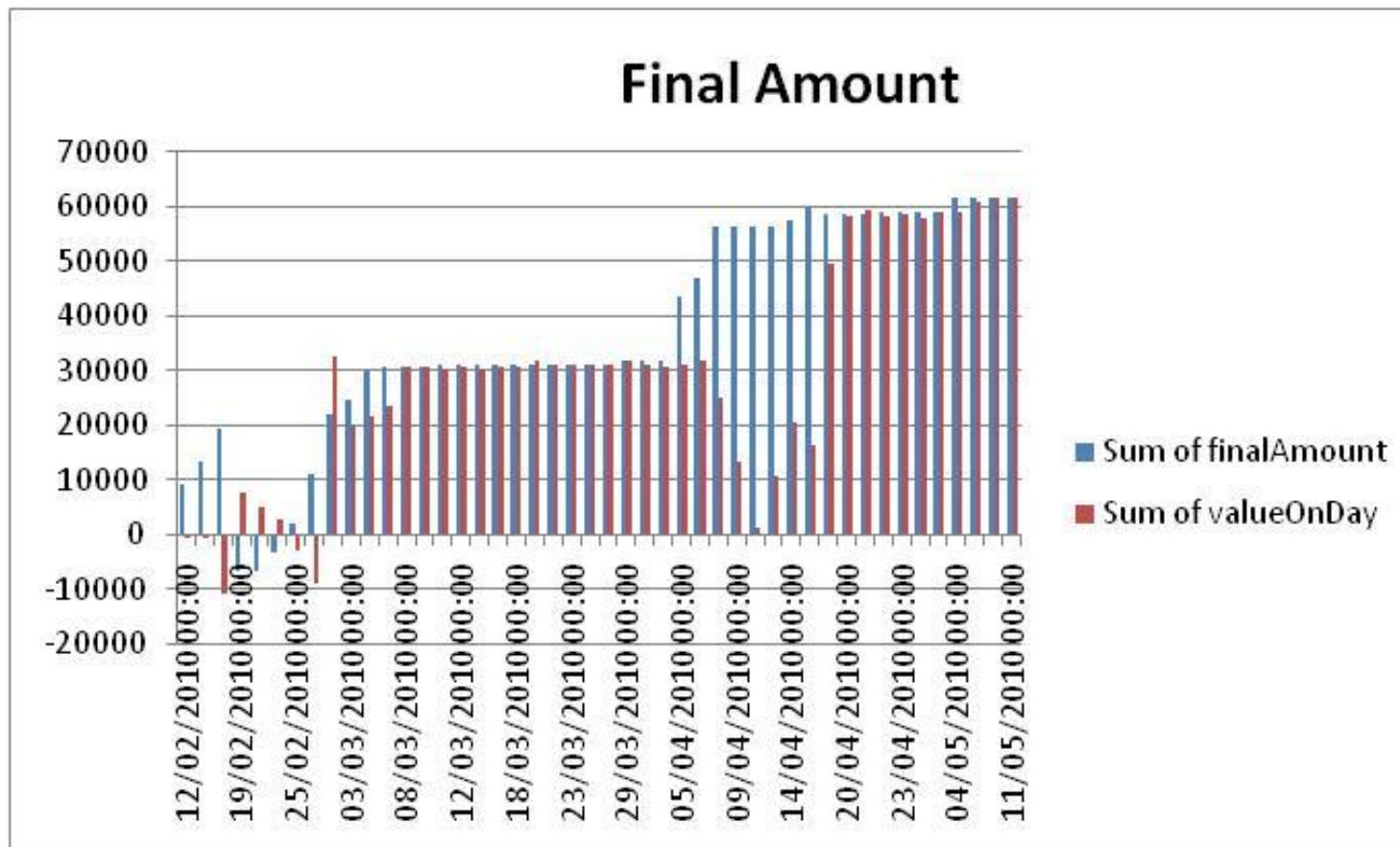


Figure 17: Live Final amount and valueOnDay

5.6.4 Breakdown

The breakdown into the actual pairs trades can be seen in Table 17 and graphically in Figure 18.

dt	12/05/2010 00:00								
periodfrom	(All)								
Sum of finalAmount	Column Labels								
Row Labels	ANAT	ESRX	INFY	ISBC	MSFT	NIHD	NTAP	XLNX	Grand Total
ALTR								10834.42433	10834.42433
BIDU				12665.05909					12665.05909
CTSH		3526.127607	11640.97204			4055.006035			19222.10568
DTV	-15873.58592								-15873.58592
GOOG					26647.5759		6494.843209		33142.41911
INFY						7352.485308			7352.485308
Grand Total	-15873.58592	3526.127607	11640.97204	12665.05909	26647.5759	11407.49134	6494.843209	10834.42433	67342.90761

Table 17: Live breakdown of pairs

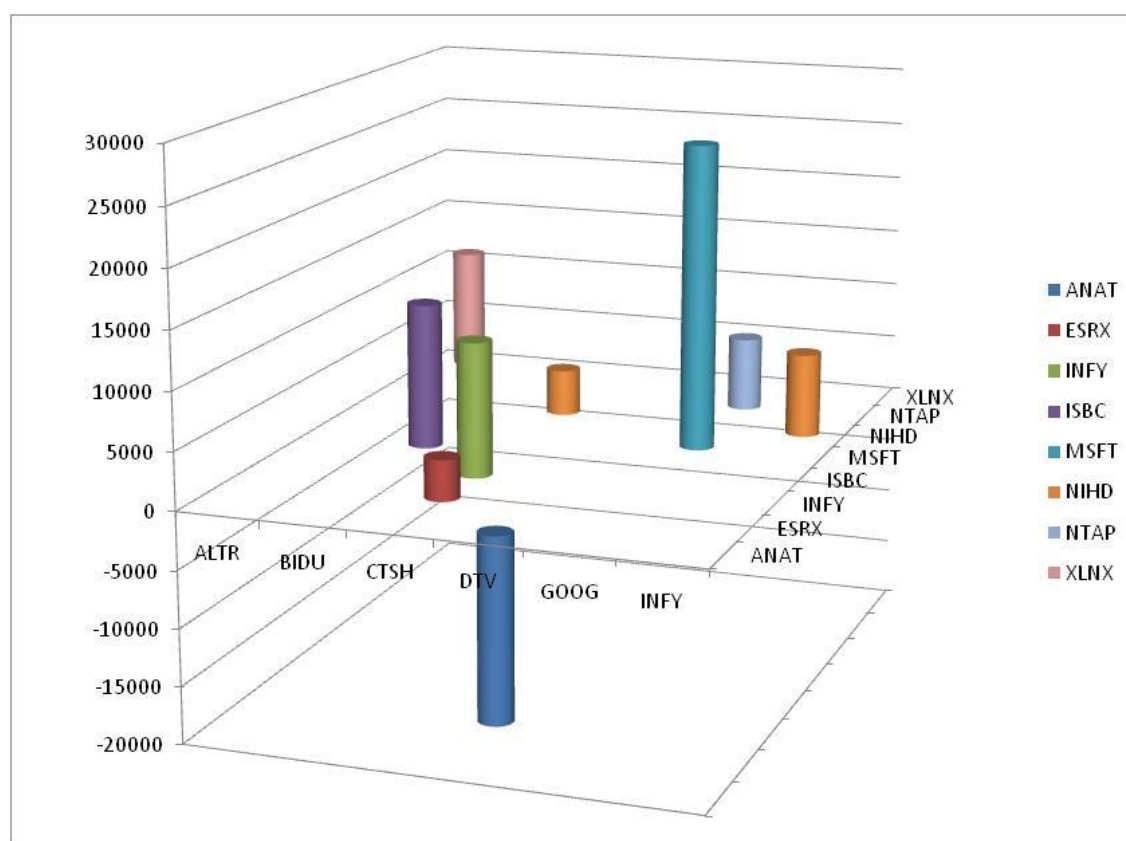


Figure 18: Live breakdown of pairs

5.6.5 Profit per trade

The profit per trade (based upon the value on the day / no. of trades) is shown in Figure 19.

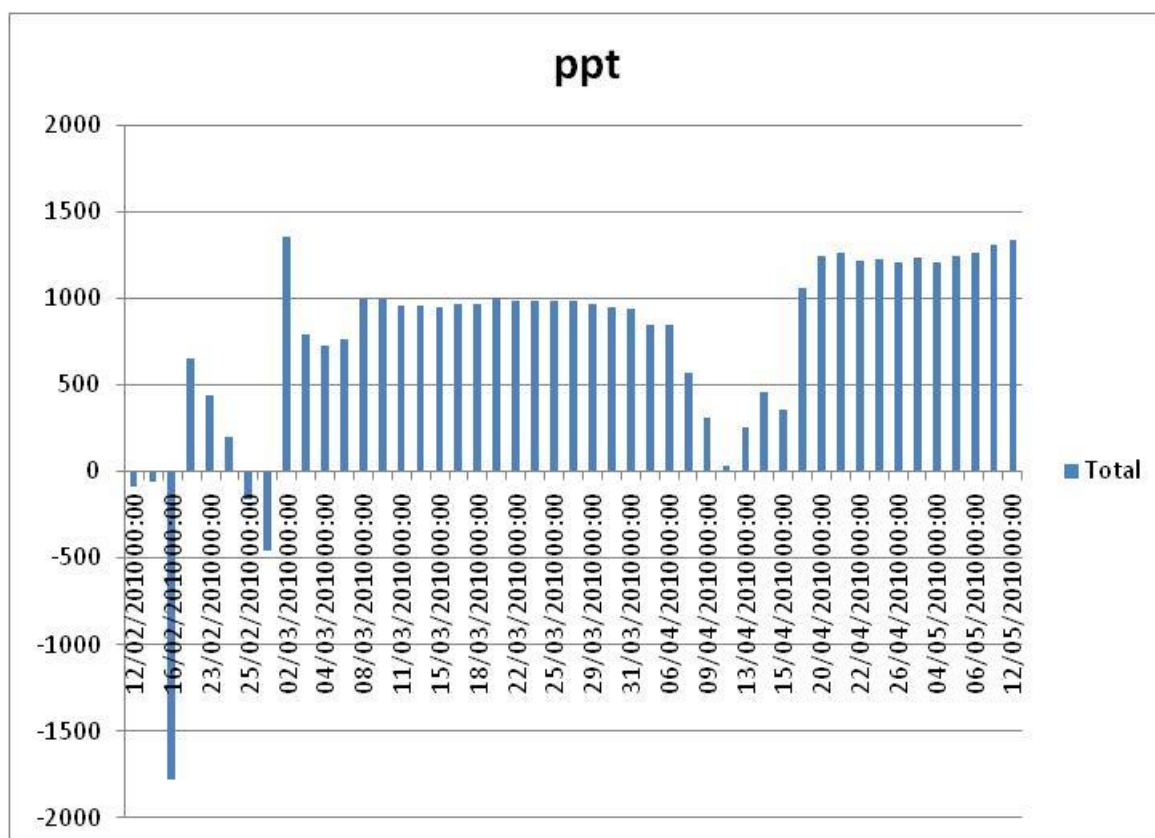


Figure 19: Live profit per trade

5.6.6 Reports

As previously mentioned, while live trading various reports are made available by the system to assist in the decision to make a pairs trade or not. Typical samples of these reports are shown in the following sections showing the report suggesting the opening of a position (Figure 20 – where it can be seen the ratio relationship has moved from the norm), on-going analysis of the position (Figure 21 – where the ratio relationship can be seen edging towards the norm once more) while open and the position when a closure is suggested (Figure 22 – where the relationship has indeed returned to the norm)^m. At all times the

^m It should be noted here that the application correctly picks up the anomaly and trades it before suggesting (and performing) a position closure. The reports detail this well.

period graphs overlaying one stock price graph alongside that of the suggested pair are made available in a report along with the up-to-date news on each stock.

