FAST FOURIER TRANSFORMS, AN ANALYSIS TOOL FOR SHARE SELECTION

by

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PREFACE

"The future belongs to those who believe in the beauty of their dreams."

~ Eleanor Rooseveld ~

I dedicate this study to Erna and Amorie who had to endure numerous

lonely hours while I was reaching for a dream.

My sincere gratitude is hereby expressed to Professor Ines Nel who believed in my ability and supported the research proposal throughout.

Maz Smart, who has been a life-long mentor and friend, for the highly valued assistance.

ABSTRACT

The advent of the modern high-speed digital computer has caused a revolution in the application of the theory of digital signal processing to a variety of problems. Digital signal processing has served to create vitality in fields often overlooked by science. One such field is the application of digital signal processing capabilities to the stock market.

In the stock market, words such as period, frequency and phase are common place. These words also form part of the engineer's vocabulary. It therefore appears that a certain degree of congruency between the fields may exist.

One specific engineering tool of interest to stock market applications seems to be the Fourier Transform. Fourier Transforms were originally developed as an engineering tool to study repetitious (cyclical) phenomena. The benefit of Fourier Transform is its ability to extract the predominate cycle(s) from a series of data, in this instance an indicator or a security's price.

Fourier Transform is based on the principal that any finite, time-ordered set of data can be approximated arbitrarily well by decomposing the data into a set of sine waves. Each sine wave has a specific cycle length, amplitude, and phase relationship to the other sine waves, and the interest lies in the decomposition of the stock data array to a basic function on which a decision can be based regarding the behaviour of the signal.

The scope of this dissertation shall be to establish weather Fourier Transforms can be used as a decision tool in the selection of Shares.

This dissertation takes the point of view that digital signal processing and the rather profound mathematics that accompany them are fields of study unto themselves and beyond the focus of the dissertation.

OPSOMMING

Die ontdekking van die moderne hoë-spoed digitale rekenaar het 'n revolusie veroorsaak op verskeie toepassings velde van digitale sein prosessering. Digitale sein prosessering het 'n nuwe era ingelei in velde wat dikwels deur die wetenskap oor die hoof gesien is. Een so 'n terrein is die toepassing van digitale sein prosessering op die aandele mark.

Woorde soos periode, frekwensie, en fase word algemeen in die aandelemark aangetref. Hierdie woorde is ook deel van die woordeskat van die ingenieur. Dit wil dus voorkom of daar 'n mate van sinergisme tuussen diè twee velde bestaan.

Een spesifieke ingenieurs instrument wat blyk toepaslik op die aandelemark te kan wees is juis die Fourier transformasie. Fourier transformasie is oorspronklik as 'n instrument vir die ingenieur ontwikkel met die doel om sikliese gebeurtenisse mee te bestudeer. Fourier transformasie het die vermoë om die onderliggende siklus in 'n data series te kan identifiseer, in hierdie geval die prys van 'n aandeel.

Fourier Transformasie is daarop gebaseer dat enige eindigende, tyd-georienteerde data reeks arbitrêr benader kan word deur die data te ontbind in 'n stel sinus golwe. Elke sinus golf het 'n spesifieke golflengte, amplitude en faseverwantskap tot die ander sinus golwe. Die betekenis van die ontleding lê daarin dat die aandeel data vereenvoudig word tot 'n basiese funksie waarop voorspellings rakende die toekomstige gedrag van die sein gemaak kan word.

Hierdie skripsie het ten doel om te bepaal of Fourier transformasie sinvol as 'n besluitnemings meganisme aangewend kan word vir die uitsoek van aandele.

As vertrekpunt vir hierdie skripsie word dit gestel dat digitale seinprosessering en die komplekse wiskunde wat daarmee gepaard gaan, buite die fokus van hierdie skripsie val.

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FFT	:	FAST FOURIER TRANSFORM
IPO	:	INITIAL PUBLIC OFFERING
CEO	:	CHIEF EXECUTIVE OFFICER
DCM	:	DEVELOPMENT CAPITAL MARKET
VCM	:	VENTURE CAPITAL MARKET
VC	:	VENTURE CAPITAL
MB	:	MAIN BOARD
ATS	:	AUTOMATED TRADING SYSTEM
JET	:	JOHANNESBURG EQUITIES TRADING
JSE	:	JOHANNESBURG STOCK EXCHANGE
BESA	:	BOND EXCHANGE OF SOUTH AFRICA
SAFEX	:	SOUTH AFRICAN FUTURES EXCHANGE
STRATE	:	SHARE TRANSACTION TOTALLY ELECTRONIC
CAPM	:	CAPITAL ASSET PRICING MODEL
APM	:	ARBITRAGE PRICING MODEL
SML	:	SECURITY MARKET LINE
EMH	:	EFFICIENT MARKET HYPOTHESIS
P/E	:	PRICE TO EARNINGS RATIO
DNA	:	DROXYRIBOSE NUCLEIC ACID

FAST FOURIER TRANSFORMS,

AN ANALYSIS TOOL FOR

SHARE SELECTION

CHAPTER 1

ORIENTATION, SCOPE OF STUDY AND METHODOLOGY

"Discovery consists of seeing what everybody has seen –
And thinking what nobody has thought."
- - - Albert Szent-Gyorgy

1.1. Orientation to this Study

Is profitable portfolio management a science, or an art? Samuelson (1989:7) is of the opinion that profitable portfolio management is in fact an art. After studying the performance of many managers over more than a decade he found that only 10 out of 10 000 were able to beat the indices. These findings are supported by Anon (1992:9) who found that most portfolio managers were unable to beat the applicable sector index in which they were active over a long period of time.

A more recent probe into the actuality of the phenomena among modern portfolio managers revealed that fund managers are performing only marginally better. Cabot-Alletzhauser (1996) attributes the failure of fund managers to beat the indices to market efficiency – everyone working off the same information. Many others on the other hand reckon that the Johannesburg Stock Exchange is not similarly efficient and that it is possible to outperform its various indices. The record however does not support this line of reasoning (Brigham & Gapenski, 1997:327). Surveys conducted by Professor Hugo Lampbrechts of the University of Pretoria shows systematic under-performance over various time frames by the average general equity unit trust manager.

The difficulty of outperforming the market is illustrated by the index funds. Not once in 25 years has the Sanlam index fund - the oldest and further back than three years, the only index fund - outperformed the All Share Index (Woodin, 1996).

Many authoritarians consider it unsophisticated to pay much attention to past performance of unit trusts, pension funds and other investment options, but it is understandable that some

comfort is found in performance league tables as a rough and ready guide to picking funds. Past performance certainly helps as an indicator of future performance, provided you also try to look at the consistency of fund performance and its volatility around its chosen benchmark.

For the reason held above, but more importantly, for purposes of establishing a baseline against which the performance of the *fast Fourier transform* (FFT) in chapter 5 can be compared, the performance of a number of funds and indices will now be considered. Table 1 reflects the performances of the largest funds on the Johannesburg Stock Exchange over a period of five years. Note, only the top performer in each category is listed. The percent expressed represents the average annual growth rate over the term. A detailed list of all the funds and their performance over different periods is listed in Appendix A.

TABLE 1 : PORTFOLIO PERFORMANCE

TOP PERFORMERS	**5 years to December '98**	
	Rank	**%**
Norwich Unit Trust	1	14,50
Guard Bank Resources	1	5,06
Old Mutual Gold	1	(2,28)
Old Mutual Industrial	1	13,49
Sage Financial Services	1	18,79
Standard Bank International	1	16,89
NIB Syfrets Value	-	3,45
NIB Syfrets Flexible	1	4,81
Southern Income	1	13,90
Investec Gilt	1	14,16
	Average	**10.25**

Source : University of Pretoria Review

Portfolio managers and investors at large are continuously involved in an intricate process of balancing the risk associated with a potential investment, against the expected return on that investment. Risk and return are synonymous in investment terms, and it goes without saying

that investors will seek the highest possible return on their investment, but at the same time aim to reduce the investment risk.

From Table 1 it can be seen that the top performer over the 5 year period managed only 18,79% on average per annum. Disappointingly is the performance of all the top funds over a five year term which averaged out at only 10,25%.

Venture Capital stocks are known to offer extremely high rewards to investors, but they are also perceived to be extremely risky (Kess, 1998:330). This perception is highly debatable, but to assess the risk involved in an investment in general, potential investors need an extremely broad sweep of information. Gathering information which is easily understood takes time, is difficult to access and mostly difficult to interpret. Such a timely process may cause opportunities to be missed (Posadas, 1998:54). A more rapid, but at the same time reliable and accurate method is desirable. It is for this reason that many investors turn to technical analysis rather than fundamental analysis.

All stocks contain traces of repetitious (cyclical) phenomena, which characterises the response of the stock to a magnitude of factors such as economic, political and managerial, to which the stock has been subjected. Since these oscillations are period, frequency and phase related, there appears to be a certain degree of congruency between stock analysis and Fourier transforms. Fourier transforms were originally developed as an engineering tool to study repetitious (cyclical) phenomena. The strength of Fourier transforms lies in its ability to extract the predominate cycle(s) from a series of data (in this instance the closing price of a security). With the predominate cycle exposed, an attempt can be made to predict the future behaviour of the cycle, by applying to the newly exposed cycle, any popular indicator.

This dissertation shall investigate the use of fast Fourier transforms as a technical analysis tool to improve the timing and accuracy of stock selection. Due to the accuracy of the tool, it could reduce the risk involved in the selection of venture capital stock.

It is the intention to prove that fast Fourier transforms can indeed change stock selection from being an art, to being a science.

1.2 Problem Statement

Investors in general are faced with two key issues when investment is considered. Firstly *which* shares to buy, and secondly *when* to buy or sell these shares. Venture Capital shares can offer extremely high return on investment if the investor is able to accurately and timely access and withdraw from the market. Due to the volatile nature of venture capital shares it is difficult to predict their future trends.

No other analysis tool is known which is concerned with identifying the predominate cycle in a data array. Fourier transforms were specifically designed to illuminate the predominate cycle in data. It is thus regarded as most appropriate to examine whether fast Fourier transforms can be employed as an analysis tool to predict the future behaviour of venture capital shares. In doing so the investor can be assisted in optimising his stock selection, and thus reducing his investment risk.

1.3 Purpose of this Study

The main purpose of this script is to determine the degree of accuracy and reliability with which fast Fourier transforms can be applied as an analysis tool in the selection of Venture Capital stocks.

1.4 Frame of Reference

From a theoretical perspective, this dissertation shall reflect on venture capital as a sector of the Johannesburg Stock Exchange with respect to its composition, a local and international perspective and the risk/return relationship associated with the venture capital environment shall be researched. Fast Fourier transforms shall be introduced and the congruency between fast Fourier transforms and stock data analysis shall be expanded upon.

From a practical point of view, the scope of the research shall be limited to the venture capital sector of the Johannesburg Stock Exchange (JSE). In evaluating the suitability and performance of fast Fourier transforms as an analysis tool, the performance of selected stock, indices and leading funds shall be evaluated.

1.5 Research Methodology

1.5.1 Literature study

The literature study provides the necessary theoretical background to the risk/reward relationship, as well as the most popular models used in determining risk. The risk/reward relationship is then linked to venture capital Stock to illuminate the extremely high returns possible in this sector of the Johannesburg Stock Exchange.

The basic theory behind fast Fourier transforms as an engineering tool for digital signal processing and the suitability of fast Fourier transforms in the analysis of cyclical phenomena is researched and introduced as a stock selection indicator.

1.5.2 Quantitative Analysis

A quantitative analysis will establish whether the stocks currently contained in the venture capital sector can indeed be accurately analysed with a higher degree of accuracy concerning their future behaviour by the application of fast Fourier transforms to the basic data.

The performance of ten randomly selected stocks from the Venture Capital Sector, analysed by means of fast Fourier transforms shall be compared to the performance of the same stock when a number of commonly used indicators are applied to them. The performance shall further be compared to the Overall Index, the venture capital index and the results of the top performing funds as contained in Table 1.

1.6 Limitations of this Study

- The research is limited to the stocks contained in the venture capital sector as of June 1999.

- The period over which the analysis is conducted is relatively short, for this study an average of only 381 days.

- Use shall only be made of daily data, inter-day analysis is not considered.

- The data analysis shall be focussed on daily closing prices.

- The market in general has been through a turbulent period making any form of analysis difficult.

- The dissertation is focussed on technical analysis and is not concerned with the fundamental analysis of stocks.

1.7 Actuality of Topic

Since the deregulation of the Johannesburg Stock Exchange in November 1995 and the subsequent introduction of an Automated Trading System (ATS) in March 1996, the trading floor has physically been brought to the investor through remote workstations. The playing ground for investors large and small have in fact been levelled to equal participation since trading operates on a first-come-first-served-bases, and is not volume driven.

More and more corporations are shifting from retirement plans in which the company make all the investment decisions, to plans in which the employee must make his own decisions and then live well or badly depending on how their investments perform (Brigham and Gapenski, 1997:143).

The listing of Sanlam in 30 November 1998 and the recent listing of Old Mutual (London and Johannesburg Stock Exchange) on 12 July 1999, has fuelled interest in the personal management of portfolio's by individuals. People have become aware of the fact that their investments in institutions (life insurance and pensions funds) in fact end up on the Johannesburg Stock Exchange and that the performance of their investment therefore depends on the yield of the Johannesburg Stock Exchange. Due to poor performance of many fund managers, many people today turn to the stock market in search of better returns on their investments. The large sums of money that have become available through retrenchment packages has further added fuel to the fire.

Many software companies (Sharefriend, Equis, IDSS, etc) have capitalised on the need in the market to offer software which enables the investor to manage his own portfolio. These

programs focus on technical analysis and thus eliminate the need for extensive fundamental analysis of the stock at question.

And finally the venture capital sector in South Africa is a young and emerging sector and one in which future growth is expected to be high.

1.8 Preview of Chapters

This dissertation is comprised as follows:

Chapter 1 provides an orientation into the field of study and briefly elaborates on the focus of this dissertation.

Chapter 2 offers an introduction to the Johannesburg Stock Exchange and researches the Venture Capital Market in terms of its existence, role and function and its attractiveness to investors and its relevance to this dissertation. A theoretical framework by means of a literature study into the valuation of stocks and the risk/return relationship is supplied. The chapter concludes with a study into stock analysis and associated techniques.

In *Chapter 3* the theory and principles of Joseph Fourier are researched to establish an understanding of fast Fourier transforms and how they can be applied as an analysis tool by the investor.

In *Chapter 4* the construction of a fast Fourier transform indicator is described. The indicator is then applied to a number of randomly selected stocks, and the degree of accuracy with which the transform can be applied, evaluated.

In *Chapter 5* the results are discussed, conclusions are drawn and recommendations made.

Chapter 6 summarises the entire study. Limitations are discussed and new research opportunities are reflected upon.