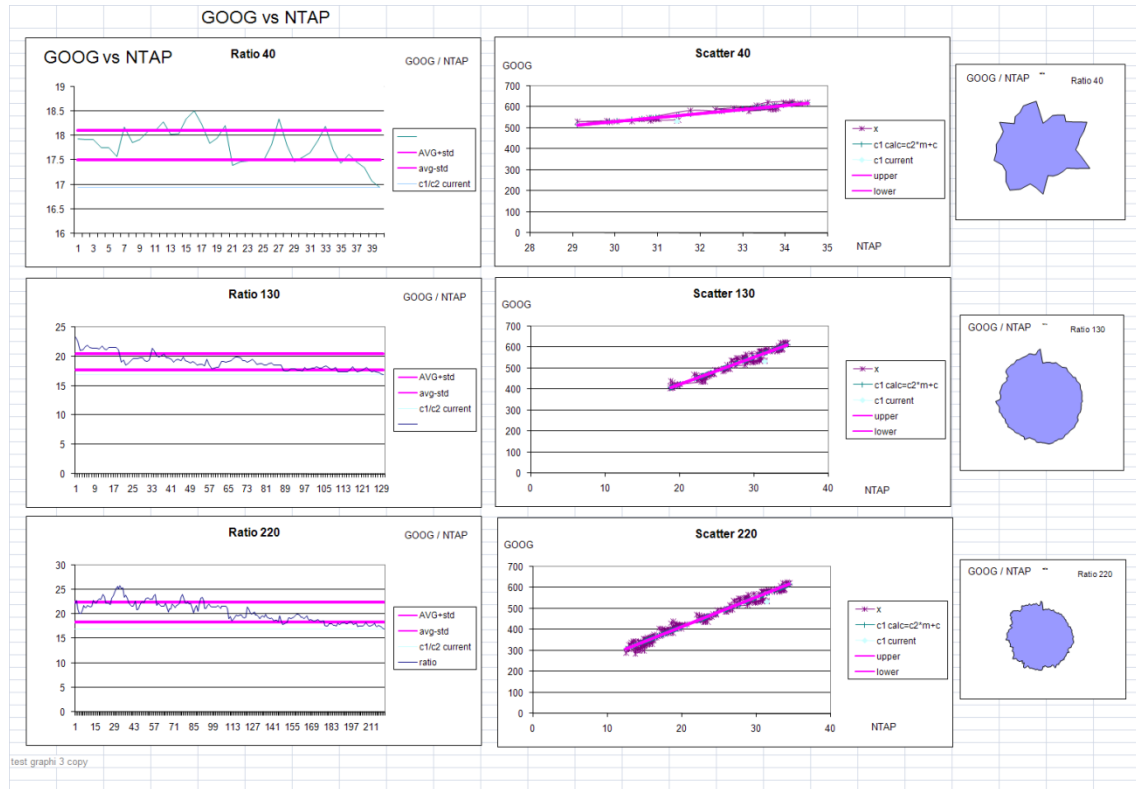


Figure 20: Live Open position suggestion^a GOOG-NTAP

40, 120 & 220 day Ratios , Scatter graphs and Radar ratio views

^a seq=8785 in the live data on the CD

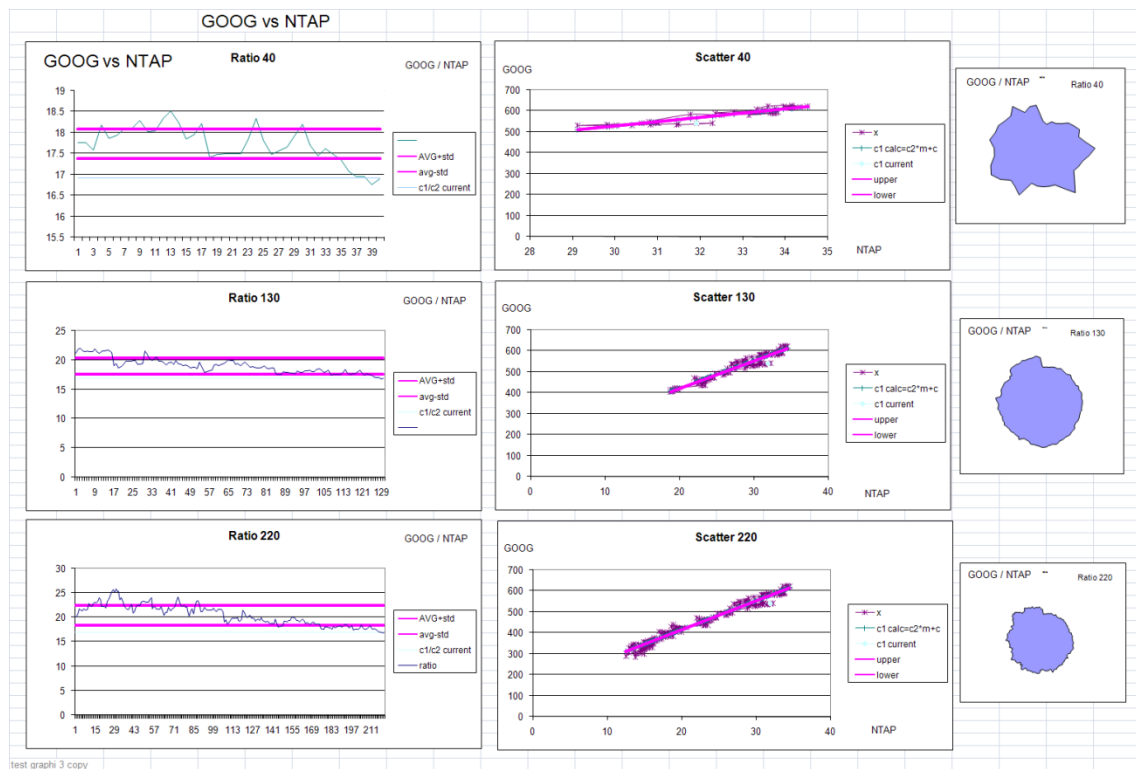


Figure 21: Live on-going position GOOG-NTAP

40, 120 & 220 day Ratios , Scatter graphs and Radar ratio views

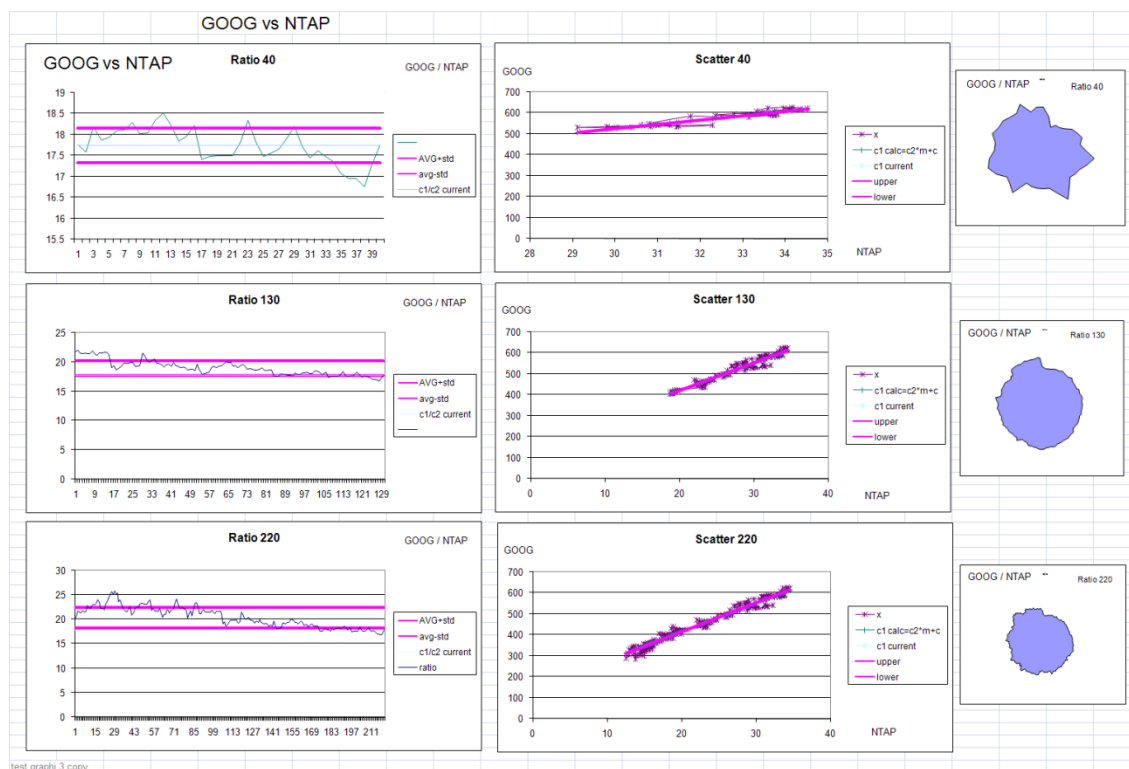


Figure 22: Live Suggested closure GOOG-NTAP

40, 120 & 220 day Ratios , Scatter graphs and Radar ratio views

Period graphs°

Figure 23 up to and including Figure 28 show the assistance given by the system via trading reports. These views are just there to enhance the confidence in the trade by confirming visually the relationships the numbers suggest.

° All available at Yahoo Finance Graphs (<http://Yahoo.com>)



Figure 23: A view of the relative performance of the stock and any unusual trading volumes in a 1 Year period



Figure 24: A view of the relative performance of the stock and any unusual trading volumes in a 3 Month period



Figure 25: A view of the relative performance of the stock and any unusual trading volumes in a 3 month period



Figure 26: 3 Months Stock Graph of first party in the pair to show unusual volume or price movement



Figure 27: 3 Months Stock Graph of second party in the pair to show unusual volume or price movement

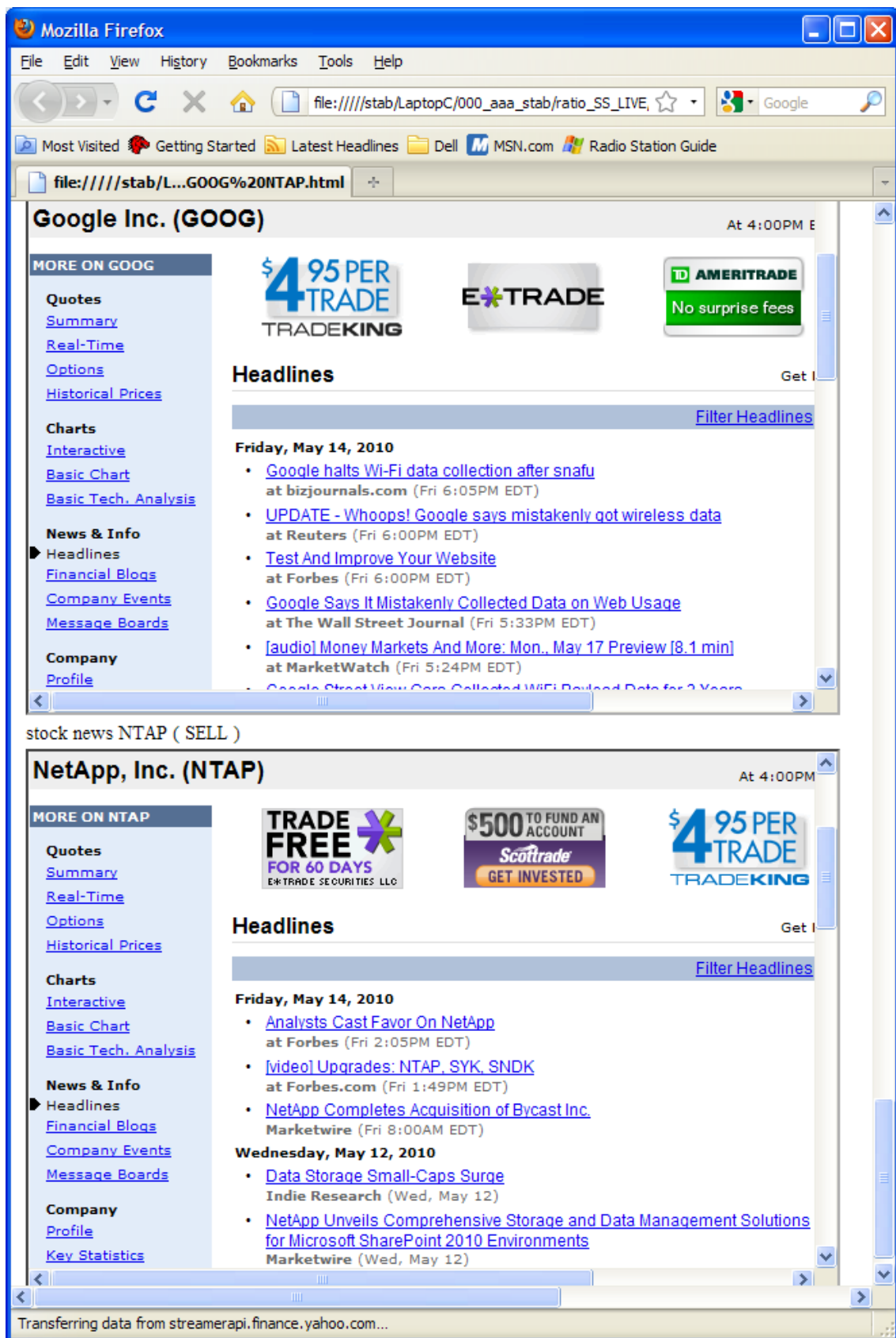


Figure 28: News from each component of the pair

5.7 Pseudo Real Time

5.7.1 Data

The data for this can be seen on the CD in the excel file **LIVE PSEUDO.xlsm** in the **pseudo live replay data** tab. Remember this is a replay for the live scenario there will only be a maximum of one trade in each pair as only end of day values are used. There will therefore be fewer trades overall.

5.7.2 Number of trades

The total of trades (positions) that have been performed on any given day can be seen in Table 18.

MH_L_VL_10B_10S_40B_40S	0.89_0.89_0.6_0_999_1.2_0.9	✓
periodfrom	20100212	✓
Row Labels	Count of noTrades	
15/03/2010	1	
17/03/2010	1	
18/03/2010	1	
19/03/2010	1	
22/03/2010	1	
23/03/2010	1	
25/03/2010	2	
26/03/2010	2	
29/03/2010	3	
30/03/2010	4	
31/03/2010	6	
05/04/2010	7	
06/04/2010	7	
08/04/2010	7	
09/04/2010	7	
12/04/2010	7	
13/04/2010	7	
14/04/2010	8	
15/04/2010	8	
19/04/2010	9	
20/04/2010	9	
21/04/2010	9	
22/04/2010	10	
23/04/2010	10	
26/04/2010	11	
27/04/2010	12	
04/05/2010	13	
05/05/2010	13	
06/05/2010	13	
07/05/2010	13	

Table 18: Live Pseudo cumulative number of trades

5.7.3 Pseudo Real Time Replay

The final amounts of each position and value of them on the day can be seen in Table 19 and graphically in Figure 29: Live Pseudo final values and value of day of positions.

MH_L_VL_10B_10S_40B_40S	0.89_0.89_0.6_0_999_1.2_0.9	
periodfrom	20100212	
Values		
Row Labels	Sum of finalAmount	Sum of valueOnDay
15/03/2010	1713.354129	0
17/03/2010	1713.354129	705.6380026
18/03/2010	1713.354129	521.4589243
19/03/2010	1713.354129	1713.354129
22/03/2010	1713.354129	1713.354129
23/03/2010	1713.354129	1713.354129
25/03/2010	2771.122201	1713.354129
26/03/2010	2771.122201	1475.755139
29/03/2010	5117.47665	2734.965131
30/03/2010	5880.06909	3244.397864
31/03/2010	8300.138638	1352.913082
05/04/2010	11539.58837	6794.871329
06/04/2010	11539.58837	8556.719204
08/04/2010	11539.58837	6956.921761
09/04/2010	11539.58837	7736.429898
12/04/2010	11539.58837	9866.817107
13/04/2010	11539.58837	11539.58837
14/04/2010	17212.05602	11539.58837
15/04/2010	17212.05602	10338.6002
19/04/2010	16863.51834	17212.05602
20/04/2010	16863.51834	15948.4602
21/04/2010	16863.51834	16774.05434
22/04/2010	17283.13573	15630.80435
23/04/2010	17283.13573	16037.00285
26/04/2010	18870.29169	15433.5345
27/04/2010	19698.67172	17225.58171
04/05/2010	24359.92283	17183.78596
05/05/2010	24359.92283	18697.00502
06/05/2010	24359.92283	21094.71637
07/05/2010	24359.92283	24359.92283

Table 19: Live Pseudo final values and value of day of positions

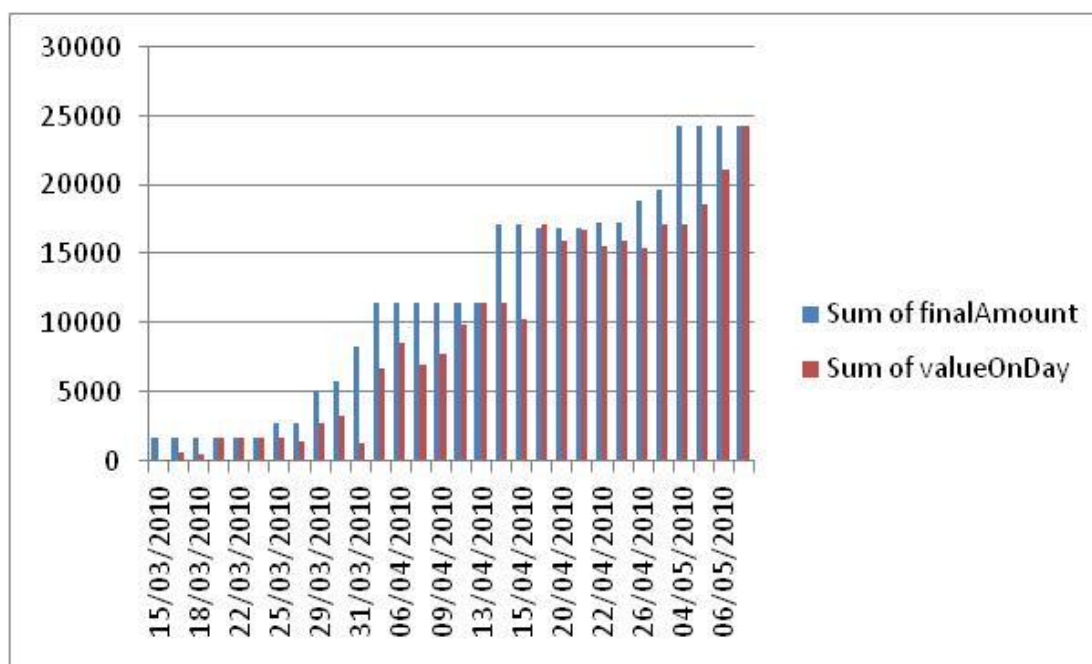


Figure 29: Live Pseudo final values and value of day of positions

5.7.4 Profit per trade

In this case the profit per trade is as seen in Table 20 and graphically in Figure 30.

MH_L_VL_10B_10S_40B_40S 0.89 0.89 0.6 0.999 1.2 0.9	
periodfrom	20100212
Row Labels	Sum of ppt
15/03/2010	0
17/03/2010	705.6380026
18/03/2010	521.4589243
19/03/2010	1713.354129
22/03/2010	1713.354129
23/03/2010	1713.354129
25/03/2010	856.6770643
26/03/2010	737.8775695
29/03/2010	911.6550435
30/03/2010	811.0994659
31/03/2010	225.4855137
05/04/2010	970.6959041
06/04/2010	1222.388458
08/04/2010	993.8459658
09/04/2010	1105.204271
12/04/2010	1409.545301
13/04/2010	1648.512624
14/04/2010	1442.448546
15/04/2010	1292.325025
19/04/2010	1912.450669
20/04/2010	1772.051134
21/04/2010	1863.783816
22/04/2010	1563.080435
23/04/2010	1603.700285
26/04/2010	1403.048591
27/04/2010	1435.465143
04/05/2010	1321.829689
05/05/2010	1438.231155
06/05/2010	1622.67049
07/05/2010	1873.840218

Table 20: Live Pseudo profit per trade

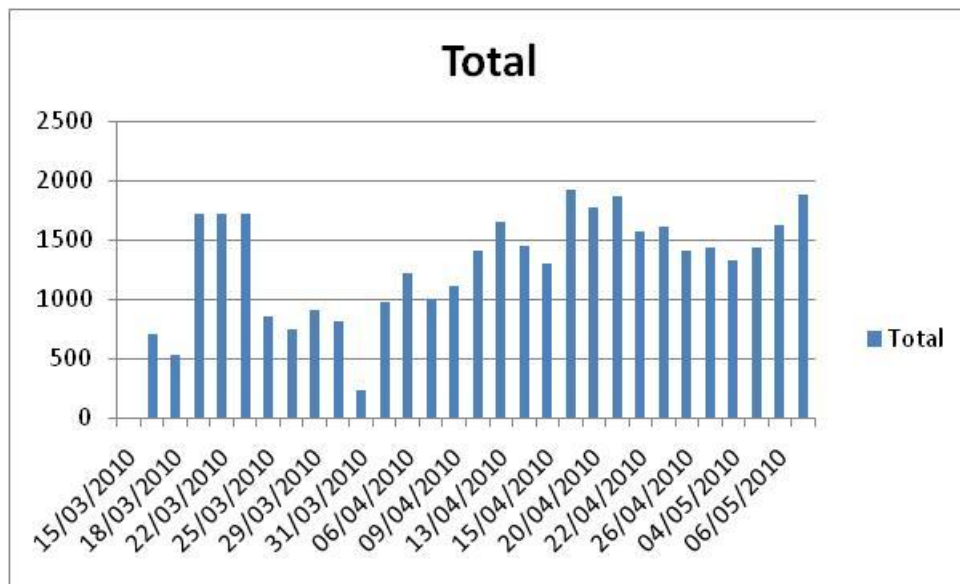


Figure 30: Live Pseudo profit per trade

5.8 Live Pseudo Replay

Data

The data for this can be seen on the CD in the excel file

LIVE_PSEUDO_REPLAY.xlsm in the **pseudo live replay data** tab.

Remember this is a replay for the live scenario there will only be a maximum of one trade in each pair as only end of day values are used.

There will therefore be less trades overall. An extract of the simulation data can be seen in Table 21.

db_name	this view	MH L VL 10B 10S 40B 40S	periodfrom	dt	seq	k ticker	y ticker	finalAmount	valueOnDay	noTrad
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	15/02/2010 00:00	9618	GOOG	NTAP	5555.267641	0	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	15/02/2010 00:00	9619	DTV	NTAP	9957.596493	0	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	16/02/2010 00:00	9618	GOOG	NTAP	5555.267641	-1135.69347	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	16/02/2010 00:00	9619	DTV	NTAP	9957.596493	-1985.795241	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	19/02/2010 00:00	9618	GOOG	NTAP	5555.267641	1933.834691	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	19/02/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	23/02/2010 00:00	9618	GOOG	NTAP	5555.267641	5555.267641	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	23/02/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	24/02/2010 00:00	9618	GOOG	NTAP	5555.267641	5555.267641	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	24/02/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	25/02/2010 00:00	9618	GOOG	NTAP	5555.267641	5555.267641	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	25/02/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	26/02/2010 00:00	9618	GOOG	NTAP	5555.267641	5555.267641	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	26/02/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	02/03/2010 00:00	9618	GOOG	NTAP	5555.267641	5555.267641	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	02/03/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	03/03/2010 00:00	9618	GOOG	NTAP	5555.267641	5555.267641	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	03/03/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	04/03/2010 00:00	9618	GOOG	NTAP	5555.267641	5555.267641	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	04/03/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	05/03/2010 00:00	9618	GOOG	NTAP	5555.267641	5555.267641	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	05/03/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	08/03/2010 00:00	9618	GOOG	NTAP	5555.267641	5555.267641	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.87_0.87_0.6_0_999_1.2_0.8	20100212	08/03/2010 00:00	9619	DTV	NTAP	9957.596493	9957.596493	1

... 11,000+ rows ...

PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	26/04/2010 00:00	9612	ALTR	XLNX	1587.155966	0	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	27/04/2010 00:00	9605	CTSH	ESRX	6936.013658	6936.013658	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	27/04/2010 00:00	9606	ALTR	XLNX	-348.5376872	-1260.612272	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	27/04/2010 00:00	9610	CTSH	INFY	419.6173915	419.6173915	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	27/04/2010 00:00	9612	ALTR	XLNX	1587.155966	854.5205671	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	27/04/2010 00:00	9613	ALTR	XLNX	828.3800219	0	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	04/05/2010 00:00	9605	CTSH	ESRX	6936.013658	6936.013658	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	04/05/2010 00:00	9606	ALTR	XLNX	-348.5376872	-1233.329077	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	04/05/2010 00:00	9610	CTSH	INFY	419.6173915	419.6173915	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	04/05/2010 00:00	9612	ALTR	XLNX	1587.155966	804.6697402	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	04/05/2010 00:00	9613	ALTR	XLNX	828.3800219	-19.22811686	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	04/05/2010 00:00	9614	CTSH	INFY	4661.251113	0	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	05/05/2010 00:00	9605	CTSH	ESRX	6936.013658	6936.013658	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	05/05/2010 00:00	9606	ALTR	XLNX	-348.5376872	-1493.314804	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	05/05/2010 00:00	9610	CTSH	INFY	419.6173915	419.6173915	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	05/05/2010 00:00	9612	ALTR	XLNX	1587.155966	537.2328494	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	05/05/2010 00:00	9613	ALTR	XLNX	828.3800219	-291.2908505	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	05/05/2010 00:00	9614	CTSH	INFY	4661.251113	2312.704409	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	06/05/2010 00:00	9605	CTSH	ESRX	6936.013658	6936.013658	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	06/05/2010 00:00	9606	ALTR	XLNX	-348.5376872	-570.7341746	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	06/05/2010 00:00	9610	CTSH	INFY	419.6173915	419.6173915	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	06/05/2010 00:00	9612	ALTR	XLNX	1587.155966	1402.389915	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	06/05/2010 00:00	9613	ALTR	XLNX	828.3800219	622.7195653	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	06/05/2010 00:00	9614	CTSH	INFY	4661.251113	2008.667654	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	07/05/2010 00:00	9605	CTSH	ESRX	6936.013658	6936.013658	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	07/05/2010 00:00	9606	ALTR	XLNX	-348.5376872	-348.5376872	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	07/05/2010 00:00	9610	CTSH	INFY	419.6173915	419.6173915	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	07/05/2010 00:00	9612	ALTR	XLNX	1587.155966	1587.155966	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	07/05/2010 00:00	9613	ALTR	XLNX	828.3800219	828.3800219	1
PSEUDO_LIVE_REPLAY	RESULTS_dayONday_cube	0.89_0.89_0.6_0_999_1_0.9	20100414	07/05/2010 00:00	9614	CTSH	INFY	4661.251113	4661.251113	1

Table 21: Live pseudo replay simulation data extract

5.8.1 Number of trades

The total of trades (positions) that have been performed on any given day can be seen in Table 22.

dt	07/05/2010													
Count of noTrades		Column Labels												
		0.87_0.87_0.6_0.999_1.2_0.6 0.87_0.87_0.6_0.999_1.2_0.5 0.87_0.87_0.6_0.999_1.4_0.6 0.87_0.87_0.6_0.999_1.4_0.5 0.89_0.89_0.6_0.999_1.0_0.8 0.89_0.89_0.6_0.999_1.0_0.9 0.89_0.89_0.6_0.999_1.2_0.6 0.89_0.89_0.6_0.999_1.2_0.5 0.89_0.89_0.6_0.999_1.4_0.6 0.89_0.89_0.6_0.999_1.4_0.5												
Row Labels		Grand Total												
20100212		25	25	23	23	30	30	13	13	12	12	15	15	236
20100303		23	23	21	21	28	28	13	13	12	12	15	15	224
20100323		21	21	19	19	24	24	12	12	11	11	14	14	202
20100414		8	8	6	6	9	9	6	6	5	5	6	6	80
Grand Total		77	77	69	69	91	91	44	44	40	40	50	50	742

Table 22: Live Pseudo Replay number of trades

5.8.2 Varying simulation start date and code trigger parameters

Using the replay set of data it was possible to not only replay the set of parameters used in trading but also to vary them to once again try to see which parameters seem optimal. To ensure they are not just optimal for the period of the replay with the start date just of the period it was also possible to replay this data with 4 start dates almost a week apart within this period. The profit from this can be seen in Table 23.

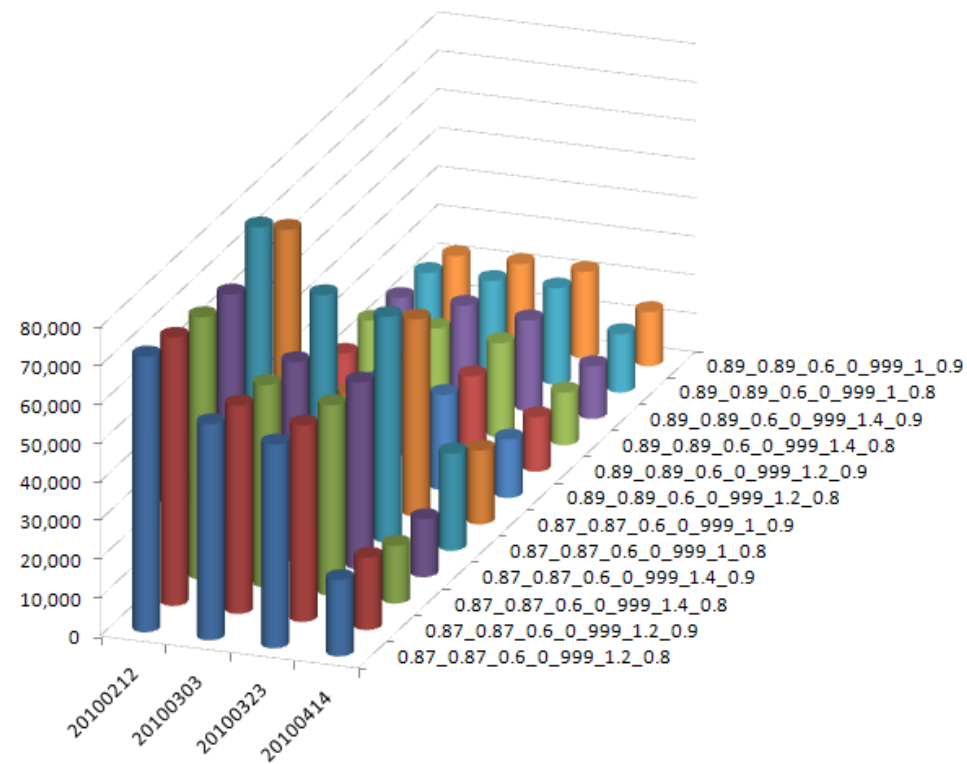


Figure 31: Comprehensive assessment

5.8.3 Per trade breakdown

I have stated that the simulation with different start dates just described does not make a loss, this is a sum of the profit/loss of the underlying trades. When the simulation is broken down some trades do indeed make a loss but the loss is not as bad as to wipe out profit made in other trades. A breakdown of individual position profit/loss can be seen in Figure 32.

PTO

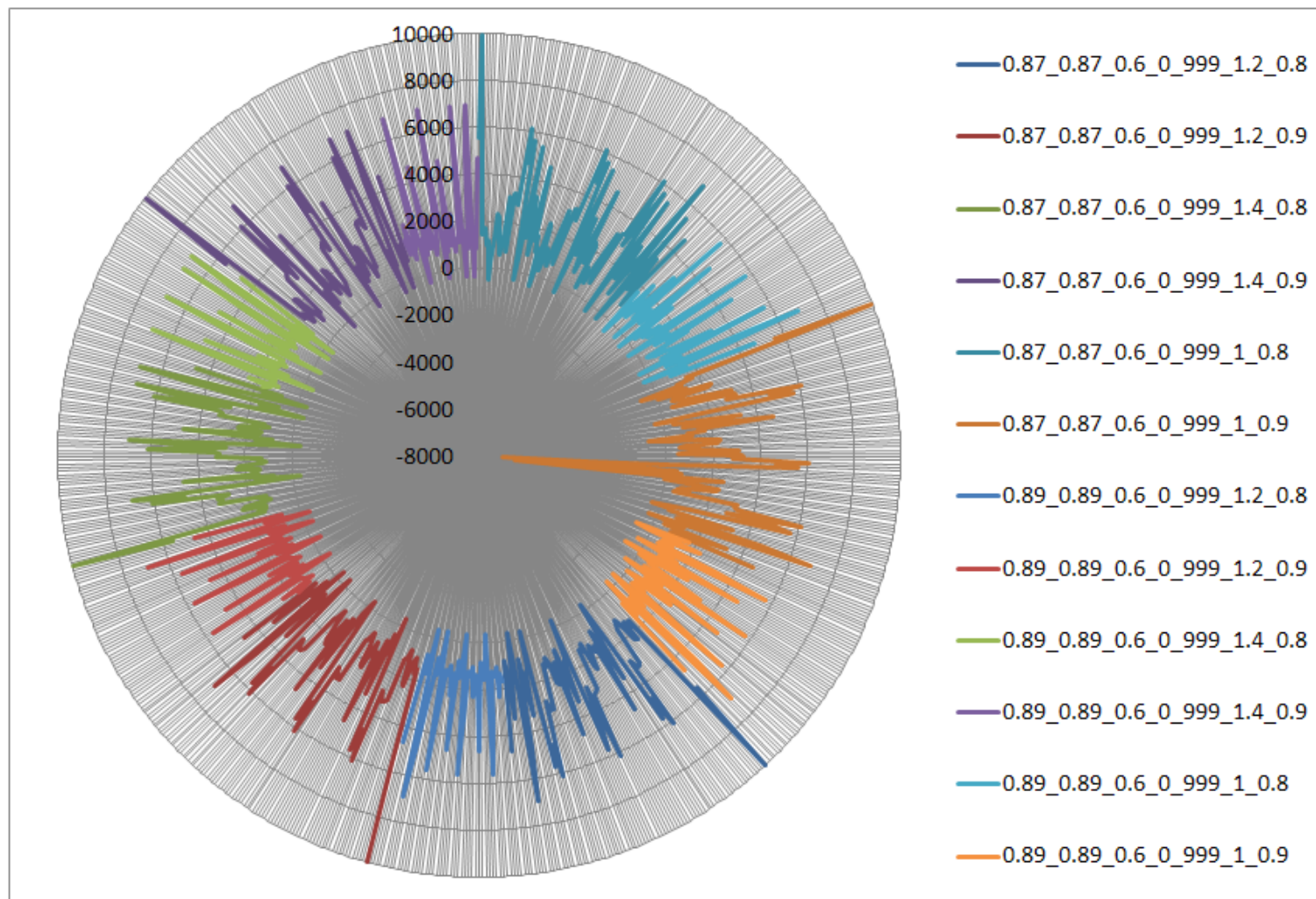


Figure 32: Per trade breakdown

5.8.4 Profit per trade

The profit per trade can be seen in Table 24. Given trade here refers really to position (which is really 2 trades – a long and a short) the profit per trade is more than acceptable if it can be continued.

dt	07/05/2010													
Sum of ppt	Column Labels													
										</				

Table 24: Profit per trade

This data can be seen graphically in Figure 33.

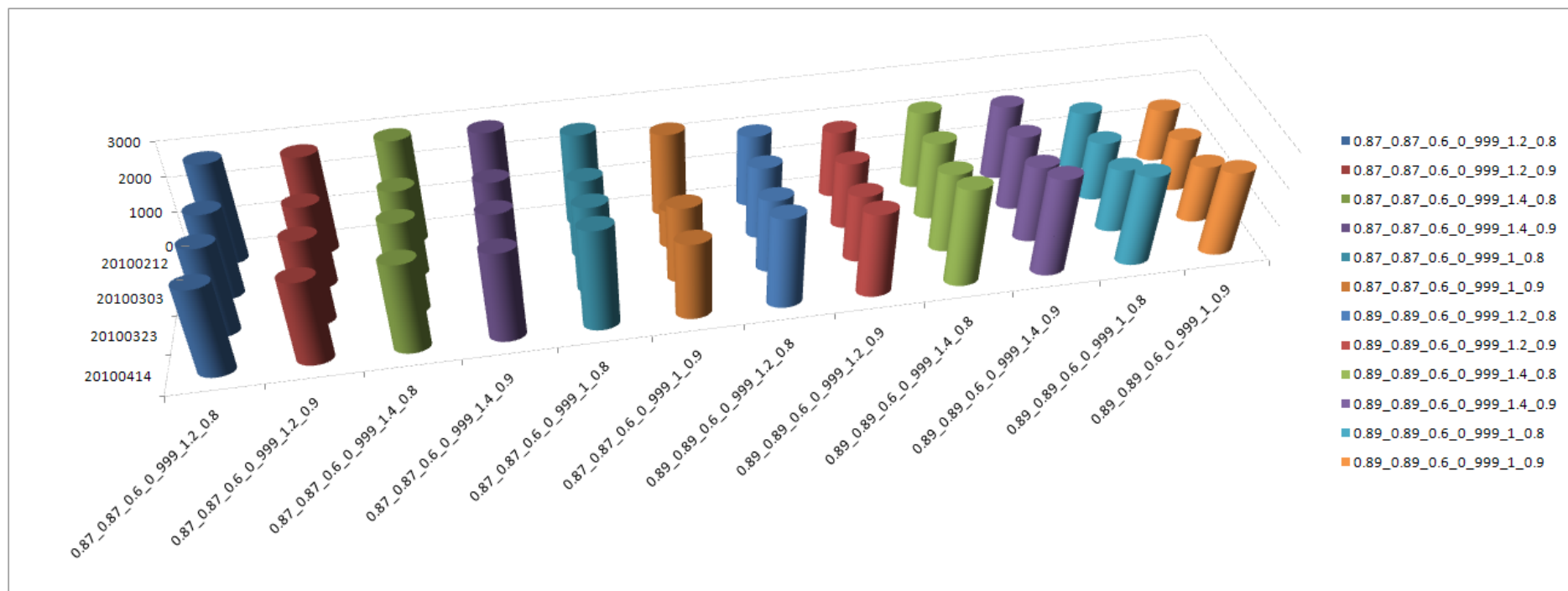


Figure 33: Profit per trade

5.8.5 Annualised Profit

Taking the data from Table 23 and looking at the number of days in each simulation, it is possible to estimate the annualised percentage profit of each the pseudo live replay runs. This can be seen in Figure 34, which highlights the largest (green) and smallest (red) profit percentage. The largest annualised percentage profit was 44.4% in the 23 day simulation while the smallest annualised percentage profit was 6.0% in the 65 day simulation.

	days in sim	0.87_0.87_0.6_0_999_1.2_0.8	0.87_0.87_0.6_0_999_1.2_0.9	0.87_0.87_0.6_0_999_1.4_0.8	0.87_0.87_0.6_0_999_1.4_0.9	0.87_0.87_0.6_0_999_1_0.8	0.87_0.87_0.6_0_999_1_0.9	0.89_0.89_0.6_0_999_1.2_0.8	0.89_0.89_0.6_0_999_1.2_0.9	0.89_0.89_0.6_0_999_1.4_0.8	0.89_0.89_0.6_0_999_1.4_0.9	0.89_0.89_0.6_0_999_1_0.8	0.89_0.89_0.6_0_999_1_0.9
20100212	84	12.4	12.1	12.9	12.7	11.2	10.2	8.8	8.1	9.5	9.1	7.2	6.5
20100303	65	13.7	13.2	14.0	13.8	12.5	6.0	11.4	10.5	12.2	11.8	9.3	8.4
20100323	45	20.4	19.6	21.1	20.7	19.8	17.3	16.7	15.3	18.0	17.3	14.5	13.0
20100414	23	39.2	37.1	39.6	39.6	44.4	33.8	40.1	37.3	43.4	43.4	40.1	37.3

Figure 34: Annualised profit

The percentage is computed based upon the raw profit in the simulation trading period as a fraction of the amount needed to fund one half of the pairs trade, which is then turned into an annualised percentage^p.

While it is clear that the results seem impressive it is worth noting that the percentage returns get larger as the number of days in the simulation gets lower. This seems to imply returns die off as time goes on. Ideally these would remain constant and not fluctuate with the period of the simulation. It is also worth noting that there were no overall losses as previously mentioned.

^p Both sides of the pairs trade may be used but it is fairer to use one half as the total number of trades have been used and not all trades are open at any one time.

CHAPTER 6 FURTHER WORK

This brief chapter is included to perhaps stimulate further work in the directions I have gone with a view to perfecting the technique. The following areas may be expanded upon with further work:

6.1 Rising, falling and level simulations

On the whole the results of simulations in these periods were inconclusive. If these had been otherwise then I may have been tempted to have traded for real.

6.2 Real time trading

While it may not be possible to trade faster than major institutions it is possible that by at least analysing the ratios for the periods here and trading as has been performed here can yield enough of a profit as to warrant continuation of the work here.