1.9 Description of Key Concepts

Risk	The probability of actually earning less than the expected return on an investment. – the greater the chance of low or negative returns, the riskier the investment (Brigham & Gapenski, 1997:146).
Venture Capital	Capital is a fundamental requirement of any business in order to start and maintain it's operations. Various sources of venture capital exist, ranging from internal or self-funding to external funding in the form of debt financing. Venture Capital is capital with a degree of risk (Keasey & Wilson, 1993:15).
Fourier Transforms	A mathematical technique which was originally developed as an engineering tool to study repetitious (cyclical) phenomena. The strength of Fourier transforms lies in it's ability to extract the predominate cycle(s) from a series of data (Achelis, 1999).
Fast Fourier Transforms	Fast Fourier transform is an abbreviated calculation that can be computed in a fraction of the time of a Fourier transform, since it saves time by decreasing the number of multiplication's required to analyse a curve. The fast Fourier transform is in fact a *Discrete Fourier Transform* algorithm which reduces the number of computations by sacrificing phase relationships and concentrates only on cycle length and amplitude (Hoffman, 1999).
Fundamental Analysis	The term fundamental as applied to stock market analysis refers to the study of the myriad background factors which affect the value of securities and hence their price. The fundamental approach assumes that a valid distinction can be made between the intrinsic value and the ruling price of a security (Joffe, 1999)
Technical Analysis	Technical analysis is the study of prices and volumes in actively traded free market systems such as the stock exchange. It

	determines the "optimum time to buy and sell stocks" as opposed to the "intrinsic value" of stocks. Timing is the critical success factor in considering an investment. It is a study of the market or stock and not of the factors that influence the market or stock. Technical analysis can therefore be regarded as a study of the history associated with a market or stock, which includes the price movement and volume of transactions. History is primarily used to predict the future behaviour of the stock (Pike, 1999).
Securities	Securities refer to cash, shares, stock, debentures, debenture stock and bonds - any medium in which money is invested in the hope of protecting the money invested, and causing the capital value of the investment to grow.
Bear Market	A "bear" market is when there is a distinct downward trend in the price of stock. This is caused by a lack of demand and the constraints on economic growth brought about by market conditions.
Bull Market	A "bull" market is simply when there is a distinct upward trend in the price of stock (shares etc.) on the exchange. This is caused by an increase in demand for investment opportunities and inherent growth in the value of companies due to favourable market conditions.
Fundamental Wave	One full cycle of a wave in a single rotation. It has the largest amplitude and persists the longest in a data series.
Harmonics	The second harmonic will be comprised of two full cycles in a single rotation, the third three cycles in a rotation and so on.
Stock	Where the term 'stock' is used it shall also mean shares. Shares is a commonly used term in the South African Investment community.

CHAPTER 2

LITERATURE RESEARCH and THEORETICAL BACKGROUND

"Security is when everything is settled. When nothing can happen to you.
Security is the denial of life."
- - - Germaine Greer.

2.1 PREFACE

Since the primary focus of this dissertation is to analyse the use of fast Fourier transforms as a means of stock selection, it is of importance to introduce the reader to the basic structure, composition and functioning of the Johannesburg Stock Exchange.

The young but growing Venture Capital market in South Africa will be researched to present a synopsis of it's composition, functioning and role within the broader South African economy. Since the analysis conducted in Chapter 5 is concerned only with the Venture Capital sector of the Johannesburg Stock Exchange, the relevance of this chapter becomes evident.

Having visited the controversial venture capital market, the reader inevitably becomes concerned with the concept of risk and return. The logical consequence is to investigate the risk/return relationship, and present the intricacies associated with risk and return. Research is then conducted into the factors that influence risk, valuation of risk and a number of popular valuation models available to investors are presented.

In conclusion to this chapter two main stream approaches to stock selection are researched – Fundamental and Technical analysis. The pro's and con's of each is discussed and a comparison is drawn between the two. Also the issue of active versus passive portfolio management is studied, focussing on market timing and stock analysis and the influence of the Efficient Market Hypothesis (EMH).

2.2 THE JOHANNESBURG STOCK EXCHANGE

"The one thing that makes life possible is permanent, intolerable uncertainty;
Not knowing what comes next."
- - - Ursula K. LeGuin.

2.2.1 Introduction

The basic purpose of a stock exchange is to create a facility where shares of companies are available for trading and companies can raise capital. In doing so they provide for their expansion, and for growth of employment and investment, which is to the benefit of the whole economy of the country.

Companies raise money, by using either debt or equity. Debt would normally imply borrowing money from banks or other financial institutions, equity can be raised by the issuance of shares to the public through the stock exchange.

2.2.2 Historical Background of the Johannesburg Stock Exchange

The Johannesburg Stock Exchange was founded in 1887, approximately at the same time that gold was discovered on the Witwatersrand. It is the largest stock exchange in Africa and with its capitalisation of R90 billion is more than 10 times larger than other African stock market.

From 1887 to 1996 trade was conducted on the trading floor based on an open outcry auction system. The Johannesburg Stock Exchange management however recognised the need to draw abreast the technology and standards of the foremost Stock Exchanges in the world. It also needed to attract international players and to improve transparency and security to market participants. November 1995 marked the beginning of a period of drastic changes to the Johannesburg Stock Exchange, the following being the most significant:

i. 1 July 1995, new listing requirements introduced regarding transparency, accessibility, increase liquidity, reduced prevarication and increased protection. (For example the Venture Capital listing requirement was reduced from R2 million to R500 000).

ii. 13 September 1995, the *Stock Exchange Control Act Amendment* Bill was approved in parliament regarding the exclusive membership of only natural persons and South African citizens.

iii. 8 November 1995, the JSE opened it doors to foreign and corporate members.

iv. March 1996, Dual-capacity trading started (the option of dealing as an agent or as a principle with a client).

v. 7 June 1996, the introduction of an Automated Trading System (ATS)

vi. 19 March 1999, a new sector classification system was implemented.

vii. Integration of the Johannesburg Stock Exchange (JSE), the South African Futures Exchange (Safex) and the Bond Exchange of South Africa (BESA)

viii. 30 July 1999, Implementation of the totally electronic share transaction system (STRATE)

2.2.3 Activities of the Johannesburg Stock Exchange

As an intermediary in the Capital Market, the activities of the Johannesburg Stock Exchange can be divided into *primary* and *secondary* activities.

The *primary function* of the Johannesburg Stock Exchange is to establish an organised market where the trading in stock is conducted. This means that the Johannesburg Stock Exchange establishes mechanisms through which public companies can generate capital through stock and government institutions through bonds. This avenue was created to enable surplus funds (pension funds, investments, life insurance funds) to be channelled to likely companies for investment purposes.

The *secondary function* of the Johannesburg Stock Exchange is to provide the machinery for trading in existing stock and securities, thereby creating a continuous market where investors can divert stock into cash.

2.2.4 The Structure of the Johannesburg Stock Exchange

The JSE is divided into various boards namely:

i. The Main Board (MB)

ii. The Development Capital Market (DCM) and,

iii. The Venture Capital Market (VCM)

Under the chairmanship of Professor Michael Katz, a comprehensive report was tabled focussed at the restructuring of the Johannesburg Stock Exchange. Recommendations from *The Research Report* of relevance to this study included the following:

i. That the Johannesburg Stock Exchange should market the advantages of listing on the Main board, the Venture Capital Market and the Development Capital Market.
ii. That the Johannesburg Stock Exchange would expand its client base and make its information service more available to interested parties.
iii. That the Johannesburg Stock Exchange must make the general public aware of its existence and functions.
iv. That the Johannesburg Stock Exchange must develop rising sectors.

After implementation of the new sector classification system on 19 March 1999, the Johannesburg Stock Exchange now comprises of 58 sectors and sub-sectors (Appendix B). The new sector structure as well as the new index structure is graphically depicted in Appendix C.

2.2.5 Performance of the Johannesburg Stock Exchange

The Johannesburg Stock Exchange has grown rapidly through the years. The five-year market summary report in Table 2 compiled by Anon (1999) reflects the performance over this term. In observing the figures, cognisance must take of the fact that South Africa is an emerging market and subjected to global market mechanisms. The past 18 months have seen two significant corrections which had a rather profound impact on the South African economy, and is clearly visible in the performance of the Johannesburg Stock Exchange over this period:

TABLE 2 : FIVE-YEAR MARKET SUMMARY OF THE JSE

Year ended December	1998	1997	1996	1995	1994
New capital raised (R billion)	89,5	50,3	28,4	19,5	10,0
Value traded (R billion)	319,3	206,8	117,1	63,3	71,8
Volume traded (billion shares)	34,4	17,9	9,0	5,2	5,8
No. of deals (million)	3,7	2,3	1,4	0,8	0,8
Liquidity (%)	26,7	16,9	10,9	7,0	7,5
Change year-on-year:					
All Share Index (%)	- 12,4	- 6,8	6,9	6,2	19,9
All Gold Index (%)	5,9	- 46,8	12,1	- 33,6	- 6,5
Financial Index (%)	- 17,0	36,1	10,1	32,8	26,5
Industrial Index (%)	- 15,6	- 6,3	- 0,8	14,4	25,3

The following highlights together with the figures summarise in the table above were taken from the annual report for 1998.

i. Uptime for the Johannesburg Equity Trading system at 99,9% was the highest since its implementation, despite the three new versions of the system which were installed during the year.

ii. Johannesburg Stock Exchange market information is currently being distributed to over 24 000 terminals of which more than 7 000 are located abroad.

iii. On 18 June 1998, a record high of 29 053 trades valued at R2,8 billion was handled by the Johannesburg Equity Trading system.

iv. The operating surplus before transfers to reserves was higher at R71,6 million compared with R33,3 million in 1997.

v. Listed companies increased from 151 in 1932 to 642 currently.

vi. Transactions have risen from 3000 per day in 1995 to 1 billion per day currently.

vii. Daily Turnover at present stands at R11,4 bn

2.3 VENTURE CAPITAL MARKET

"The young do not know enough to be prudent,
and therefore they attempt the impossible and achieve it,
Generation after Generation."
- - - Pearl S. Buck.

2.3.1 Introduction

For purposes of this dissertation the focus will be placed on the venture capital market and stock within the venture capital sector. This choice is exercised since the author believes venture capital can be a significant driver of the economy in the future through the creation of small businesses and the subsequent employment associated with it. It is also chosen due to the role it plays in fostering good entrepreneurs and develops their skills to produce profitably. Finally it is chosen because of the potential high rates of return offered by it to the investor.

To this end, venture capital is as yet, still very much in its infancy and deeply submerged in the broader South African economy. But as has happened elsewhere in the world, South African venture capital is on the brink of explosive growth (Ryan, 1998:71)

2.3.2 What is Venture Capital

The word *Venture* suggests that this type of capital involves a degree of risk and even something of a gamble. Specifically, the venture capital industry supplies capital and other resources to entrepreneurs in business with high growth potential in the hopes of achieving a high rate of return on invested funds (Timmons, 1999:441). Venture capital is defined by most people as money for start-ups and good ideas. Private investors, family and friends are the principle source of capital tapped by the budding entrepreneurs. However, most venture capital companies broaden the definition of venture capital to include money for expansion of existing business. It is this latter definition that is primarily accepted to embrace the scope of venture capital (Ryan, 1998:71).

Venture capital can be compartmentalised into different types or categories of venture capital. The highest risk is seed capital which is used to build prototypes of innovative ideas or to conduct limited test markets. Next riskiest is start-up capital which applies to well-developed business plans. Then comes early stage investment when the expansion of a business is under way. Lastly, and the least risky, is the latter stage development, which includes management buy-outs and expansion capital (Ryan, 1998:71). The entire investing process involves many stages, and throughout the whole process, venture capital firms seek to add value in several ways such as evaluating opportunities, providing technical and management assistance and attracting additional capital and resources. The process usually takes up to 10 years to unfold (Timmons, 1999:441).

2.3.3 Attractiveness of Venture Capital

Most start-up companies and small businesses find lack of access to finance one of the major obstacles to starting and growing their ventures. As a result many business ideas with good potential end up being abandoned, especially if they are at the start-up phase, for lack of adequate financing (Bukula, 1996:18).

Venture capital differs from bank credit in a number of ways. Venture capitalists do not provide credit and therefore do not require any collateral, they provide equity and are thus much like ordinary shareholders. The venture capitalists money is made from capital appreciation and dividends, the venture capitalist is thus in essence a business partner. When the business prospers, he prospers, and by the same token when the business fails, he too makes a loss. Value is created by advise, skills and the personal network of the venture capitalist brings to the new enterprise. These often include legal access, accounting services and other favourable arrangements (Lach, 1998:73).

The attractiveness further lies in the fact that although at a higher risk, venture capital companies are at the start of an exponential growth phase. The investment should appreciate at least ten times by the end of the investment period, which is approximately five years (Bukula, 1996:18).

2.3.4 An Historical Perspective of Venture Capital

In the 1970's, the high technology industry was relatively young, but evolving. A few large institutions such as Hewlett Packard, IBM and Xerox had developed strong track records in this new field. They however, continued to finance themselves in traditional ways, using assets as collateral against loans. Unfortunately this financing model created barriers to entry for cash-constrained start-ups, such as software companies that needed to capitalise quickly on market opportunities.

The *first generation* of venture financing really then began, with wealthy pioneers such as Arthur Rock revolutionising the financing of high-technology, high potential companies. This new type of financing saw the wealthy investors buying the stocks of companies still in their infancy. The model worked well and by the 1980's companies such as Apple, Lotus, Microsoft and Oracle succeeded in this manner. The investment banks then took the most promising companies public, where the financial markets upheld the values (Tims, 1999:2).

The success of the early initial public offering drove the *second generation* of venture capital. Venture capitalists refined the process of preparing a company for Initial Public Offering (IPO) by focussing on revenue growth and cash management. Where the first generation of venture capitalists were successful simply because they were willing to invest, the values of the second generation lay in their expertise at transforming private companies into public companies. The refinement brought great results and more than 600 venture-backed companies went public in the USA from 1995 to 1998.

The 1990's heralded the beginning of the *third generation* of venture capitalism. Venture capital firms began hiring staff with executive operational experience to help Chief Executive Officers (CEO's) to start-up and define business strategies and recruit the right talent for their companies. Early indications of the third generation results suggest success with both a strong sense of general business acumen and a wider range of financing options for young companies being developed. In addition to offering better counsel, venture capitalists have begun to specialise by focussing on particular technology areas or on regional investments (Tims, 1999:3).

2.3.5 The Future of Venture Capital

The *forth generation* of venture capitalists is likely to emerge with the turn of the millennium. With an even greater sense of focus, venture firms will continue to refine their investment strategies into technologies, specific stages of investment and also vertical markets. While narrowing their focus, their scope of service is expected to enlarge by supporting companies, not only in the boardroom, but now also at functional management level.

These new venture firms will not only identify, but also incubate interesting new investments to create companies from scratch. The approach will also extend into foreign markets as international venture funding becomes a reality (Tims, 1999:3).