At best, this work has relied upon near real time batch downloads of 20 minute delayed prices and the downloading of end-of-day prices for period simulation. It is both possible and likely major institutions are still using this technique to generate revenues and have advanced there spotting to use real time pricing. Further work may be beneficial along this line of research.

6.3 Parameter wrapping

Within the “what to buy code” (see the CD, Java\code folder and ss_param_based_wtb3.java) there can be seen a number of strategies that can be used. The one used for this thesis uses one called avgbase40. The strategy itself is picked up from a file (with <name>.strategy) in the runtime directory on the PC and needs a name corresponding to the name of the strategy in the code.

There are currently sections of code wrapping the trading parameters that check:

1. The current values of r for each period are greater than those set in the trading parameter table in the database^q.
2. The ratio for the given period has been exceeded by the multiple of the standard deviation^r
3. The high and medium level regression lines have positive slopes
4. All stocks have prices above 5 (not doing so has caused problems in the past)
5. There exists an r2 value in the past month greater than the current last calculated value (i.e. an attempt to spot the time

^q + " and GTBS.PER_HIGH_r > TP.r2medNHigh \n" //20080918
+ " and GTBS.PER_MED_r > TP.r2medNHigh \n"
+ " and GTBS.PER_LOW_r > TP.r2low \n"

^r + " and ABS(avg40ratio*Y.closingPrice-X.closingPrice) \n"
+ " > stdevp40buyfactor*GTBS.stdevp40*Y.closingPrice \n"

when the deviation is getting greater than the norm and not moving back towards the norm)^s

I believe more work could be performed to find the optimal point of trading such that trades occur when the movement back to the norm starts and not as it is moving further away from the norm.

6.4 Changing regression values

Regression values are currently calculated at the end of the week. Computing these each day prove a better strategy and warrants additional work.

The effect of r2 values changing over time have been noted in the simulations. This work has included work to compensate for value in the regression measures changing – with positions being closed when they move adversely. It may be pertinent to do forward projections on regression values to spot when company stock is becoming more closely linked.

```
s + " and exists \n" // 20090625 see cr
+ " ( select * \n"
+ "   from GEN_TRD_basis_HIST as GEN_TRD_basisR2LIMIT \n"
+ "   where GEN_TRD_basisR2LIMIT.TD > \n"
+ "         (select dateadd(m,-1,max( ll.dt )) from last_load as ll)\n"
+ "   and GEN_TRD_basisR2LIMIT.X_ticker = GTBS.X_ticker \n"
+ "   and GEN_TRD_basisR2LIMIT.Y_ticker = GTBS.Y_ticker \n"
+ "   and GEN_TRD_basisR2LIMIT.PER_LOW_r > GTBS.PER_LOW_r \n"
+ " )\n\n"
```

I believe historical checks on values of r^2 when trading to establish first and second order derivatives may also be worth further work. Knowing if an r^2 value is rising or falling and what it is likely to do could be factored into the trading decision process. I believe this could be done by increasing the frequency of the batch regression run from weekly to daily and fitting either a linear or quadratic prediction to the data and then incorporating the suggested trend movement into the what to buy program decision making.

6.5 Profit and Loss

There are many possible ways of looking at profit and loss from a pairs investor point of view. Two ways in particular are: Where the investor has an infinite supply of money in the bank and takes out whatever position the trading system suggests; the second assumes the investor has a fixed amount of money and conducts trades of a nominal amount each until the money is used up.

The former is the method I have used as the returns can be viewed as an average of all suggested trades. While infinite money in the bank may not be a realistic assumption it must be remembered that the nominal of each position can be adjusted to fit the investor's purse strings and so the maximum outstanding is never more than the investor had.

The latter is a more realistic model as people have limited money but it does not give the theoretical amount to be gained. This is worth noting when looking at results in depth. Unfortunately I did not get this far into the analysis.

The tailing off of profit, mentioned in section 5.8.5, is worth further investigation as the behaviour seems quite interesting and not what would really be expected.

CHAPTER 7 CONCLUSIONS

7.1 Rising, Falling and Level Market Movement Simulations

The method needs volatility of price movements, so it is somewhat intuitive that the results from the level simulations are uninspiring. A larger percentage of profit for all trading parameter values can be seen in the results for the rising simulation. In the falling simulation there are unpredictable profit and loss peaks which should not occur with an infallible method. The cause of this cannot be pinpointed at this point, it would however be a nice piece of research for an M.Sc. student to investigate why such an event happens. It seems similar in nature to the gains and losses seen in the early stages of “gamblers ruin” of the frequency of tossed heads in coin flipping. This may lead us to conclude that the method has not yet been perfected and the optimal parameters not yet found.

The strategy and parameters employed in this work did not produce the anticipated and consistent gains^t.

7.2 Testing

Testing has shown that the application works. Simulation within the set of rising, falling and level scenarios however, has failed to conclusively find the holy grail parameter set of values that yield profit regardless of the date the simulation starts at. Despite positive results with the

^t Claimed in other works

performance in real time trading (with several starting points used to test further) profit was obtained in all replay runs. As yet however I have not been bold enough to invest my own money in the technique.

I believe the key to a successful strategy is one which on the whole outperforms the general market and this cannot be said to be the case, at least for the testing and simulations I have performed. Again the key decision with any strategy has to be “Would you invest your own money in the venture?”.

7.3 Performance in a Real time scenario

The strategy for trading (detailed parameters and strategy for which are detailed in section 6.3 Parameter Wrapping). In the real-time and subsequent real time replay (with different start dates) the simulation yielded promising results (by which I mean a person could almost make a living assuming savings at hand are there to enable all trades).

While significant annualised percentage gains of between 6.0% and 44.1% have been achieved in later simulations this could be due to factors present in the market at the time and as yet unconsidered influences.

Significant though the results are, the absence of similar consistent profit in the rising, falling and level simulations makes me hold back from trading. Call me sceptical or cautious, but as a person who has

lost significant money before – I do not want to do it again. I will wait until the work is perfected!

7.4 Trading Reports

The reports that are produced to guide the taking out of a position or monitoring it have proved very useful and necessary. The two basic reports consist of a historical summary of the ratio of the stock prices in the pair shown as a ratio against time horizontally and as a polar plot for all three periods 60, 130 and 22 days. The aim of this ratio report is to show the variation from the norm (with standard deviation from the norm) shown to allow a “by eye” analysis of trend has been proven useful.

The internet based report aiming to show the relative performance of the pairs over 3 time periods, the current price graph of each company in the pair and any current new items relating to the company’s in the pair, has also proved its worth to the application.

The splits report produced to inform of corporate actions has also proved useful in identifying trading trigger glitches as not being real triggers.

7.5 General feeling

While the interpretation of results does not bode well for a totally infallible alchemist dream, I still believe that somewhere in this method

is a holy grail. I believe the credit crunch may have adversely affected the financial side of the sectors I have been using. Further work may be able to establish this.

APPENDIX 1. Proof of code

7.6 Testing and Setup

Proof of code was done as a unit test comparing LINEST computations for a known price history with that of the code and values placed into the database. A spreadsheet was then used to generate the historical test data for the 3 simulations in this appendix to test the trigger mechanism for trading in different scenarios (see **testdata.xls** on attached CD).

The historical data generated and used in the 3 simulations is the same. Graphs for the stock prices are shown in Figure 35 (the tabulated data can be seen on the enclosed DVD as it is too long to be included here in text form).

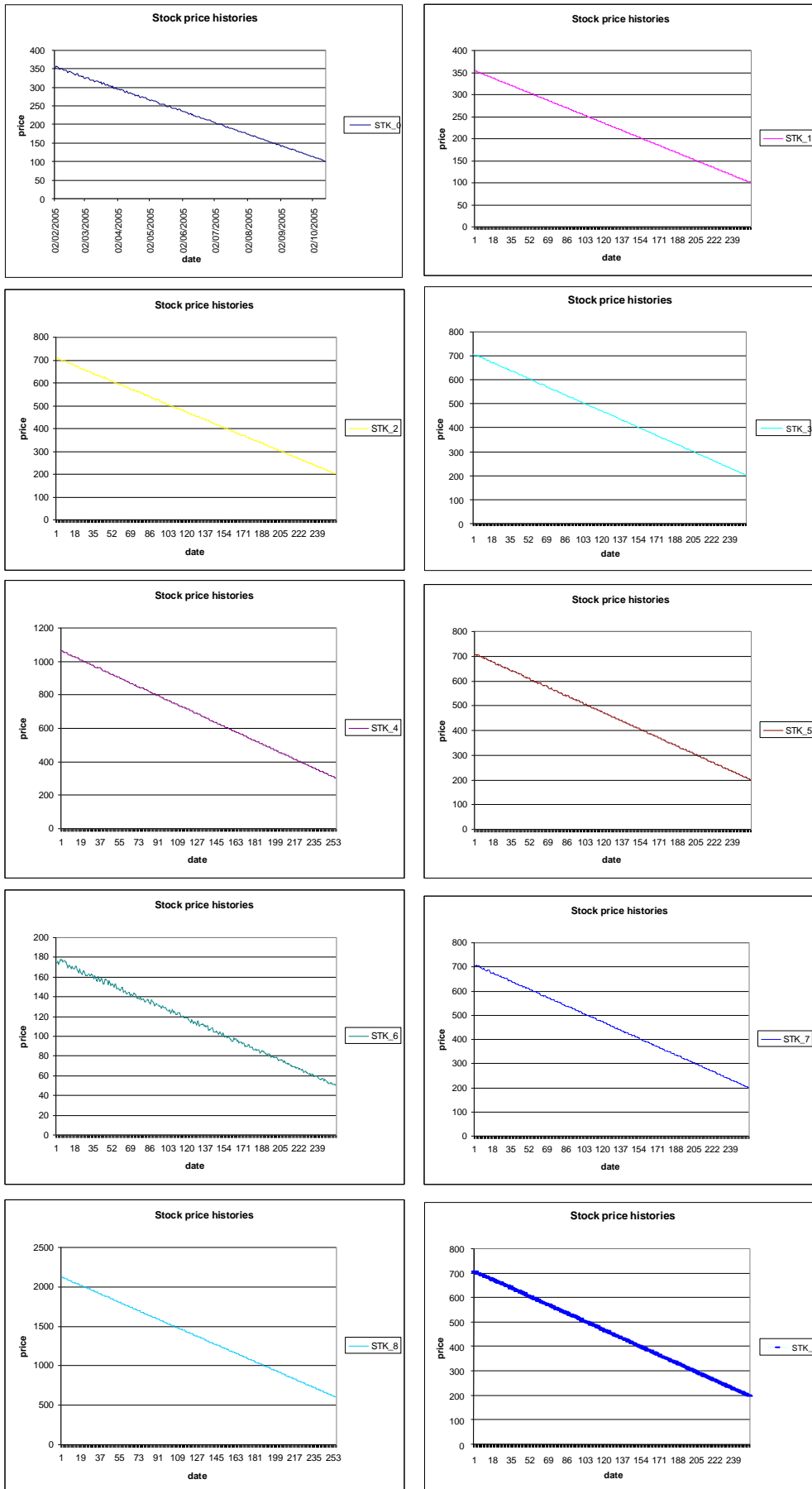


Figure 35: Historical price graphs for simulated stocks

7.6.1 Regression Data

The regression data (just prior to the 1st simulation days price file being loaded) can be seen in Figure 36 (and on the CD) for the simulation data.

X_id	Y_id	MAX_P	m	c	r	X_current	X_pctChar	X_chir	X_volu	Y_current	X_pnrV	Y_pnrV	TD	JT	PER_LOW	PER_LOW	PER_LOW	PER_MED	PER_MED	PER_MED	PER_MED	PER_HIGH	PER_HIGH	PER_HIGH	last_OVERNIGHT	lastL	stdevp	stdevp2	stdevp3	stdevp4	avg120r	avg60r	avg10r
STK_0	STK_1	220	1.1166667	-11.776667	0.9736662	99.25	0	0	0	99	99.64	100	14/0/0007	1.0039912	-0.038759	0.99732166	0.99594123	0.870437641	0.99945349	0.99947093	0.380499727	0.99963116	10-Mar-08	0.22	0.81292089	1.22525741	0.89411055	0.81292089	1.00150133	1.00150133	1.00366248	1.0036658	
STK_0	STK_2	220	0.55050161	-10.4892458	0.96377674	99.25	0	0	0	198.5	99.64	200.96	14/0/0007	0.5004955	-0.04073228	0.9963010	0.49603862	0.40858272	0.99921596	0.50047776	-0.10239014	0.99951251	10-Mar-08	0.22	1.44407351	2.81289039	2.11494528	1.44407351	0.50020866	0.50020866	0.50032032	0.50042571	
STK_0	STK_3	220	0.55472788	-11.4089976	0.9805945	99.25	0	0	0	198.5	99.64	200.72	14/0/0007	0.50357136	-0.04632442	0.99625059	0.49740419	0.788918482	0.49933019	0.27299576	0.99954798	10-Mar-08	0.22	1.44508005	2.71490357	2.03637382	1.44508005	0.50004636	0.50004636	0.50008414	0.500027712		
STK_0	STK_4	220	0.3669833	-10.4254463	0.96568516	99.25	0	0	0	297.75	99.64	299.89	14/0/0007	0.3340962	-0.22056432	0.99757666	0.33198688	0.594278127	0.99943534	0.33315032	0.109160238	0.99958746	10-Mar-08	0.22	1.75060678	3.88746469	2.6995225	1.75060678	0.3333467	0.3333467	0.33378752	0.3337854	
STK_0	STK_5	220	0.58986251	-18.5935916	0.9789868	99.25	0	0	0	198.5	99.64	200.84	14/0/0007	0.50284555	-0.43242019	0.99688009	0.49812703	0.583707894	0.99939451	0.49938904	0.251147129	0.99955788	10-Mar-08	0.22	1.2992494	2.68471302	1.86055197	1.2992494	0.50005647	0.50005647	0.50101874	0.5009943	
STK_0	STK_6	220	2.17776117	-8.77484414	0.80598248	99.25	0	0	0	49.625	99.64	49.64	14/0/0007	1.98272069	1.472925779	0.98213218	1.97795487	1.624194365	0.98647636	1.99550196	0.36365625	0.98785303	10-Mar-08	0.22	0.79551124	1.47929438	1.12862326	0.79551124	1.99949185	1.99949185	2.00758465	2.00655818	
STK_0	STK_7	220	0.56323213	-13.1443964	0.96856362	99.25	0	0	0	198.5	99.64	200.23	14/0/0007	0.50255226	-0.46988247	0.99623226	0.49869279	0.39591009	0.99928891	0.50004189	0.002631813	0.99950084	10-Mar-08	0.22	1.45153123	2.84883428	2.0138828	1.45153123	0.50006233	0.50006233	0.50056866	0.50047582	
STK_0	STK_8	220	0.18057985	-8.5913686	0.97401605	99.25	0	0	0	595.5	99.64	600.65	14/0/0007	0.16891774	-0.00078213	0.99733555	0.16590373	0.899044254	0.99941377	0.16654826	0.159713519	0.99962639	10-Mar-08	0.22	3.67706422	7.38042892	4.59678076	3.67706422	0.16689145	0.16689145	0.16691525	0.16690022	
STK_0	STK_9	220	0.5471551	-9.90257311	0.96760394	99.25	0	0	0	198.5	99.64	201.01	14/0/0007	0.50654607	-1.35155680	0.99848917	0.4984357	0.521078322	0.9935367	0.49933854	0.285905393	0.99954153	10-Mar-08	0.22	1.39030353	2.73414456	1.92103811	1.39030353	0.50009899	0.50009899	0.50084532	0.49992728	
STK_1	STK_2	220	0.49286179	1.222915703	0.96863786	99	0	0	0	198.5	100	200.96	14/0/0007	0.49849037	0.000892155	0.99892887	0.50065307	-0.46784411	0.99981212	0.50074848	-0.48555182	0.99990422	10-Mar-08	0.22	0.77717487	1.24683741	1.03530775	0.77717487	0.4994585	0.4994585	0.49849465	0.49849882	
STK_1	STK_3	220	0.49421447	0.867178457	0.96867552	99	0	0	0	198.5	100	200.72	14/0/0007	0.50163556	-0.6217759	0.99029287	0.49943757	-0.0639274	0.99984832	0.49959221	-0.10657046	0.99990736	10-Mar-08	0.22	0.66626519	1.23905441	0.93251729	0.66626519	0.49929689	0.49929689	0.49901336	0.49835302	
STK_1	STK_4	220	0.32559342	2.168966274	0.99375057	99	0	0	0	297.75	100	299.89	14/0/0007	0.33296906	-0.14194247	0.99960185	0.33333097	-0.27201251	0.99991785	0.33332631	-0.27123447	0.9999539	10-Mar-08	0.22	0.7095868	1.29945199	1.02830673	0.7095868	0.33284746	0.33284746	0.33257067	0.3325032	
STK_1	STK_5	220	0.52476549	-5.37444716	0.96241105	99	0	0	0	198.5	100	200.84	14/0/0007	0.50071365	-0.36108348	0.99914074	0.50012869	-0.27855246	0.99862757	0.49964735	-0.1268652	0.9999023	10-Mar-08	0.22	0.69304133	1.26202587	0.9620758	0.69304133	0.49930763	0.49930763	0.49919157	0.49907029	
STK_1	STK_6	220	1.98415792	0.919019849	0.85691572	99	0	0	0	49.625	100	49.64	14/0/0007	1.97513763	1.479137763	0.98521284	1.98602267	0.756249805	0.99702829	1.99655115	-0.01922099	0.98624386	10-Mar-08	0.22	0.72369056	1.33789321	1.03652317	0.72369056	1.99648818	1.99648818	2.00025123	2.00177268	
STK_1	STK_7	220	0.50435902	-1.2118062	0.94474882	99	0	0	0	198.5	100	200.23	14/0/0007	0.50066584	-0.4599079	0.99936613	0.5007263	-0.47895311	0.99940407	0.50031398	-0.38114461	0.99989899	10-Mar-08	0.22	0.59536915	1.28175003	0.95508139	0.59536915	0.49931243	0.49931243	0.49874088	0.49854789	
STK_1	STK_8	220	0.16164626	-8.96433439	0.99963028	99	0	0	0	595.5	100	600.65	14/0/0007	0.16624355	0.044659616	0.99989899	0.16858148	-0.17371449	0.99997997	0.16662354	-0.22020096	0.99989899	10-Mar-08	0.22	0.71276063	1.27599154	1.01604637	0.71276063	0.16644165	0.16644165	0.16641465	0.16625804	
STK_1	STK_9	220	0.4901526	1.645887929	0.99453448	99	0	0	0	198.5	100	201.01	14/0/0007	0.50450083	-1.3003239	0.99905411	0.50044851	-0.3448969	0.9986263	0.49960163	-0.09410159	0.99990515	10-Mar-08	0.22	0.72164956	1.24358484	0.99508562	0.72164956	0.49934072	0.49934072	0.49901778	0.49800216	
STK_2	STK_3	220	0.98979087	2.08606315	0.96159221	198.5	0	0	0	198.5	200.96	200.72	14/0/0007	1.00528361	-0.00346541	0.99823611	0.99737321	0.832398303	0.99963733	0.99759072	0.798972611	0.99980227	10-Mar-08	0.22	0.99116552	1.79559751	1.44193412	0.99116552	0.99986811	0.99986811	1.00105014	0.99971735	
STK_2	STK_4	220	0.65081756	5.086850354	0.97477687	198.5	0	0	0	297.75	200.96	299.89	14/0/0007	0.66717115	-0.0049353	0.99832692	0.66565125	0.460889087	0.99968196	0.6655886	0.470514811	0.99984669	10-Mar-08	0.22	1.45458619	2.36985823	2.02328038	1.45458619	0.66642315	0.66642315	0.66715743	0.66701656	
STK_2	STK_5	220	1.05032064	-10.2872372	0.97603501	198.5	0	0	0	198.5	200.96	200.84	14/0/0007	1.00307506	-0.39460841	0.99745577	0.99875393	0.443545773	0.99961773	0.99770055	0.758462121	0.99979667	10-Mar-08	0.22	1.19254355	1.82060699	1.478336	1.19254355	0.99970781	0.99970781	1.0014105	1.0011564	
STK_2	STK_6	220	4.02745411	-0.61821424	0.86677698	198.5	0	0	0	49.625	200.96	49.64	14/0/0007	3.95562622	3.376300215	0.98264919	3.96466274	2.477752658	0.9970159	3.96891992	0.95974544	0.98020242	10-Mar-08	0.22	0.77938646	1.35358694	1.03868258	0.77938646	3.99733888	3.99733888	4.01264405	4.01560862	
STK_2	STK_7	220	1.01124155	-2.33230774	0.98715742	198.5	0	0	0	198.5	200.96	200.23	14/0/0007	1.00335197	-0.67586393	0.99842233	0.99965256	0.045631215	0.99964061	0.99903707	0.248448356	0.99980412	10-Mar-08	0.22	0.93927719	1.78461701	1.43711644	0.93927719	0.99971662	0.99971662	1.0005036	1.00010745	
STK_2	STK_8	220	0.32423266	5.83293779	0.98737501	198.5	0	0	0	595.5	200.96	600.65	14/0/0007	0.33312194	0.355150992	0.99873981	0.33266801	0.647164198	0.99980501	0.33274231	0.569526364	0.99989712	10-Mar-08	0.22	2.52884743	8.83275563	3.17013222	2.52884743	0.33324719	0.33324719	0.33326204	0.33352036	
STK_2	STK_9	220	0.98197625	3.572121338	0.9799566	198.5	0	0	0	198.5	200.96	201.01	14/0/0007	1.01089955	-2.33410667	0.9978384	0.99939024	0.312236833	0.99961172	0.9976115	0.822397143	0.99980405	10-Mar-08	0.22	1.09091676	1.78748413	1.48896379	1.09091676	0.99977386	0.99977386	1.00105965	0.99901321	
STK_3	STK_4	220	0.65846153	2.754442176	0.95811111	198.5	0	0	0	297.75	200.72	299.89	14/0/0007	0.66326359	1.13018544	0.996943	0.66732263	-0.33207719	0.99979967	0.6671359	-0.2912852	0.99986406	10-Mar-08	0.22	1.1561812	2.23153139	1.60577723	1.1561812	0.66663712	0.66663712	0.66646082	0.66720438	
STK_3	STK_5	220	1.06144956	-12.556432	0.9483206	198.5	0	0	0	198.5	200.72	200.84	14/0/0007	0.99739179	0.704103477	0.99839477	1.00124616	-0.34434464	0.9997044	1.00001624	-0.00113046	0.99980671	10-Mar-08	0.22	0.94724942	1.7751252	1.29998877	0.94724942	1.00002889	1.00002889	1.00136398	1.00143993	
STK_3	STK_6	220	3.97110135	2.384625143	0.84100305	198.5	0	0	0	49.625	200.72	49.64	14/0/0007	3.93441559	4.381869569	0.98437547	3.97592945	1.730801704	0.99868421	3.99626049	0.191738789	0.98025582	10-Mar-08	0.22	0.74389893	1.33332922	1.06135436	0.74389893	3.99862472	3.99862472	4.00844174	4.01680763	
STK_3	STK_7	220	1.01850381	-3.79352729	0.99391479	198.5	0	0	0	198.5	200.72	200.23	14/0/0007	0.99727289	0.518900806	0.99857257	1.00243119	-0.73778547	0.99969419	1.00134826	-0.50913904	0.99979698	10-Mar-08	0.22	0.89343577	1.80786343	1.32068942	0.89343577	1.00003878	1.00003878	0.99964611	1.0003626	
STK_3	STK_8	220	0.32623108	4.637826219	0.99782225	198.5	0	0	0	595.5	200.72	600.65	14/0/0007	0.33113738	1.519412455	0.99909379	0.33349	-0.1321797	0.99984294	0.33335143	-0.18923493	0.99990112	10-Mar-08										