2.3.6 The Venture Capital Sector of the Johannesburg Stock Exchange

Listing requirement during the early 80's excluded the listing of new companies who had the potential of opening new avenues of economic development. This subsequently lead to the establishment of new board called the Development Capital Market in August 1984. Listing requirements were less stringent and costs were lower in the development capital market. The Development Capital Market has been considered to be both a volatile board and an unqualified success by the Johannesburg Stock Exchange management. Be this as it may, the Development Capital Market is regarded as a successful innovation in so far as raising capital for new ventures is concerned (Raats, 1998:40).

The research conducted by Raats (1998:40) indicates that despite the coexistence, since 1984, of the Johannesburg Stock Exchanges Main Board and the Development Capital Market Board, the feeling still existed that some new companies were being denied the opportunity of using the Johannesburg Stock Exchange as a capital raising medium for risky operations. This lead to the establishment in 1989 of the Venture Capital Market, yet another board with listing requirements even less demanding than those of the Development Capital Market.

2.3.7 Criteria for Listing in the Venture Capital Sector

Applicants seeking listing on the Venture Capital Market must satisfy the following criteria (full script in Appendix D):

i. Subscription capital of at least R500,000.

ii. Not less than 1,000,000 equity shares in issue.

iii. Indicate above average credible returns.

iv. A minimum of 5% of each class of equity share to be held by the public.

v. At least 75 public shareholders for equity shares, 25 for preference shares and 10 for debentures.

vi. Minimum initial issue price of not less that 50c per share.

vii. The majority of directors and managers must have successful records of achievement.

In terms of the Johannesburg Stock Exchange listing requirements companies listing in the Venture Capital Market do not require a trading history while those listing in the Development Capital Market do.

2.3.8 Venture Capital Investment in South Africa

There is known to be an inverse relationship between publicity and venture capital, and much of the information and activity is beyond the public domain. Until recently venture capitalists refrained from publicising their investments. In fact many venture capital providers tested the resolve and innovation of the aspiring entrepreneurs by whether or not they can track them down. For this reason it is difficult to paint a true picture of the status of venture capital investment in South Africa. Of recent however a changing scenario has emerged in that venture capitalists have started publicising in lieu of better investment opportunities (Nel, 1999).

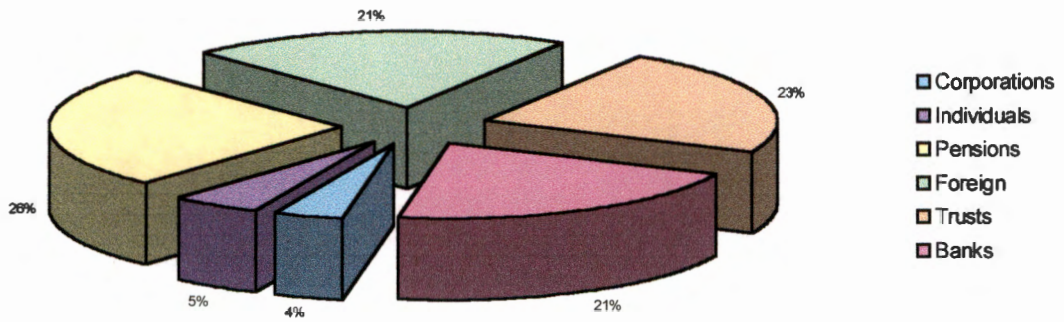
De Haan, 1998:71 is of the opinion that the Venture Capital Market in South Africa is guestimated at a puny $2bn, compared to the $175bn in the United States of America and

$22bn in Holland. Research by Craig Mullet of Nijenrode University in Holland shows venture capital in South Africa is comprised as follows;

i.	R300m	4%	Corporations
ii.	R400m	5%	Individuals
iii.	R2,1bn	26%	Pension funds / Insurance companies
iv.	R1,7bn	21%	Foreign
v.	R1,8bn	23%	Public listed trusts
vi.	R1,7bn	21%	Banks

The composition of venture capital investment in South Africa is depicted graphically in Figure 1. De Haan suggests that due to the intensely private nature of venture capital, the real percentage attributable to individuals and corporations could be considerably higher.

FIGURE 1 : COMPOSITION OF SOUTH AFRICAN VENTURE CAPITAL



2.3.9 Current Stocks Comprising Venture Capital Sector

The Venture Capital sector of the Johannesburg Stock Exchange is currently comprised of forty-nine companies (see Appendix E). By and large it is the Information Technology companies in which the largest portion of venture capital has been invested.

2.3.10 Investors Sentiment Regarding Venture Capital Stocks

Are Venture Capital stocks actually risky, or are they merely perceived to be risky? Looking at it from the potential investors point of view, an investment in shares is in fact an investment in equity as these shares form part of the equity base of the listed company. The investor thus receives income from the investment in the equity capital through the collection of dividends, but also through the growth in market price of the share which is realised when the share is sold (Lamprechts, 1990:5). Since venture capital companies are know to grow fast, the perception exists that fast growth is risky growth.

The real reason for the perception is offered by Tims (1999:1) in his assessment that the high level of risk lies in the fact that these new venture companies, because of being in their infancy, have few assets to offer as security. Instead, the investor brings equity into the company, essentially making collateral of the intellectual property and potential of the new firm.

Timmons (1999:416) is of the opinion that while the high-risk/high-reward and low-risk/low-reward relationship (a so called law of economics and finance) works fairly well in efficient, mature and relatively perfect capital markets, just the opposite occurs all too often in entrepreneurial finance to have much comfort with this law. Time and again, some of the most profitable, highest return venture capital investments have been quite low risk propositions from the outset.

Joubert (1998:55) reflects on the fact that investing in the main board of the Johannesburg Stock Exchange could be risky, even driving a car to work is risky. The task of the investor is to figure out which applies, the actual risk of investing in a company, or the perception associated with it.

Together with this is the fact that venture capitalist's set stringent criteria for their investments. Suppliers of venture capital look for very high growth potential where they can quintuple their investment in five years. They therefore place an extremely high premium on the quality of management in the venture and require complimentary business skills of previous entrepreneurial experience, a sound track record and reputation (Timmons, 1999:445).

Why is venture capital so big in Britain and the USA? De Haan (1998:73) ascribes it to the fact that it is run by people with intimate knowledge of the industry in which they specialise.

Gerhardt (1999:4) agrees that angels and venture capitalists are interested, firstly and foremost, in the quality of the people involved in the venture. To achieve a return of three to five times their investment in five to seven years (30 - 40% annual return) investors make sure that entrepreneurs prove themselves to have drive, determination, commitment, experience and the capability of effectively implementing the business plan before the venture capitalist will be attracted.

Lowenthal (1999) stresses the importance of *due diligence* to investors. If management doesn't perform, the stock price doesn't rise. Venture capital is all about management, management, management !

These are interesting points made regarding the risk/return relationship and the quality of management of the new venture firm, and one the author appreciates. Surely these are exceptional qualities that should rather create confidence than signal risk. All too often the unfortunate perception is held that venture capital stocks in particular are simply too risky to consider.

2.4 VALUATION OF STOCKS

"What would you attempt to do if you knew you would not fail?"

- - - Dr. Robert Schuller

2.4.1 Introduction

"Hazard; a peril; exposure to loss or injury." This according to *Webster's* is the definition of risk and refers to the chance that some unfavourable event will occur. Investment risk is related to the probability of actually earning less than the expected return – the greater the chance of low or negative returns, the riskier the investment (Brigham & Gapenski, 1997:146).

Investors aim at achieving profitable return on their investment, while at the same time minimising the risk associated with the particular investment. Unfortunately, "risklessness" and "return" are not synonymous concepts in the investment arena. To find a single stock in which these two parameters are both present is a rearity.

Before an investor decides to invest in equity capital, the safety or risklessness of such an investment is compared to alternative forms of investment such as savings accounts, fixed deposits, unit trusts, treasury bonds and numerous other investment opportunities. However, to the potential investor, the risk associated with a particular investment must be defined more precisely and the manner in which investment is measured and valued needs to be understood.

2.4.2 Valuation of Risk

Potential investors examine the risk/return relationship pertaining to an investment to determine where the highest return can be generated against the lowest possible risk (Brigham & Gapenski, 1997:153). But risk can be measured in a number of different ways, and different conclusions about an assets riskiness can be reached depending on the measure employed.

Firstly, the phenomena of risk aversion of the individual investor will affect the amount of risk the investor is prepared to take, judged against the possible returns. This will lead to different choices by different investors regarding the riskiness of the same investment. The amount of *serious money* at stake will also bias the risk aversion of the investor (Brigham & Gapenski, 1997:153).

Secondly, the riskiness of financial assets (stocks, bonds) can be considered in two ways: on *a stand-alone basis* where the asset is considered in isolation, or in *portfolio context*, where the asset is held as one of a number of assets in a portfolio. For purposes of this study, investments shall be considered in isolation.

And thirdly Timmons (1999:416) mentions that established company valuation methods, such as those based on discounted cash flow models seem to favour the seller, rather than the buyer.

2.4.3 Valuation of Stocks

Literature is swarmed with methods and techniques with which to determine the value of stock. This section will briefly focus on a number of models and methods in use to offer the reader an insight into methods used under fundamental analysis. This background is offered due to the fact that these models form the background to fundamental analysis, which is not focussed on in this dissertation.

2.4.4 Capital Asset Pricing Model

The *Capital Asset Pricing Model* (CAPM) is an important tool used to analyse the relationship between risk and rates of return. The CAPM is of particular importance to investors who are primarily concerned with portfolio risk rather than the risk of an individual stock in the portfolio. The CAPM measures the relevant riskiness of an individual stock's riskiness to a well-diversified portfolio. Brigham & Gapenski (1997:164) make the point that although a stock may be quite risky if held by itself, much of its risk can be eliminated by diversification. This results in its relevant risk, which contributes to the portfolio's risk, being much smaller than its stand alone risk.

The capital asset pricing model is a single-factor model that specifies risk as a function of only one factor, the stock's beta coefficient. The *Beta Coefficient* (*b*) of a stock indicates the tendency of the stock to move up and down with the market. If a stock is average and it tends to move up and down with the market, for example the Johannesburg Stock Exchange overall index, the stock by definition will have a beta of 1. A stock twice as volatile as the market will have a beta of 2. Beta thus measures a stock's volatility relative to an average stock.

The expected return can be calculated by graphically plotting the line as a *Security Market Line* (SML). The beta coefficient is measured by the slope of the stock's characteristic line, which is found by regressing historical returns on the stock versus historical returns on the market (Brigham & Gapenski, 1997:221). Stock's that lie on the SML are in equilibrium with the market.

Mention must however be made of the fact that the capital asset pricing model is based on some rather unrealistic assumptions, and it cannot be empirically verified. For example no transaction costs, no taxes, unlimited access to financing and homogeneous investor expectations. Even still, because of its logical appeal, the capital asset pricing model is generally used in the cost of capital estimation process.

$$k_s = Risk - free\ rate + Risk\ premium$$

$$= k_{RF} + (k_M - k_{RF})\, b_i.$$

Where ; k_s = *Cost of equity*
K_M = *Required return on the market*
K_{RF} = *Risk free rate of return*
b_i = *The companies beta*

2.4.5 Arbitrage Pricing Theory

Stephan Ross was of the opinion that perhaps the risk/return relationship was more complex than having the stocks required return as a function of only one factor, the beta coefficient. The hypothesis of Ross held the notion that required return could be a function of two or more factors. Ross proposed an approach called the Arbitrage Pricing Theory (APT) in

which required return could be a function of any number of risk factors (Brigham & Gapenski, 1997:217).

The APT is a younger, but more general theory than the CAPM but has the advantage that it permits several economic factors' to influence individual stock returns, and relies on fewer assumptions than the CAPM. The practical use of the APT has however to date been limited since the APT does not tell us which factors influence return, or which factors may appear in the model.

$$k_i = k_{RF} + (\lambda_1 - k_{RF})\, B_{il} + \ldots + (\lambda_J - K_{RF})\, b_{ij}.$$

Where	k_i	=	*Realised rate of return on stock i.*
	k_{RF}	=	*Risk free rate of return*
	λ_j	=	*Required rate of return on portfolio*
	b_{ij}	=	*Sensitivity of stock I to economic factor j.*

2.4.6 Efficient Market Hypothesis.

A body of theory called the *Efficient market Hypothesis (EMH)* holds that (1) stocks are always in equilibrium and (2) that it is impossible for an investor to consistently 'beat the market'. The reason underlining the hypothesis is that the number of stocks available are out-numbered by 1,000 to 1 by analysts. This means that each stock is followed and scrutinised by 1,000 professional analysts who would instantly take advantage of any bargain which becomes available. Due to disclosure requirements, new information is received and analysed by all analysts at the same time, whereby immediate adjustment take place by all at the same time (Brigham and Gapenski, 1997:319).

The Efficient Market Hypothesis states that stocks are always fairly valued thus the market price is equal to the value of the resultant dividend stream. The required return on the stock is equal to the expected return ( ), and all stock's expected returns plot on the Security Market Line (SML).

From the research conducted by Malan (1998), to determine the degree of market efficiency of the Johannesburg Stock Exchange, it was found that the Johannesburg Stock Exchange in fact is an operationally efficient market. Malan also investigated the implementation of the

Share TRAnsaction Totally Electronic (STRATE) system for the Johannesburg Stock Exchange and arrived at the conclusion that South Africa will truly be in line with international markets regarding operational efficiency. Bhana (1994:93) and Thompson & Ward (1995:60) agree that the Johannesburg Stock Exchange is a highly efficient market with regard to highly traded shares and found that the market reacts speedily on published information.

The benefits of implementing STRATE are vast. South Africa will be on international norm, and risk and cost to the investor will be reduced. The specific benefits according to Anon (1997:8) are the following:

- Risk of tainted script reduced
- Simultaneous final irrevocable electronic settlement
- Immediate transfer of ownership on settlement, securing all rights as a shareholder
- Reduction of risk associated with misplaced or forged share certificates
- No physical handling of certificates and payment

2.5 STOCK ANALYSIS

"Opportunities flit by while we sit regretting the chances we have lost..."

--- Jerome K. Jerome, 1889

2.5.1 Introduction

In this section two main approaches to analysis - technical and fundamental analysis of stocks will be evaluated. The two methods will also be placed in comparison to each other in an attempt to establish which is the preferential instrument in the analysis of stocks.

2.5.2 The Evolution of Information

The advent of computers have had far reaching effects on the investing community. World stock markets have long been driven by a need for more and more information, both on the companies listed on the exchange as well as local and world events that could effect the price of the stocks.

Everyone in the world increasingly lives in what Marshall McLuhan and Alvin Toffler call, the *Global Village*. In South Africa we can all see the beginnings of a phenomenal change in our way of life, and these changes will continue to sweep across the world and into our continent. It will leave a society for our children that is substantially different to the one we now know.

Looking back at the evolution of information, one can remember that carrier pigeons were one of the first tools used to speed up the flow of information. Then came the telegraph and ticker tapes. These stood at the beginning of efficient use by financiers of technology to aid them in their analysis of investments.

Today, all of society relies heavily on computers to aid in making decisions quickly and accurately. Not only this, but computers have aided in affording investors more time for research and investing issues.