7.7 Simulation 1

7.7.1 Simulation data

This simulation loads pre-formulated price files which follow the trend for all simulated stocks in the generated history. No trades should be generated as no deviations from the trends are present.

The simulation data shown in Figure 37 (the days data files are shown on the right hand side, the data which follows the trend of the history is shown on the left hand side). The prognosis column contains an explanation for any manual modification of the original trend stock pattern on the day. The expected column shows what the 'what to buy' code should do on the day.

original following trend										Tweeked data										Prognosis					Expectatio
NASDAQ com Oct 15, 2007 Points*										NASDAQ com Oct 15, 2007 Points*															
STK_2	STK_2	\$	198.5	0	0.00%	0	0			STK_2	STK_2	\$	198.5	0	0.00%	0	0	0							
STK_1	STK_1	\$	99	0	0.00%	0	0			STK_1	STK_1	\$	99	0	0.00%	0	0	0							
STK_3	STK_3	\$	198.5	0	0.00%	0	0			STK_3	STK_3	\$	198.5	0	0.00%	0	0	0							
STK_4	STK_4	\$	297.75	0	0.00%	0	0			STK_4	STK_4	\$	297.75	0	0.00%	0	0	0							
STK_5	STK_5	\$	198.5	0	0.00%	0	0			STK_5	STK_5	\$	198.5	0	0.00%	0	0	0							
STK_6	STK_6	\$	49.625	0	0.00%	0	0			STK_6	STK_6	\$	49.625	0	0.00%	0	0	0							
STK_7	STK_7	\$	198.5	0	0.00%	0	0			STK_7	STK_7	\$	198.5	0	0.00%	0	0	0							
STK_8	STK_8	\$	595.5	0	0.00%	0	0			STK_8	STK_8	\$	595.5	0	0.00%	0	0	0							
STK_9	STK_9	\$	198.5	0	0.00%	0	0			STK_9	STK_9	\$	198.5	0	0.00%	0	0	0							
STK_0	STK_0	\$	99.25	0	0.00%	0	0			STK_0	STK_0	\$	99.25	0	0.00%	0	0	0							
NASDAQ										NASDAQ															
NASDAQ com Oct 16, 2007 Points*										NASDAQ com Oct 16, 2007 Points*															
STK_2	STK_2	\$	196.5	0	0.00%	0	0			STK_2	STK_2	\$	196.5	0	0.00%	0	0	0							
STK_1	STK_1	\$	98	0	0.00%	0	0			STK_1	STK_1	\$	98	0	0.00%	0	0	0							
STK_3	STK_3	\$	196.5	0	0.00%	0	0			STK_3	STK_3	\$	196.5	0	0.00%	0	0	0							
STK_4	STK_4	\$	294.75	0	0.00%	0	0			STK_4	STK_4	\$	294.75	0	0.00%	0	0	0							
STK_5	STK_5	\$	196.5	0	0.00%	0	0			STK_5	STK_5	\$	196.5	0	0.00%	0	0	0							
STK_6	STK_6	\$	49.125	0	0.00%	0	0			STK_6	STK_6	\$	49.125	0	0.00%	0	0	0							
STK_7	STK_7	\$	196.5	0	0.00%	0	0			STK_7	STK_7	\$	196.5	0	0.00%	0	0	0							
STK_8	STK_8	\$	589.5	0	0.00%	0	0			STK_8	STK_8	\$	589.5	0	0.00%	0	0	0							
STK_9	STK_9	\$	196.5	0	0.00%	0	0			STK_9	STK_9	\$	196.5	0	0.00%	0	0	0							
STK_0	STK_0	\$	98.25	0	0.00%	0	0			STK_0	STK_0	\$	98.25	0	0.00%	0	0	0							
NASDAQ										NASDAQ															
NASDAQ com Oct 17, 2007 Points*										NASDAQ com Oct 17, 2007 Points*															
STK_2	STK_2	\$	194.5	0	0.00%	0	0			STK_2	STK_2	\$	194.5	0	0.00%	0	0	0							
STK_1	STK_1	\$	97	0	0.00%	0	0			STK_1	STK_1	\$	97	0	0.00%	0	0	0							
STK_3	STK_3	\$	194.5	0	0.00%	0	0			STK_3	STK_3	\$	194.5	0	0.00%	0	0	0							
STK_4	STK_4	\$	291.75	0	0.00%	0	0			STK_4	STK_4	\$	291.75	0	0.00%	0	0	0							
STK_5	STK_5	\$	194.5	0	0.00%	0	0			STK_5	STK_5	\$	194.5	0	0.00%	0	0	0							
STK_6	STK_6	\$	48.625	0	0.00%	0	0			STK_6	STK_6	\$	48.625	0	0.00%	0	0	0							
STK_7	STK_7	\$	194.5	0	0.00%	0	0			STK_7	STK_7	\$	194.5	0	0.00%	0	0	0							
STK_8	STK_8	\$	583.5	0	0.00%	0	0			STK_8	STK_8	\$	583.5	0	0.00%	0	0	0							
STK_9	STK_9	\$	194.5	0	0.00%	0	0			STK_9	STK_9	\$	194.5	0	0.00%	0	0	0							
STK_0	STK_0	\$	97.25	0	0.00%	0	0			STK_0	STK_0	\$	97.25	0	0.00%	0	0	0							
NASDAQ										NASDAQ															
NASDAQ com Oct 18, 2007 Points*										NASDAQ com Oct 18, 2007 Points*															
STK_2	STK_2	\$	192.5	0	0.00%	0	0			STK_2	STK_2	\$	192.5	0	0.00%	0	0	0							
STK_1	STK_1	\$	96	0	0.00%	0	0			STK_1	STK_1	\$	96	0	0.00%	0	0	0							
STK_3	STK_3	\$	192.5	0	0.00%	0	0			STK_3	STK_3	\$	192.5	0	0.00%	0	0	0							
STK_4	STK_4	\$	288.75	0	0.00%	0	0			STK_4	STK_4	\$	288.75	0	0.00%	0	0	0							
STK_5	STK_5	\$	192.5	0	0.00%	0	0			STK_5	STK_5	\$	192.5	0	0.00%	0	0	0							
STK_6	STK_6	\$	48.125	0	0.00%	0	0			STK_6	STK_6	\$	48.125	0	0.00%	0	0	0							
STK_7	STK_7	\$	192.5	0	0.00%	0	0			STK_7	STK_7	\$	192.5	0	0.00%	0	0	0							
STK_8	STK_8	\$	577.5	0	0.00%	0	0			STK_8	STK_8	\$	577.5	0	0.00%	0	0	0							
STK_9	STK_9	\$	192.5	0	0.00%	0	0			STK_9	STK_9	\$	192.5	0	0.00%	0	0	0							
STK_0	STK_0	\$	96.25	0	0.00%	0	0			STK_0	STK_0	\$	96.25	0	0.00%	0	0	0							
NASDAQ										NASDAQ															
NASDAQ com Oct 19, 2007 Points*										NASDAQ com Oct 19, 2007 Points*															
STK_2	STK_2	\$	190.5	0	0.00%	0	0			STK_2	STK_2	\$	190.5	0	0.00%	0	0	0							
STK_1	STK_1	\$	95	0	0.00%	0	0			STK_1	STK_1	\$	95	0	0.00%	0	0	0							
STK_3	STK_3	\$	190.5	0	0.00%	0	0			STK_3	STK_3	\$	190.5	0	0.00%	0	0	0							
STK_4	STK_4	\$	285.75	0	0.00%	0	0			STK_4	STK_4	\$	285.75	0	0.00%	0	0	0							
STK_5	STK_5	\$	190.5	0	0.00%	0	0			STK_5	STK_5	\$	190.5	0	0.00%	0	0	0							
STK_6	STK_6	\$	47.625	0	0.00%	0	0			STK_6	STK_6	\$	47.625	0	0.00%	0	0	0							
STK_7	STK_7	\$	190.5	0	0.00%	0	0			STK_7	STK_7	\$	190.5	0	0.00%	0	0	0							
STK_8	STK_8	\$	571.5	0	0.00%	0	0			STK_8	STK_8	\$	571.5	0	0.00%	0	0	0							
STK_9	STK_9	\$	190.5	0	0.00%	0	0			STK_9	STK_9	\$	190.5	0	0.00%	0	0	0							
STK_0	STK_0	\$	95.25	0	0.00%	0	0			STK_0	STK_0	\$	95.25	0	0.00%	0	0	0							
NASDAQ										NASDAQ															
NASDAQ com Oct 20, 2007 Points*										NASDAQ com Oct 20, 2007 Points*															
STK_2	STK_2	\$	188.5	0	0.00%	0	0			STK_2	STK_2	\$	188.5	0	0.00%	0	0	0							
STK_1	STK_1	\$	94	0	0.00%	0	0			STK_1	STK_1	\$	94	0	0.00%	0	0	0							
STK_3	STK_3	\$	188.5	0	0.00%	0	0			STK_3	STK_3	\$	188.5	0	0.00%	0	0	0							
STK_4	STK_4	\$	282.75	0	0.00%	0	0			STK_4	STK_4	\$	282.75	0	0.00%	0	0	0							
STK_5	STK_5	\$	188.5	0	0.00%	0	0			STK_5	STK_5	\$	188.5	0	0.00%	0	0	0							
STK_6	STK_6	\$	47.125	0	0.00%	0	0			STK_6	STK_6	\$	47.125	0	0.00%	0	0	0							
STK_7	STK_7	\$	188.5	0	0.00%	0	0			STK_7	STK_7	\$	188.5	0	0.00%	0	0	0							
STK_8	STK_8	\$	565.5	0	0.00%	0	0			STK_8	STK_8	\$	565.5	0	0.00%	0	0	0							
STK_9	STK_9	\$	188.5	0	0.00%	0	0			STK_9	STK_9	\$	188.5	0	0.00%	0	0	0							
STK_0	STK_0	\$	94.25	0	0.00%	0	0			STK_0	STK_0	\$	94.25	0	0.00%	0	0	0							
NASDAQ										NASDAQ															
NASDAQ com Oct 21, 2007 Points*										NASDAQ com Oct 21, 2007 Points*															
STK_2	STK_2	\$	186.5	0	0.00%	0	0			STK_2	STK_2	\$	186.5	0	0.00%	0	0	0							
STK_1	STK_1	\$	93	0	0.00%	0	0			STK_1	STK_1	\$	93	0	0.00%	0	0	0							
STK_3	STK_3	\$	186.5	0	0.00%	0	0			STK_3	STK_3	\$	186.5	0	0.00%	0	0	0							
STK_4	STK_4	\$	279.75	0	0.00%	0	0			STK_4	STK_4	\$	279.75	0	0.00%	0	0	0							
STK_5	STK_5	\$	186.5	0	0.00%	0	0			STK_5	STK_5	\$	186.5	0	0.00%	0	0	0							
STK_6	STK_6	\$	46.625	0	0.00%	0	0			STK_6	STK_6	\$	46.625	0	0.00%	0	0	0							
STK_7	STK_7	\$	186.5	0	0.00%	0	0			STK_7	STK_7	\$	186.5	0	0.00%	0	0	0							
STK_8	STK_8	\$	559.5	0	0.00%	0	0			STK_8	STK_8	\$	559.5	0	0.00%	0	0	0							
STK_9	STK_9	\$	186.5	0	0.00%	0	0			STK_9	STK_9	\$	186.5	0	0.00%	0	0	0							
STK_0	STK_0	\$	93.25	0	0.00%	0	0			STK_0	STK_0	\$	93.25	0	0.00%	0	0	0							
NASDAQ										NASDAQ															