Today it is unthinkable for an investor to be without a computer or terminal on his desk giving him access to some form of electronic information relating to his field of expertise be it comparative graphs of share movements, real-time information or the latest world news.

Financial investments and trading information, which used to be exclusively available to executives in their boardrooms, is now available to small investors in their homes through computers. There are huge databases available to anybody anywhere in the world. The gap between things happening and the dissemination of the information is constantly shortening. What we are witnessing is a drive to create free flow of information, instantly, anytime, anywhere and in any form required.

Information is crucial in investment. Many companies distribute world-wide or local financial information and news, as it happens in many ways, so as to meet the users budget. Investors can have permanent connections and receive live feeds of information on several financial topics, and for those who do not need to have instant access to these details, they simply receive software which enables their computers to gather the information from the provider at night. This once-a-day service when combined with the supplied advice and technical or fundamental analysis, can be effective to anticipate the markets sentiment and increase the prospect of successful and profitable investing.

2.5.3 Fundamental Analysis

The term *fundamentals* as applied to stock market analysis refers to the study of the myriad background factors which affect the value of securities and hence their price. These factors include economic, industry, political, social and company relevant conditions that impact on the value of the companies stock. The fundamental analysis approach assumes that a distinction can be made between the intrinsic value and the ruling market price of a stock. Accordingly a stock should be purchased if it is priced below its intrinsic value, but should be sold if its market price exceeds its intrinsic value (Achelis, 1999).

The variation between the intrinsic value and the market price of a stock can be ascribed to the existence of an imperfect market and in particular to the inadequate flow of information. Accordingly the intrinsic value should equal the market price when all participants in the market are simultaneously in possession of the same information. The fundamental analysis

further assumes that over time, the increasing flow of information will narrow the gap between the intrinsic value and the market price, to a point of equilibrium. Thus, *ceteris paribus*, the market price will return to the intrinsic value through the action of market forces time and again.

According to Joffe (1999), fundamentals can be broadly categorised into the following two fields, *macro-fundamentals* and *micro-fundamentals*.

2.5.4 Macro-Fundamentals

This term refers to the financial, economic, political and social environment in which stock markets function. The term embraces such factors as inflation, interest rates, fiscal policy, foreign investment, currency fluctuations and so on. Joffe (1999) offers a brief consideration of some of these factors and indicate their influence on the stock market.

- Inflation

Escalating inflation, is a consequence of the over supply of money, in comparison to the available supply of goods and services. In such an environment the price of goods and services increases. Insofar as an increase in money supply may prove stimulatory to business and generate improved corporate profits, inflation has also tended to favour investment in Industrial and Financial stock.

- Interest rates

When stock markets enjoy declining interest rates, particularly short term ones, they more often then not react positively to them. The reason for this is that investors believe they can receive higher returns on their savings by investing in the markets. Conversely when the monetary authorities allow these rates to rise (to cool off inflationary pressures in the economy) the stock market tends to decline.

- Fiscal policy

When taxes increase, consumers have less money to spend, and shares of consumer-oriented companies usually become adversely affected. Contrary to this, a tax-reduction is often stimulatory to the stock market.

- Foreign investment

A developing country like South Africa is unable by itself to generate sufficient capital to produce economic growth commensurate with the expansion of the population. The amount of capital foreign entrepreneurs invest here (considering the ongoing violence, strikes, civil disobedience and numerous other factors) will largely determine our economic well-being, and may clearly impact negatively on share prices and influence the progress of the stock market.

Another aspect to consider is the possible lifting of exchange controls at some point in the future. Even minor adjustments to these laws could produce net outflows of capital as a result of the larger corporations' ability to transfer capital to destinations outside SA, where the risk versus reward ratio is likely to be more favourable.

- Currency fluctuations

Political stability and the rate of inflation are two of the factors in a country that influence the supply and demand for its currency, which in turn determine its value.

A decline in the currency will often cause a country's exports to become cheaper to foreign buyers, and hence will be beneficial to the shares of export-oriented companies. On the other hand, imports become more expensive, and this tends to adversely affect the profitability of import-oriented companies. Of course if the country's trading partners have equally weak (or equally strong) currencies, then it will lose this relative advantage.

2.5.5 Micro-Fundamentals

This term refers to those factors affecting the profitability of individual companies or groups of companies. Included in this category are such factors as quality of management, net asset value, debt and equity ratios, new product research and numerous others. Indeed virtually all the parameters normally disclosed in a company's financial statements fall within the ambit of the micro-fundamental analyst. Joffe (1999) offers an insight into a number of these and indicates their influence on the stock market.

- Product-demand

Product demand has a profound impact on stock pricing. For instance, in recent years the health allegations against asbestos-producers and their products have adversely affected their share prices. Similarly reports of the development of cheap non-platinum-based catalytic converters for motor-car emissions have depressed platinum shares from time to time.

- Obsolescence

Micro-fundamentals further concerns itself with the question of obsolescence - for instance the development of the fax machine was a tremendous setback for the manufacturers of telex machines, and similarly the computer to the typewriter.

- Timing

Perhaps the major problem confronting the fundamental analyst is that of timing, as the stock market often makes a major turn before the economy does. Historically, one can show that bull markets normally start when the tide of business is low and at an ebb and gloom is all-pervasive. Conversely bear markets often start at times of great prosperity, when the economy is so to speak bursting at the seams and optimism reigns. It is therefore not difficult to see how anyone who relies solely on the fundamental approach to stock market analysis is prone to be late in calling the turns in the market.

- Herd instinct

Finally the fundamentalist also frequently has difficulty in coping with mass (or group) psychology, otherwise known as 'herd instinct.' This implies that when the public base their investment decisions on high profile statements by political or business leaders, such action is almost invariably too late, since the market will already have discounted them. This is one of the reasons for overheating of the market. Sentiment will buoy the market until it is no longer a true reflection of value, at which stage a correction becomes a distinct possibility.

In brief, the fundamentalist may be able to work out what a given company will earn, but has no way of determining what the investment community will be prepared to pay for those earnings.

- Quality of Information

Fundamental information is of course quite easy to come by. Newsletters, newspapers, financial magazines, brokerage house letters, and others are all full of information and opinions at both the macro and micro-fundamental levels. Few people however have the time to read all this information, much less weigh up the often contradictory evidence and opinions presented. Furthermore even if they do, will they have the courage to stick to their conclusions when others voice their equally forceful but opposite opinions? Another problem facing the fundamentalist is possible bias from the person presenting the information.

- Price to Asset Ratio

The price/asset ratio of a stock is the market value to owners equity ratio of the stock. Analysts regard the stocks of companies which have a low price to asset ratio as a safer investment due to the perception that asset value represents the floor price of the stock.

- Price to Earning Ratio

Many analysts prefer to choose stocks with a low price to earnings ratio (P/E). This choice stems from a belief that a low P/E ratio is more likely to earn return from low P/E stocks than high P/E stocks. The danger in doing this is that the earnings used in the ratio is a measure of past performance, while in fact the investor is purchasing a right in future earnings.

2.5.6 Technical Analysis

Technical analysis is the study of market action (price and volume) primarily through the use of charts and for the purpose of forecasting future price trends in actively traded free market systems such as the stock exchange. It determines the optimum time to buy and sell stocks as opposed to the intrinsic value of stocks. The basic philosophy underlying technical analysis is that the stock price reflects all determinants of price including fundamental, economic, political and psychological factors. This does not imply that the market is totally efficient in absorbing all relevant data. There is probably general disagreement concerning the value of a stock because every investor has their own perspective and their own needs

and hopes. Therefore, the value of a stock is simply the market value, that is the current market price (Pike, 1999).