7.7.2 Final day Reports

As this is basically the control set of data for the simulation the final days report showing all trading activity is empty (see Figure 38, and RESULT_SPA.xls on the attached CD in the folder C:\000_aaa_stab\THESIS 2010\CD\TESTDATA\Simulation 1\20071020).

seq	openDt	closeDt	x_ticker	x_quantity	x_openPrice	x_closePrice	y_ticker	y_quantity	y_openPrice	y_closePrice	x_PL_pct	y_PL_pct	totPct	reason	reason	PER_high_r	PER_med_r	PER_low_r	openingLastL

Figure 38: Simulation 1 - Final day Report

7.8 Simulation 2

7.8.1 Simulation data

The format of the test follows that of section 7.7.1. In this case a manual glitch is added to the what-would-have-been original trend data for the stock, deliberately to cause trades relating to the changed stock. The prognosis column of the data file shows what the resultant data implies and the expectation column shows what should happen. This is shown in Figure 39.

original following trend										Tweeked data												
NASDAQ.com Oct 15, 2007 Points*										NASDAQ.com Oct 15, 2007 Points*										Prognosis		Expectation
STK_2	STK_2	\$	198.5	0	0.00%	0	0	STK_2	STK_2	\$	198.5	0	0.00%	0	0							
STK_1	STK_1	\$	99	0	0.00%	0	0	STK_1	STK_1	\$	99	0	0.00%	0	0							
STK_3	STK_3	\$	198.5	0	0.00%	0	0	STK_3	STK_3	\$	198.5	0	0.00%	0	0							
STK_4	STK_4	\$	297.75	0	0.00%	0	0	STK_4	STK_4	\$	297.75	0	0.00%	0	0							
STK_5	STK_5	\$	198.5	0	0.00%	0	0	STK_5	STK_5	\$	198.5	0	0.00%	0	0							
STK_6	STK_6	\$	49.625	0	0.00%	0	0	STK_6	STK_6	\$	49.625	0	0.00%	0	0							
STK_7	STK_7	\$	198.5	0	0.00%	0	0	STK_7	STK_7	\$	198.5	0	0.00%	0	0							
STK_8	STK_8	\$	595.5	0	0.00%	0	0	STK_8	STK_8	\$	595.5	0	0.00%	0	0							
STK_9	STK_9	\$	198.5	0	0.00%	0	0	STK_9	STK_9	\$	198.5	0	0.00%	0	0							
STK_0	STK_0	\$	99.25	0	0.00%	0	0	STK_0	STK_0	\$	99.25	0	0.00%	0	0							
NASDAQ										NASDAQ												
NASDAQ.com Oct 16, 2007 Points*										NASDAQ.com Oct 16, 2007 Points*												
STK_2	STK_2	\$	196.5	0	0.00%	0	0	STK_2	STK_2	\$	196.5	0	0.00%	0	0							
STK_1	STK_1	\$	98	0	0.00%	0	0	STK_1	STK_1	\$	98	0	0.00%	0	0							
STK_3	STK_3	\$	196.5	0	0.00%	0	0	STK_3	STK_3	\$	196.5	0	0.00%	0	0							
STK_4	STK_4	\$	294.75	0	0.00%	0	0	STK_4	STK_4	\$	294.75	0	0.00%	0	0							
STK_5	STK_5	\$	196.5	0	0.00%	0	0	STK_5	STK_5	\$	190	0	196.50%	0	0	6.5	STK_5 is cheap					
STK_6	STK_6	\$	49.125	0	0.00%	0	0	STK_6	STK_6	\$	49.125	0	0.00%	0	0		BUY STK_5					
STK_7	STK_7	\$	196.5	0	0.00%	0	0	STK_7	STK_7	\$	196.5	0	0.00%	0	0							
STK_8	STK_8	\$	589.5	0	0.00%	0	0	STK_8	STK_8	\$	589.5	0	0.00%	0	0							
STK_9	STK_9	\$	196.5	0	0.00%	0	0	STK_9	STK_9	\$	196.5	0	0.00%	0	0							
STK_0	STK_0	\$	98.25	0	0.00%	0	0	STK_0	STK_0	\$	98.25	0	0.00%	0	0							
NASDAQ										NASDAQ												
NASDAQ.com Oct 17, 2007 Points*										NASDAQ.com Oct 17, 2007 Points*												
STK_2	STK_2	\$	194.5	0	0.00%	0	0	STK_2	STK_2	\$	194.5	0	0.00%	0	0							
STK_1	STK_1	\$	97	0	0.00%	0	0	STK_1	STK_1	\$	97	0	0.00%	0	0							
STK_3	STK_3	\$	194.5	0	0.00%	0	0	STK_3	STK_3	\$	194.5	0	0.00%	0	0							
STK_4	STK_4	\$	291.75	0	0.00%	0	0	STK_4	STK_4	\$	291.75	0	0.00%	0	0							
STK_5	STK_5	\$	194.5	0	0.00%	0	0	STK_5	STK_5	\$	194.5	0	0.00%	0	0							
STK_6	STK_6	\$	48.625	0	0.00%	0	0	STK_6	STK_6	\$	48.625	0	0.00%	0	0							
STK_7	STK_7	\$	194.5	0	0.00%	0	0	STK_7	STK_7	\$	194.5	0	0.00%	0	0							
STK_8	STK_8	\$	583.5	0	0.00%	0	0	STK_8	STK_8	\$	583.5	0	0.00%	0	0							
STK_9	STK_9	\$	194.5	0	0.00%	0	0	STK_9	STK_9	\$	194.5	0	0.00%	0	0							
STK_0	STK_0	\$	97.25	0	0.00%	0	0	STK_0	STK_0	\$	97.25	0	0.00%	0	0							
NASDAQ										NASDAQ												
NASDAQ.com Oct 18, 2007 Points*										NASDAQ.com Oct 18, 2007 Points*												
STK_2	STK_2	\$	192.5	0	0.00%	0	0	STK_2	STK_2	\$	192.5	0	0.00%	0	0							
STK_1	STK_1	\$	96	0	0.00%	0	0	STK_1	STK_1	\$	96	0	0.00%	0	0							
STK_3	STK_3	\$	192.5	0	0.00%	0	0	STK_3	STK_3	\$	192.5	0	0.00%	0	0							
STK_4	STK_4	\$	288.75	0	0.00%	0	0	STK_4	STK_4	\$	288.75	0	0.00%	0	0							
STK_5	STK_5	\$	192.5	0	0.00%	0	0	STK_5	STK_5	\$	200	0	192.50%	0	0	-7.5	STK_5 is expensive					
STK_6	STK_6	\$	48.125	0	0.00%	0	0	STK_6	STK_6	\$	48.125	0	0.00%	0	0		SELL STK_5					
STK_7	STK_7	\$	192.5	0	0.00%	0	0	STK_7	STK_7	\$	192.5	0	0.00%	0	0							
STK_8	STK_8	\$	577.5	0	0.00%	0	0	STK_8	STK_8	\$	577.5	0	0.00%	0	0							
STK_9	STK_9	\$	192.5	0	0.00%	0	0	STK_9	STK_9	\$	192.5	0	0.00%	0	0							
STK_0	STK_0	\$	96.25	0	0.00%	0	0	STK_0	STK_0	\$	96.25	0	0.00%	0	0							
NASDAQ										NASDAQ												
NASDAQ.com Oct 19, 2007 Points*										NASDAQ.com Oct 19, 2007 Points*												
STK_2	STK_2	\$	190.5	0	0.00%	0	0	STK_2	STK_2	\$	190.5	0	0.00%	0	0							
STK_1	STK_1	\$	95	0	0.00%	0	0	STK_1	STK_1	\$	95	0	0.00%	0	0							
STK_3	STK_3	\$	190.5	0	0.00%	0	0	STK_3	STK_3	\$	190.5	0	0.00%	0	0							
STK_4	STK_4	\$	285.75	0	0.00%	0	0	STK_4	STK_4	\$	285.75	0	0.00%	0	0							
STK_5	STK_5	\$	190.5	0	0.00%	0	0	STK_5	STK_5	\$	190.5	0	0.00%	0	0							
STK_6	STK_6	\$	47.625	0	0.00%	0	0	STK_6	STK_6	\$	47.625	0	0.00%	0	0							
STK_7	STK_7	\$	190.5	0	0.00%	0	0	STK_7	STK_7	\$	190.5	0	0.00%	0	0							
STK_8	STK_8	\$	571.5	0	0.00%	0	0	STK_8	STK_8	\$	571.5	0	0.00%	0	0							
STK_9	STK_9	\$	190.5	0	0.00%	0	0	STK_9	STK_9	\$	190.5	0	0.00%	0	0							
STK_0	STK_0	\$	95.25	0	0.00%	0	0	STK_0	STK_0	\$	95.25	0	0.00%	0	0							
NASDAQ										NASDAQ												
NASDAQ.com Oct 20, 2007 Points*										NASDAQ.com Oct 20, 2007 Points*												
STK_2	STK_2	\$	188.5	0	0.00%	0	0	STK_2	STK_2	\$	188.5	0	0.00%	0	0							
STK_1	STK_1	\$	94	0	0.00%	0	0	STK_1	STK_1	\$	94	0	0.00%	0	0							
STK_3	STK_3	\$	188.5	0	0.00%	0	0	STK_3	STK_3	\$	188.5	0	0.00%	0	0							
STK_4	STK_4	\$	282.75	0	0.00%	0	0	STK_4	STK_4	\$	282.75	0	0.00%	0	0							
STK_5	STK_5	\$	188.5	0	0.00%	0	0	STK_5	STK_5	\$	188.5	0	0.00%	0	0							
STK_6	STK_6	\$	47.125	0	0.00%	0	0	STK_6	STK_6	\$	47.125	0	0.00%	0	0							
STK_7	STK_7	\$	188.5	0	0.00%	0	0	STK_7	STK_7	\$	188.5	0	0.00%	0	0							
STK_8	STK_8	\$	565.5	0	0.00%	0	0	STK_8	STK_8	\$	565.5	0	0.00%	0	0							
STK_9	STK_9	\$	188.5	0	0.00%	0	0	STK_9	STK_9	\$	188.5	0	0.00%	0	0							
STK_0	STK_0	\$	94.25	0	0.00%	0	0	STK_0	STK_0	\$	94.25	0	0.00%	0	0							
NASDAQ										NASDAQ												
NASDAQ.com Oct 21, 2007 Points*										NASDAQ.com Oct 21, 2007 Points*												
STK_2	STK_2	\$	186.5	0	0.00%	0	0	STK_2	STK_2	\$	186.5	0	0.00%	0	0							
STK_1	STK_1	\$	93	0	0.00%	0	0	STK_1	STK_1	\$	93	0	0.00%	0	0							
STK_3	STK_3	\$	186.5	0	0.00%	0	0	STK_3	STK_3	\$	186.5	0	0.00%	0	0							
STK_4	STK_4	\$	279.75	0	0.00%	0	0	STK_4	STK_4	\$	279.75	0	0.00%	0	0							
STK_5	STK_5	\$	186.5	0	0.00%	0	0	STK_5	STK_5	\$	186.5	0	0.00%	0	0							
STK_6	STK_6	\$	46.625	0	0.00%	0	0	STK_6	STK_6	\$	46.625	0	0.00%	0	0							
STK_7	STK_7	\$	186.5	0	0.00%	0	0	STK_7	STK_7	\$	186.5	0	0.00%	0	0							
STK_8	STK_8	\$	559.5	0	0.00%	0	0	STK_8	STK_8	\$	559.5	0	0.00%	0	0							
STK_9	STK_9	\$	186.5	0	0.00%	0	0	STK_9	STK_9	\$	186.5	0	0.00%	0	0							
STK_0	STK_0	\$	93.25	0	0.00%	0	0	STK_0	STK_0	\$	93.25	0	0.00%	0	0							
NASDAQ										NASDAQ												

7.9 Final day Reports

For each day a days report can be seen on the CD. The final days report can be seen in Figure 40, which shows the results of all trades in line with expectation (RESULT_SPA.xls on the attached CD in the folder CD\TESTDATA\Simulation 2\20071020).

openDt	closeDt	x_ticker	x_quantity	x_openPrice	x_closePrice	y_ticker	y_quantity	y_openPrice	y_closePrice	x_PL_pct	y_PL_pct	totPct	reason4Clos	PER_high_r	PER_med_r	PER_low_r	openingLastL
16/10/2007 00:00	17/10/2007 00:00	STK_1	-1020.408163	98	97	STK_5	526.31579	190	194.5	1.020408163	2.368421053	3.388829216	ratio < .75*S1	0.9999023	0.9998294	0.9992046	0.0160618
16/10/2007 00:00	17/10/2007 00:00	STK_2	-508.9058524	196.5	194.5	STK_5	526.31579	190	194.5	1.017811705	2.368421053	3.386232757	ratio < .75*S1	0.9997967	0.999618	0.997692	0.034851236
16/10/2007 00:00	17/10/2007 00:00	STK_3	-508.9058524	196.5	194.5	STK_5	526.31579	190	194.5	1.017811705	2.368421053	3.386232757	ratio < .75*S1	0.9998074	0.9997045	0.9984213	0.037782924
16/10/2007 00:00	17/10/2007 00:00	STK_4	-339.2705683	294.75	291.75	STK_5	526.31579	190	194.5	1.017811705	2.368421053	3.386232757	ratio < .75*S1	0.999876	0.9997916	0.9988568	0.051430635
16/10/2007 00:00	17/10/2007 00:00	STK_5	526.3157895	190	194.5	STK_0	-1017.8117	98.25	97.25	2.368421053	1.017811705	3.386232757	ratio < .75*S1	0.9995587	0.9994015	0.9972199	0.056617695
16/10/2007 00:00	17/10/2007 00:00	STK_5	526.3157895	190	194.5	STK_6	-2035.6234	49.125	48.625	2.368421053	1.017811705	3.386232757	ratio < .75*S1	0.9982467	0.9970846	0.9867381	0.070138704
16/10/2007 00:00	17/10/2007 00:00	STK_5	526.3157895	190	194.5	STK_7	-508.90585	196.5	194.5	2.368421053	1.017811705	3.386232757	ratio < .75*S1	0.9997784	0.9996336	0.9982767	0.034487948
16/10/2007 00:00	17/10/2007 00:00	STK_5	526.3157895	190	194.5	STK_8	-169.63528	589.5	583.5	2.368421053	1.017811705	3.386232757	ratio < .75*S1	0.9998856	0.9997953	0.9988626	0.010257466
16/10/2007 00:00	17/10/2007 00:00	STK_5	526.3157895	190	194.5	STK_9	-508.90585	196.5	194.5	2.368421053	1.017811705	3.386232757	ratio < .75*S1	0.9997957	0.999628	0.9978141	0.040032856
18/10/2007 00:00	19/10/2007 00:00	STK_1	1041.666667	96	95	STK_5	-500	200	190.5	-1.04166667	4.75	3.708333333	ratio < .75*S1	0.9998924	0.9997759	0.9976127	0.012337151
18/10/2007 00:00	19/10/2007 00:00	STK_2	519.4805195	192.5	190.5	STK_5	-500	200	190.5	-1.03896104	4.75	3.711038961	ratio < .75*S1	0.9997926	0.9995666	0.9963627	0.021436103
18/10/2007 00:00	19/10/2007 00:00	STK_3	519.4805195	192.5	190.5	STK_5	-500	200	190.5	-1.03896104	4.75	3.711038961	ratio < .75*S1	0.9998022	0.9996577	0.9969926	0.01883139
18/10/2007 00:00	19/10/2007 00:00	STK_4	346.3203463	288.75	285.75	STK_5	-500	200	190.5	-1.03896104	4.75	3.711038961	ratio < .75*S1	0.9998655	0.9997418	0.9972667	0.03426005
18/10/2007 00:00	19/10/2007 00:00	STK_5	-500	200	190.5	STK_0	1038.961	96.25	95.25	4.75	-1.03896104	3.711038961	ratio < .75*S1	0.9995589	0.9993788	0.9957695	0.061315632
18/10/2007 00:00	19/10/2007 00:00	STK_5	-500	200	190.5	STK_6	2077.9221	48.125	47.625	4.75	-1.03896104	3.711038961	ratio < .75*S1	0.998325	0.9971802	0.9849982	0.156792179
18/10/2007 00:00	19/10/2007 00:00	STK_5	-500	200	190.5	STK_7	519.48052	192.5	190.5	4.75	-1.03896104	3.711038961	ratio < .75*S1	0.9997692	0.9995831	0.996837	0.024553756
18/10/2007 00:00	19/10/2007 00:00	STK_5	-500	200	190.5	STK_8	173.16017	577.5	571.5	4.75	-1.03896104	3.711038961	ratio < .75*S1	0.9998763	0.9997408	0.9973657	0.009063013
18/10/2007 00:00	19/10/2007 00:00	STK_5	-500	200	190.5	STK_9	519.48052	192.5	190.5	4.75	-1.03896104	3.711038961	ratio < .75*S1	0.9997847	0.9995782	0.9963388	0.019690633

Figure 40: Simulation 2 - Final day report

7.10 Simulation 3

7.10.1 Simulation data

The format of the test follows that of section 7.7.1. In this case several manual glitches are added to the what-would-have-been original trend data for the stock, deliberately to cause trades relating to the changed stock. The prognosis column of the data file shows what the resultant data implies and the expectation column shows what should happen. This is shown in Figure 41.

original following trend										Tweeked data										Prognosis		Expectation	
NASDAQ.com Oct 15, 2007 Points*										NASDAQ.com Oct 15, 2007 Points*													
STK_2	STK_2	\$	198.5	0	0.00%	0	0	STK_2	STK_2	\$	198.5	0	0.00%	0	0								
STK_1	STK_1	\$	99	0	0.00%	0	0	STK_1	STK_1	\$	99	0	0.00%	0	0								
STK_3	STK_3	\$	198.5	0	0.00%	0	0	STK_3	STK_3	\$	198.5	0	0.00%	0	0								
STK_4	STK_4	\$	297.75	0	0.00%	0	0	STK_4	STK_4	\$	297.75	0	0.00%	0	0								
STK_5	STK_5	\$	198.5	0	0.00%	0	0	STK_5	STK_5	\$	198.5	0	0.00%	0	0								
STK_6	STK_6	\$	49.625	0	0.00%	0	0	STK_6	STK_6	\$	49.625	0	0.00%	0	0								
STK_7	STK_7	\$	198.5	0	0.00%	0	0	STK_7	STK_7	\$	198.5	0	0.00%	0	0								
STK_8	STK_8	\$	595.5	0	0.00%	0	0	STK_8	STK_8	\$	595.5	0	0.00%	0	0								
STK_9	STK_9	\$	198.5	0	0.00%	0	0	STK_9	STK_9	\$	198.5	0	0.00%	0	0								
STK_0	STK_0	\$	99.25	0	0.00%	0	0	STK_0	STK_0	\$	99.25	0	0.00%	0	0								
NASDAQ										NASDAQ													
NASDAQ.com Oct 16, 2007 Points*										NASDAQ.com Oct 16, 2007 Points*													
STK_2	STK_2	\$	196.5	0	0.00%	0	0	STK_2	STK_2	\$	196.5	0	0.00%	0	0								
STK_1	STK_1	\$	98	0	0.00%	0	0	STK_1	STK_1	\$	98	0	0.00%	0	0								
STK_3	STK_3	\$	196.5	0	0.00%	0	0	STK_3	STK_3	\$	196.5	0	0.00%	0	0								
STK_4	STK_4	\$	294.75	0	0.00%	0	0	STK_4	STK_4	\$	294.75	0	0.00%	0	0								
STK_5	STK_5	\$	196.5	0	0.00%	0	0	STK_5	STK_5	\$	200	0	196.50%	0	0			-3.5	STK_5 is expensive				
STK_6	STK_6	\$	49.125	0	0.00%	0	0	STK_6	STK_6	\$	49.125	0	0.00%	0	0				SELL STK_5				
STK_7	STK_7	\$	196.5	0	0.00%	0	0	STK_7	STK_7	\$	196.5	0	0.00%	0	0								
STK_8	STK_8	\$	589.5	0	0.00%	0	0	STK_8	STK_8	\$	589.5	0	0.00%	0	0								
STK_9	STK_9	\$	196.5	0	0.00%	0	0	STK_9	STK_9	\$	196.5	0	0.00%	0	0								
STK_0	STK_0	\$	98.25	0	0.00%	0	0	STK_0	STK_0	\$	98.25	0	0.00%	0	0								
NASDAQ										NASDAQ													
NASDAQ.com Oct 17, 2007 Points*										NASDAQ.com Oct 17, 2007 Points*													
STK_2	STK_2	\$	194.5	0	0.00%	0	0	STK_2	STK_2	\$	194.5	0	0.00%	0	0								
STK_1	STK_1	\$	97	0	0.00%	0	0	STK_1	STK_1	\$	97	0	0.00%	0	0								
STK_3	STK_3	\$	194.5	0	0.00%	0	0	STK_3	STK_3	\$	194.5	0	0.00%	0	0								
STK_4	STK_4	\$	291.75	0	0.00%	0	0	STK_4	STK_4	\$	291.75	0	0.00%	0	0								
STK_5	STK_5	\$	194.5	0	0.00%	0	0	STK_5	STK_5	\$	194.5	0	0.00%	0	0								
STK_6	STK_6	\$	48.625	0	0.00%	0	0	STK_6	STK_6	\$	48.625	0	0.00%	0	0								
STK_7	STK_7	\$	194.5	0	0.00%	0	0	STK_7	STK_7	\$	194.5	0	0.00%	0	0								
STK_8	STK_8	\$	583.5	0	0.00%	0	0	STK_8	STK_8	\$	583.5	0	0.00%	0	0								
STK_9	STK_9	\$	194.5	0	0.00%	0	0	STK_9	STK_9	\$	194.5	0	0.00%	0	0								
STK_0	STK_0	\$	97.25	0	0.00%	0	0	STK_0	STK_0	\$	97.25	0	0.00%	0	0								
NASDAQ										NASDAQ													
NASDAQ.com Oct 18, 2007 Points*										NASDAQ.com Oct 18, 2007 Points*													
STK_2	STK_2	\$	192.5	0	0.00%	0	0	STK_2	STK_2	\$	192.5	0	0.00%	0	0								
STK_1	STK_1	\$	96	0	0.00%	0	0	STK_1	STK_1	\$	96	0	0.00%	0	0								
STK_3	STK_3	\$	192.5	0	0.00%	0	0	STK_3	STK_3	\$	192.5	0	0.00%	0	0								
STK_4	STK_4	\$	288.75	0	0.00%	0	0	STK_4	STK_4	\$	288.75	0	0.00%	0	0								
STK_5	STK_5	\$	192.5	0	0.00%	0	0	STK_5	STK_5	\$	189.99	0	192.50%	0	0			2.51	STK_5 is cheap				
STK_6	STK_6	\$	48.125	0	0.00%	0	0	STK_6	STK_6	\$	46	0	48.13%	0	0			2.125	STK_6 is cheap				
STK_7	STK_7	\$	192.5	0	0.00%	0	0	STK_7	STK_7	\$	192.5	0	0.00%	0	0								
STK_8	STK_8	\$	577.5	0	0.00%	0	0	STK_8	STK_8	\$	577.5	0	0.00%	0	0								
STK_9	STK_9	\$	192.5	0	0.00%	0	0	STK_9	STK_9	\$	192.5	0	0.00%	0	0								
STK_0	STK_0	\$	96.25	0	0.00%	0	0	STK_0	STK_0	\$	96.25	0	0.00%	0	0								
NASDAQ										NASDAQ													
NASDAQ.com Oct 19, 2007 Points*										NASDAQ.com Oct 19, 2007 Points*													
STK_2	STK_2	\$	190.5	0	0.00%	0	0	STK_2	STK_2	\$	190.5	0	0.00%	0	0								
STK_1	STK_1	\$	95	0	0.00%	0	0	STK_1	STK_1	\$	95	0	0.00%	0	0								
STK_3	STK_3	\$	190.5	0	0.00%	0	0	STK_3	STK_3	\$	190.5	0	0.00%	0	0								
STK_4	STK_4	\$	285.75	0	0.00%	0	0	STK_4	STK_4	\$	285.75	0	0.00%	0	0								
STK_5	STK_5	\$	190.5	0	0.00%	0	0	STK_5	STK_5	\$	190.5	0	0.00%	0	0								
STK_6	STK_6	\$	47.625	0	0.00%	0	0	STK_6	STK_6	\$	47.625	0	0.00%	0	0								
STK_7	STK_7	\$	190.5	0	0.00%	0	0	STK_7	STK_7	\$	190.5	0	0.00%	0	0								
STK_8	STK_8	\$	571.5	0	0.00%	0	0	STK_8	STK_8	\$	571.5	0	0.00%	0	0								
STK_9	STK_9	\$	190.5	0	0.00%	0	0	STK_9	STK_9	\$	190.5	0	0.00%	0	0								
STK_0	STK_0	\$	95.25	0	0.00%	0	0	STK_0	STK_0	\$	95.25	0	0.00%	0	0								
NASDAQ										NASDAQ													
NASDAQ.com Oct 20, 2007 Points*										NASDAQ.com Oct 20, 2007 Points*													
STK_2	STK_2	\$	188.5	0	0.00%	0	0	STK_2	STK_2	\$	191	0	188.50%	0	0			-2.5	STK_2 is expensive				
STK_1	STK_1	\$	94	0	0.00%	0	0	STK_1	STK_1	\$	92	0	94.00%	0	0			2	STK_1 is cheap				
STK_3	STK_3	\$	188.5	0	0.00%	0	0	STK_3	STK_3	\$	190	0	188.50%	0	0			-1.5	STK_3 is expensive				
STK_4	STK_4	\$	282.75	0	0.00%	0	0	STK_4	STK_4	\$	279	0	282.75%	0	0			3.75	STK_4 is cheap				
STK_5	STK_5	\$	188.5	0	0.00%	0	0	STK_5	STK_5	\$	188.5	0	0.00%	0	0								
STK_6	STK_6	\$	47.125	0	0.00%	0	0	STK_6	STK_6	\$	46.625	0	0.00%	0	0								
STK_7	STK_7	\$	188.5	0	0.00%	0	0	STK_7	STK_7	\$	188.5	0	0.00%	0	0								
STK_8	STK_8	\$	565.5	0	0.00%	0	0	STK_8	STK_8	\$	565.5	0	0.00%	0	0								
STK_9	STK_9	\$	188.5	0	0.00%	0	0	STK_9	STK_9	\$	188.5	0	0.00%	0	0								
STK_0	STK_0	\$	94.25	0	0.00%	0	0	STK_0	STK_0	\$	94.25	0	0.00%	0	0								
NASDAQ										NASDAQ													
NASDAQ.com Oct 21, 2007 Points*										NASDAQ.com Oct 21, 2007 Points*													
STK_2	STK_2	\$	186.5	0	0.00%	0	0	STK_2	STK_2	\$	186.5	0	0.00%	0	0								
STK_1	STK_1	\$	93	0	0.00%	0	0	STK_1	STK_1	\$	93	0	0.00%	0	0								
STK_3	STK_3	\$	186.5	0	0.00%	0	0	STK_3	STK_3	\$	186.5	0	0.00%	0	0								
STK_4	STK_4	\$	279.75	0	0.00%	0	0	STK_4	STK_4	\$	279.75	0	0.00%	0	0								
STK_5	STK_5	\$	186.5	0	0.00%	0	0	STK_5	STK_5	\$	186.5	0	0.00%	0	0								
STK_6	STK_6	\$	46.625	0	0.00%	0	0	STK_6	STK_6	\$	46.625	0	0.00%	0	0								
STK_7	STK_7	\$	186.5	0	0.00%	0	0	STK_7	STK_7	\$	186.5	0	0.00%	0	0								
STK_8	STK_8	\$	559.5	0	0.00%	0	0	STK_8	STK_8	\$	559.5	0	0.00%	0	0								
STK_9	STK_9	\$	186.5	0	0.00%	0	0	STK_9	STK_9	\$	186.5	0	0.00%	0	0								
STK_0	STK_0	\$	93.25	0	0.00%	0	0	STK_0	STK_0	\$	93.25	0	0.00%	0	0								
NASDAQ										NASDAQ													

7.10.2 Final day Reports

The final day (and all day) report are as expected and can be seen in the date folders (format YYYYMMDD) in the CD\TESTDATA\Simulation 3\ folder on the attached CD. There are too many to include here. The final day's report can be seen in Figure 42.

seq	openDt	closeDt	x_ticker	x_quantity	x_openPrice	x_closePrice	y_ticker	y_quantity	y_openPrice	y_closePrice	x_PL_pct	y_PL_pct	totPct	reason4Closing	PER_high_r	PER_med_r	PER_low_r	openingLastL
203	16/10/2007 00:00	17/10/2007 00:00	STK_1	1020.408163	98	97	STK_5	-500	200	194.5	-1.020408163	2.75	1.729591837	ratio < .75*STDEVP	0.9999023	0.9998294	0.9992046	0.009727674
204	16/10/2007 00:00	17/10/2007 00:00	STK_2	508.9058524	196.5	194.5	STK_5	-500	200	194.5	-1.017811705	2.75	1.732188295	ratio < .75*STDEVP	0.9997967	0.999618	0.997692	0.01685929
205	16/10/2007 00:00	17/10/2007 00:00	STK_3	508.9058524	196.5	194.5	STK_5	-500	200	194.5	-1.017811705	2.75	1.732188295	ratio < .75*STDEVP	0.9998074	0.9997045	0.9984213	0.013927602
206	16/10/2007 00:00	17/10/2007 00:00	STK_4	339.2705683	294.75	291.75	STK_5	-500	200	194.5	-1.017811705	2.75	1.732188295	ratio < .75*STDEVP	0.999876	0.9997916	0.9985658	0.026135155
207	16/10/2007 00:00	17/10/2007 00:00	STK_5	-500	200	194.5	STK_0	1017.811705	98.25	97.25	2.75	-1.017811705	1.732188295	ratio < .75*STDEVP	0.9995587	0.9994015	0.9972199	0.045163475
208	16/10/2007 00:00	17/10/2007 00:00	STK_5	-500	200	194.5	STK_6	2035.62341	49.125	48.625	2.75	-1.017811705	1.732188295	ratio < .75*STDEVP	0.9982467	0.9970846	0.9867381	0.133423637
209	16/10/2007 00:00	17/10/2007 00:00	STK_5	-500	200	194.5	STK_7	508.9058524	196.5	194.5	2.75	-1.017811705	1.732188295	ratio < .75*STDEVP	0.9997784	0.9996336	0.9982767	0.016402637
210	16/10/2007 00:00	17/10/2007 00:00	STK_5	-500	200	194.5	STK_8	169.6352841	589.5	583.5	2.75	-1.017811705	1.732188295	ratio < .75*STDEVP	0.9998856	0.9997953	0.9989826	0.006706062
211	16/10/2007 00:00	17/10/2007 00:00	STK_5	-500	200	194.5	STK_9	508.9058524	196.5	194.5	2.75	-1.017811705	1.732188295	ratio < .75*STDEVP	0.9997957	0.999628	0.9978141	0.010857729
212	18/10/2007 00:00	19/10/2007 00:00	STK_3	-519.4805195	192.5	190.5	STK_5	526.3434918	189.99	190.5	1.038961039	0.268435181	1.30739622	ratio < .75*STDEVP	0.9998105	0.9996986	0.9979905	0.013731735
213	18/10/2007 00:00	19/10/2007 00:00	STK_3	-519.4805195	192.5	190.5	STK_6	2173.913043	46	47.625	1.038961039	0.532608696	4.571569735	ratio < .75*STDEVP	0.9983466	0.9970444	0.9846557	0.255156153
214	18/10/2007 00:00	19/10/2007 00:00	STK_1	-1041.666667	96	95	STK_5	526.3434918	189.99	190.5	1.041666667	0.268435181	1.310101847	ratio < .75*STDEVP	0.9999002	0.999815	0.9987032	0.003824566
215	18/10/2007 00:00	19/10/2007 00:00	STK_1	-1041.666667	96	95	STK_6	2173.913043	46	47.625	1.041666667	0.532608696	4.574275362	ratio < .75*STDEVP	0.9983364	0.9971762	0.9856631	0.115055102
216	18/10/2007 00:00	19/10/2007 00:00	STK_2	-519.4805195	192.5	190.5	STK_5	526.3434918	189.99	190.5	1.038961039	0.268435181	1.30739622	ratio < .75*STDEVP	0.9997995	0.9996015	0.9972758	0.011212188
217	18/10/2007 00:00	19/10/2007 00:00	STK_2	-519.4805195	192.5	190.5	STK_6	2173.913043	46	47.625	1.038961039	0.532608696	4.571569735	ratio < .75*STDEVP	0.9982802	0.9971523	0.9835621	0.245670083
218	18/10/2007 00:00	19/10/2007 00:00	STK_4	-346.3203463	288.75	285.75	STK_5	526.3434918	189.99	190.5	1.038961039	0.268435181	1.30739622	ratio < .75*STDEVP	0.9998727	0.9997787	0.9983436	0.014414072
219	18/10/2007 00:00	19/10/2007 00:00	STK_4	-346.3203463	288.75	285.75	STK_6	2173.913043	46	47.625	1.038961039	0.532608696	4.571569735	ratio < .75*STDEVP	0.9983269	0.9971699	0.9862797	0.354591413
220	18/10/2007 00:00	19/10/2007 00:00	STK_5	526.3434918	189.99	190.5	STK_0	-1038.961039	96.25	95.25	0.268435181	1.038961039	1.30739622	ratio < .75*STDEVP	0.9995663	0.9994081	0.996671	0.007954966
221	18/10/2007 00:00	19/10/2007 00:00	STK_5	-526.3434918	189.99	190.5	STK_6	2173.913043	46	47.625	-0.268435181	0.532608696	3.264173515	ratio < .75*STDEVP	0.9983321	0.9972302	0.9864755	0.198868925
222	18/10/2007 00:00	19/10/2007 00:00	STK_5	526.3434918	189.99	190.5	STK_7	-519.4805195	192.5	190.5	0.268435181	1.038961039	1.30739622	ratio < .75*STDEVP	0.9997763	0.9996187	0.997779	0.009996188
223	18/10/2007 00:00	19/10/2007 00:00	STK_5	526.3434918	189.99	190.5	STK_8	-173.1601732	577.5	571.5	0.268435181	1.038961039	1.30739622	ratio < .75*STDEVP	0.9998842	0.9997808	0.9984934	0.002499492
224	18/10/2007 00:00	19/10/2007 00:00	STK_5	526.3434918	189.99	190.5	STK_9	-519.4805195	192.5	190.5	0.268435181	1.038961039	1.30739622	ratio < .75*STDEVP	0.9997931	0.9996164	0.9971845	0.01472747
225	18/10/2007 00:00	19/10/2007 00:00	STK_6	2173.913043	46	47.625	STK_0	-1038.961039	96.25	95.25	0.532608696	1.038961039	4.571569735	ratio < .75*STDEVP	0.9979244	0.9967755	0.9828925	0.019305724
226	18/10/2007 00:00	19/10/2007 00:00	STK_6	2173.913043	46	47.625	STK_7	-519.4805195	192.5	190.5	0.532608696	1.038961039	4.571569735	ratio < .75*STDEVP	0.9982657	0.9971701	0.9853414	0.011335188
227	18/10/2007 00:00	19/10/2007 00:00	STK_6	2173.913043	46	47.625	STK_8	-173.1601732	577.5	571.5	0.532608696	1.038961039	4.571569735	ratio < .75*STDEVP	0.9983048	0.9971923	0.9853949	0.003541855
228	18/10/2007 00:00	19/10/2007 00:00	STK_6	2173.913043	46	47.625	STK_9	-519.4805195	192.5	190.5	0.532608696	1.038961039	4.571569735	ratio < .75*STDEVP	0.9982481	0.997023	0.9841757	0.012449149
229	20/10/2007 00:00	21/10/2007 00:00	STK_1	1086.956522	92	93	STK_0	-1061.007958	94.25	93.25	1.086956522	1.061007958	2.147964479	ratio < .75*STDEVP	0.9996432	0.9995176	0.9975443	0.013813244
230	20/10/2007 00:00	21/10/2007 00:00	STK_1	1086.956522	92	93	STK_3	-526.3157895	190	186.5	1.086956522	1.842105263	2.929061785	ratio < .75*STDEVP	0.9999128	0.9998593	0.9983305	0.018065067
231	20/10/2007 00:00	21/10/2007 00:00	STK_1	1086.956522	92	93	STK_4	-358.4229391	279	279.75	1.086956522	-0.268817204	0.818139317	ratio < .75*STDEVP	0.9999565	0.9999233	0.9996138	0.003001216
232	20/10/2007 00:00	21/10/2007 00:00	STK_1	1086.956522	92	93	STK_5	-530.5039788	188.5	186.5	1.086956522	1.061007958	2.147964479	ratio < .75*STDEVP	0.9999014	0.9998101	0.9984283	0.010999045
233	20/10/2007 00:00	21/10/2007 00:00	STK_1	1086.956522	92	93	STK_6	-2122.015915	47.125	46.625	1.086956522	1.061007958	2.147964479	ratio < .75*STDEVP	0.9983743	0.9971861	0.9844225	0.008010034
234	20/10/2007 00:00	21/10/2007 00:00	STK_1	1086.956522	92	93	STK_7	-530.5039788	188.5	186.5	1.086956522	1.061007958	2.147964479	ratio < .75*STDEVP	0.9999048	0.9998538	0.9994169	0.011357382
235	20/10/2007 00:00	21/10/2007 00:00	STK_1	1086.956522	92	93	STK_8	-176.8346596	565.5	559.5	1.086956522	1.061007958	2.147964479	ratio < .75*STDEVP	0.9999893	0.9999803	0.99992	0.003608031
236	20/10/2007 00:00	21/10/2007 00:00	STK_1	1086.956522	92	93	STK_9	-530.5039788	188.5	186.5	1.086956522	1.061007958	2.147964479	ratio < .75*STDEVP	0.9999102	0.9998416	0.9991209	0.014753531
237	20/10/2007 00:00	21/10/2007 00:00	STK_2	-523.5602094	191	186.5	STK_0	1061.007958	94.25	93.25	2.356020942	-1.061007958	1.295012985	ratio < .75*STDEVP	0.9995288	0.9992625	0.9964143	0.043922971
238	20/10/2007 00:00	21/10/2007 00:00	STK_2	-523.5602094	191	186.5	STK_1	1086.956522	92	93	2.356020942	1.086956522	3.442977464	ratio < .75*STDEVP	0.9999071	0.9998214	0.9990411	0.07316388
239	20/10/2007 00:00	21/10/2007 00:00	STK_2	-523.5602094	191	186.5	STK_3	526.3157895	190	186.5	2.356020942	-1.842105263	0.513915679	ratio < .75*STDEVP	0.9998106	0.9996558	0.9984938	0.00081746
240	20/10/2007 00:00	21/10/2007 00:00	STK_2	-523.5602094	191	186.5	STK_4	358.4229391	279	279.75	2.356020942	0.268817204	2.624838147	ratio < .75*STDEVP	0.9998558	0.9996988	0.9984313	0.01818923
241	20/10/2007 00:00	21/10/2007 00:00	STK_2	-523.5602094	191	186.5	STK_5	530.5039788	188.5	186.5	2.356020942	-1.061007958	1.295012985	ratio < .75*STDEVP	0.9998005	0.9996101	0.997058	0.013885277
242	20/10/2007 00:00	21/10/2007 00:00	STK_2	-523.5602094	191	186.5	STK_7	530.5039788	188.5	186.5	2.356020942	-1.061007958	1.295012985	ratio < .75*STDEVP	0.9998102	0.9996416	0.9984635	0.012958202
243	20/10/2007 00:00	21/10/2007 00:00	STK_2	-523.5602094	191	186.5	STK_8	176.8346596	565.5	559.5	2.356020942	-1.061007958	1.295012985	ratio < .75*STDEVP	0.9998994	0.9998156	0.9988345	0.004697383
244	20/10/2007 00:00	21/10/2007 00:00	STK_2	-523.5602094	191	186.5	STK_9	530.5039788	188.5	186.5	2.356020942	-1.061007958	1.295012985	ratio < .75*STDEVP	0.9998137	0.9996364	0.9981639	0.00615789
245	20/10/2007 00:00	21/10/2007 00:00	STK_3	-526.3157895	190	186.5	STK_0	1061.007958	94.25	93.25	1.842105263	-1.061007958	0.781097306	ratio < .75*STDEVP	0.9995726	0.9993428	0.9967576	0.046440944
246	20/10/2007 00:00	21/10/2007 00:00	STK_3	-526.3157895	190	186.5	STK_4	358.4229391	279	279.75	1.842105263	0.268817204	2.110922467	ratio < .75*STDEVP	0.9998707	0.9998044	0.9991559	0.018891536
247	20/10/2007 00:00	21/10/2007 00:00	STK_3	-526.3157895	190	186.5	STK_5	530.5039788	188.5	186.5	1.842105263	-1.061007958	0.781097306	ratio < .75*STDEVP	0.9998086	0.9997073	0.997748	0.01502536
248	20/10/2007 00:00	21/10/2007 00:00	STK_3	-526.3157895	190	186.5	STK_7	530.5039788	188.5	186.5	1.842105263	-1.061007958	0.781097306	ratio < .75*STDEVP	0.9998196	0.9997206	0.9987777	0.014291629
249	20/10/2007 00:00	21/10/2007 00:00	STK_3	-526.3157895	190	186.5	STK_8	176.8346596	565.5	559.5	1.842105263	-1.061007958	0.781097306	ratio < .75*STDEVP	0.99990			

APPENDIX 2. Database

7.11 General Relationships described

A NASDAQ_company (PK:ticker) has one price (the “current” price) loaded in last_load (PK: ticker) during a dataload

A NASDAQ_company (PK:ticker) has one or more NASDAQ_equity_price (PK:ticker, dt)

A NASDAQ_equity_price (PK:ticker, dt) is the most current or end of day price for a NASDAQ_company (PK:ticker)

A SuggestedPositionArchive (PK:seq, AK: x_ticker, y_ticker, openDate) is for a pair (an x any y ticker) of NASDAQ_company (PK:ticker)

A NASDAQ_company (PK:ticker) may be a part of one or more SuggestedPositionArchive (PK:seq, AK: x_ticker, y_ticker, openDate)

The last_load table contains the last loaded prices data from a source file scraped from the NASDAQ exchange web site. Data is 20 minute delayed. srcFile identifies the file (100 = nasdaq 100 and FIN = nasdaq financial)

One open position (i.e. not closed) only is allowed on SuggestedPositionArchive. This is relaxed when operating real-time.

7.12 Entity Model

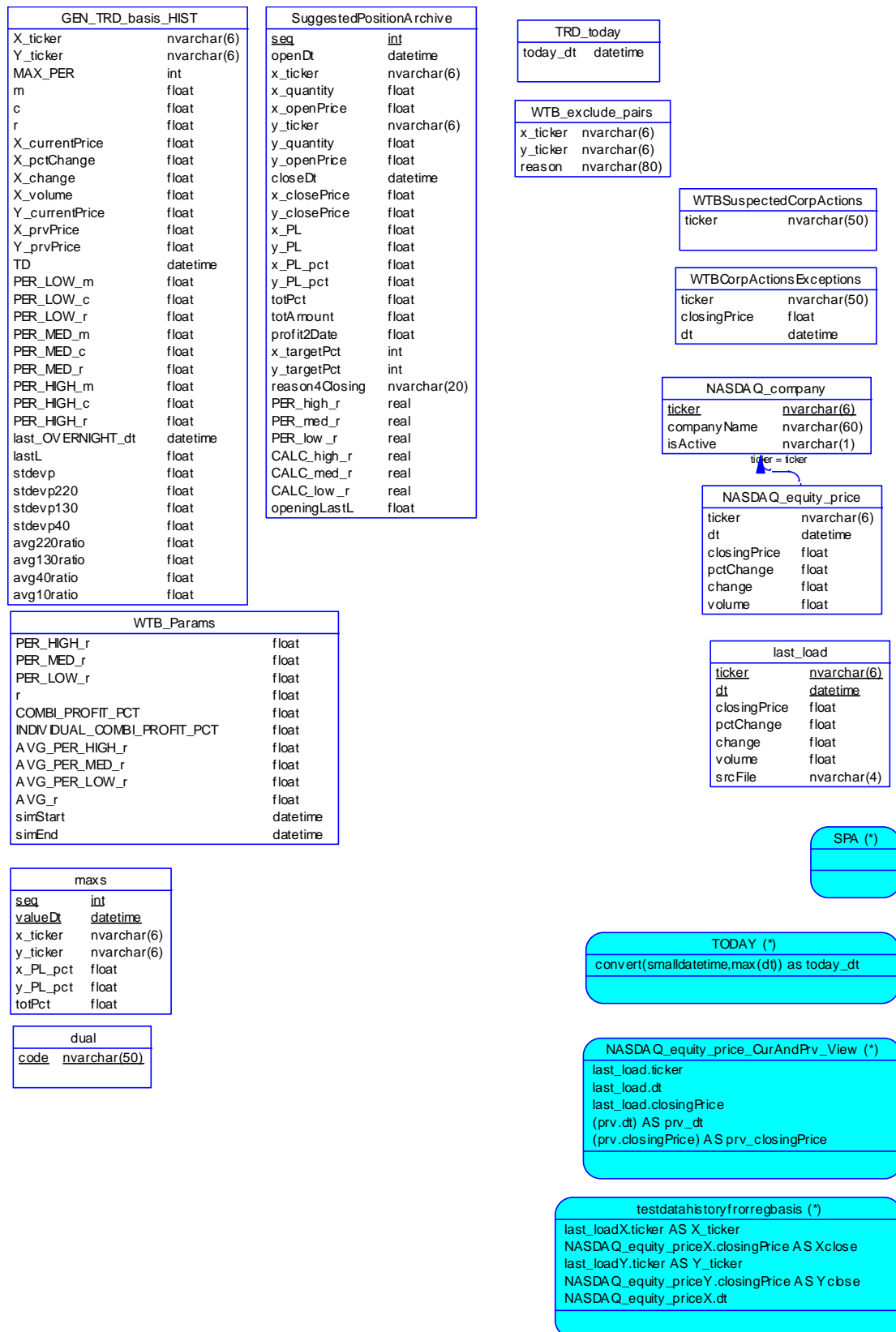


Figure 43: Entity model

7.13 Main tables

7.13.1 Table: GEN_TRD_basis_HIST

The table that holds historical regression data.

Tickers for each stock pair

X_ticker	char(10)	null	,
Y_ticker	char(10)	null	,

The maximum number of days in the regression calculation (220 days if all required data is there)

MAX_PER	int	default '(0)'	null	,
---------	-----	---------------	------	---

Linear regression line and r2 values for the periods 10, 40, 130 and 22

periods, respectively as follows

m	float	null	,
c	float	null	,
r	float	null	,
PER_LOW_m	float	null	,
PER_LOW_c	float	null	,
PER_LOW_r	float	null	,
PER_MED_m	float	null	,
PER_MED_c	float	null	,
PER_MED_r	float	null	,
PER_HIGH_m	float	null	,
PER_HIGH_c	float	null	,
PER_HIGH_r	float	null	,

Current financial data

X_currentPrice	float	null	,
X_pctChange	float	null	,
X_change	float	null	,
X_volume	float	null	,
Y_currentPrice	float	null	,
X_prvPrice	float	null	,
Y_prvPrice	float	null	,

The trade date the regression data is calculated for. Note on trade date n the regression data n-1 should be used

TD	datetime	null	,
----	----------	------	---

The date and time the calculation was placed on the table

last_OVERNIGHT_dt	datetime	null	,
-------------------	----------	------	---

distance of the current scatter point x,y from the regression line

lastL	float	default '(0)'	null	,
-------	-------	---------------	------	---

as a multiple of the standard deviation of the average period price ratio in use for trading. The standard deviations and ratios are recorded for the periods 10, 40, 130 and 22 periods, respectively as follows:

stdevp	float	default '(0)' null ,
stdevp40	float	default '(0)' null ,
stdevp130	float	default '(0)' null ,
stdevp220	float	default '(0)' null ,
avg10ratio	float	default '(0)' null ,
avg40ratio	float	default '(0)' null ,
avg130ratio	float	default '(0)' null ,
avg220ratio	float	default '(0)' null ,

7.13.2 Table: SuggestedPositionArchive

The archived positions. A position is taken by the what to buy program and involves a buy or sell of the x ticker (representing the company) and a counter position resulting a neutral hedge position in the y ticker. Each position is allocated a unique seq (sequential number) this can be seen in the maxs table showing the position P&L over the duration of the position. A position shows the open date and close date (if closed) along with the open and closing prices of the position. The total P&L of the position along with the total percentage profit (realised or unrealised) and a percentage P&L in each. Each time a new set of prices is loaded this table is modified to reflect the new prices and P&L.

seq	int	default '(0)' not null,
openDt	datetime	null ,
x_ticker	char(10)	null ,
x_quantity	float	default '(0)' null ,
x_openPrice	float	default '(0)' null ,
y_ticker	char(10)	null ,
y_quantity	float	default '(0)' null ,
y_openPrice	float	default '(0)' null ,
closeDt	datetime	null ,
x_closePrice	float	default '(0)' null ,
y_closePrice	float	default '(0)' null ,
x_PL	float	default '(0)' null ,
y_PL	float	default '(0)' null ,
x_PL_pct	float	default '(0)' null ,
y_PL_pct	float	default '(0)' null ,
totPct	float	default '(0)' null ,
totAmount	float	default '(0)' null ,
profit2Date	float	default '(0)' null ,
x_targetPct	int	default '(0)' null ,
y_targetPct	int	default '(0)' null ,
reason4Closing	char(10)	null ,
PER_high_r	real	default '(0)' null ,
PER_med_r	real	default '(0)' null ,

```

PER_low_r      real      default '(0)' null ,
CALC_high_r    real      default '(0)' null ,
CALC_med_r     real      default '(0)' null ,
CALC_low_r     real      default '(0)' null ,
openingLastL   float     default '(0)' null

```

when a position is closed the reason is also given in the column called reason4Closing (this can be because a stock has left the index or the r2 value is less than when the position was taken out, a stop loss has been hit or a good profit has been made.

<PER> | <CALC> high med and low values show the r2 value at the start of the position (the calc set is a duplicate and is present for only through lack of tidiness)

7.13.3 /* Table: WTB_exclude_pairs */

Pairs to be excluded can be placed in this table

```

x_ticker      char(10)    null ,
y_ticker      char(10)    null ,
reason        char(10)    null

```

7.13.4 /* Table: WTB_Params */

```

PER_HIGH_r    float      default '(0)' null ,
PER_MED_r     float      default '(0)' null ,
PER_LOW_r     float      default '(0)' null ,
r             float      default '(0)' null ,
COMBI_PROFIT_PCT float    default '(0)' null ,
INDIVIDUAL_COMBI_PROFIT_PCT float default '(0)' null ,
AVG_PER_HIGH_r float      default '(0)' null ,
AVG_PER_MED_r float      default '(0)' null ,
AVG_PER_LOW_r float      default '(0)' null ,
AVG_r         float      default '(0)' null ,
simStart      datetime    default '5/23/2004' null ,
simEnd        datetime    default '5/30/2004' null

```

7.13.5 /* Table: WTBCorpActionsExceptions */

```

ticker        char(10)    null ,
closingPrice   float      default '(0)' null ,
dt            datetime    null

```

7.13.6 /* Table: WTBSuspectedCorpActions */

```

ticker        char(10)    null

```

7.13.7 /* Table: NASDAQ_company */

ticker	char(10)	not null,
companyName	char(10)	null ,
isActive	char(10)	default 'Y' null

7.13.8 /* Table: NASDAQ_equity_price */

ticker	char(10)	not null,
dt	datetime	not null,
closingPrice	float	default '(0)' null ,
pctChange	float	default '(0)' null ,
change	float	default '(0)' null ,
volume	float	default '(0)' null

7.14 Create table and views

The main tables and views from the database are presented in the schema can be seen on the attached CD in the file crebas.sql.

7.15 Table last_load

ticker is the symbol used to identify the company on the exchange

(eg MSFT= Microsoft)

dt is the date.

closingPrice is the currently obtained price from the exchange and when stored historically in NASDAQ_equity_price is the closing price for the day.

Other fields are typical financial data.

7.16 Full Database List

Tables and views can be see listed on the CD in CD\DatabaseEntities\crebas.sql .

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