The technical analyst, like any craftsman, has a number of tools at his disposal. It is essential that the true craftsman uses the appropriate tool. The technician cannot haphazardly accept buy and sell signals from a sophisticated technical analysis package, without understanding the nuances and when it is appropriate to use the signals.

According to Kelly (1993:443) the technical approach also holds that the market price of stock is fixed by supply and demand and that the intrinsic value of the stock can be largely disregarded. The supply and demand effect can best be described through the Walrus equilibrium process: Each new price in the market clears the market of excess supply and demand to equal at a new equilibrium price, therefore the market remains in equilibrium. The participants in the market will only trade once new information is available. Then a new equilibrium price is set which once more clears the market (Brigham & Gapenski, 1997:319).

2.5.7 Fundamental vs Technical Analysis

No stock will be available at a bargain price in an efficient market. If this is true, then a stock that happens to be available at a price that is below the market price will be taken up fast. It therefore goes without saying that when these rare opportunities present themselves, the investor must be able to determine the value of the stock quickly and accurately. Timing is the critical success factor in considering an investment in stock, unit trusts, options, commodities and futures. The author of this relies heavily on this aspect in his preference for Technical analysis, as it is his point of view that the fundamental information, however thorough, becomes available to late.

The fundamental approach holds the notion that in the event of a stock being uncovered which is believed to be under its true value, it is in reality only under its value if the market thinks it is and will not be for long. Although distortions may exist in the short term, the longer-term perspective will ensure that the price of all stock will eventually tend towards prices established by the markets logical assessment of all relevant factors. For this reason, the focus of technical analysis is purely on attempting to understand the implications of

price movements that the underlying forces of supply and demand cause. The value of the stock is not its concern.

Technical analysis also has the advantage that the only analysis required is a thorough study of price movements and this study inevitably extends to an analysis of volume of shares traded. When compared to fundamental analysis, an almost unbounded collection and analysis of data that includes (but does not limit itself to) the financial, marketing, managerial and strategic functions of the company is required. It is easy to see that while financial institutions have the resources to perform such Herculean tasks, it is quite beyond the scope of most private investors (Pike, 1999).

The study of price and volume requires many calculations that computers perform best. To this end, a myriad of technical analysis software is available to meet the needs of both beginners and sophisticated technicians.

Carter & Van Auken (1990:81) conducted a survey amongst investment managers to determine which methods they employed to analyse stock and manage portfolios. It was found that 74% of the respondents employed fundamental analysis. In fact they rated the importance of applying fundamental analysis at an average 4,48 on a 5-point scale. Only 26% of investment managers employed technical analysis. In their assessment of the importance of technical analysis in stock selection, a rating of 2,42 on the 5-point scale was awarded.

Technical analysis benefits any actively traded market such as stock, unit trusts, options, commodities and futures. The technical annalist in effect believes that it is the movement of the market that leads to movement of underlying economical factors, rather than the other way around (Achelis, 1999).

Fundamentals are faced with a mounting problem in that not all published information pertaining to a companies financial statements are necessarily accurate, trustworthy or unbiased.

The critics of technical analysis are of the opinion that past behaviour is not necessarily an indication of future behaviour. The large number of interpretations attributed to price

movement makes technical analysis an extremely subjective technique. This subjectivity can be compared to the discount rates and price to earnings ratios employed in fundamental analysis.

The author is of the opinion that the choice of fundamental versus technical information is more a question of weather earnings per share (fundamental), or rather the price to earnings ratio has the greatest influence on stock prices. It can be concluded that the answer lies not in one or the other, but rather in the strengths of both to arrive at a decision. In essence this boils down to using fundamental analysis to identify sound and healthy stocks that show promise, and then to employ technical analysis to optimise the timing.

It goes without saying that profit cannot be maximised by simply purchasing fundamentally sound stocks at random. To the same extent one does not simply acquire technically attractive stocks without knowing they have a sound fundamental base.

2.5.8 The Choice Exercised by Modern Portfolio Managers

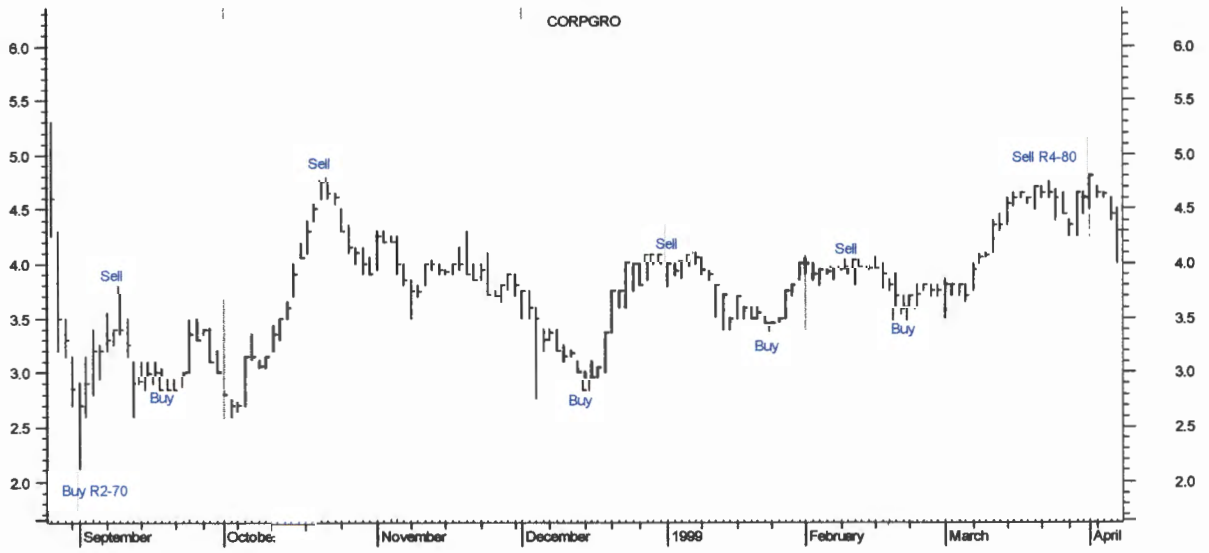
De Wet (1999) conducted a survey into the preference of South African portfolio managers regarding the use of technical and fundamental analysis, which is very much in line with the survey conducted by Carter & Van Auken (1990:81). De Wet decided to approach only the firms which possessed over research units. Of the forty-seven firms approached, twenty-eight responses were received. On average, only 18,5% of respondents employed technical analysis. Many of the large companies such as Society General Frankel Pollock use no (0%) technical analysis. There were a limited number of investors who mainly used technical analysis, such as Standard Equities Pty Ltd.

2.5.9 Active Portfolio Management

Two main components are applicable when the concept of active portfolio management is at question, timing and stock analysis. Active portfolio management encompasses both active analyses of stocks, as well as active trading in stocks. It must however be understood that being active does not always include the activity of buying and selling, as much effort can be expended in researching, analysing and monitoring stocks, without any physical transaction taking place.

The aspect of timing can best be illustrated by evaluating a graph of a randomly selected stock listed on the Johannesburg Stock Exchange. To simplify the concept, it is assumed that the market consists of only one stock. Perfect timing appears when the investor is able to enter and exit the market precisely on the turning point of the market. Figure 2 depicts the share history of Corpgro. It is assumed for purposes of the analogy that the investors found Corpgro to be undervalued on 1September 1998 and bought the share at R2-70. From this point onward investor A precisely enters and exits the market on each turn of the market. Investor A's return on his initial investment of R10,000 amounts to R 56,600 (466%) on 1 April 1999. This phenomena is theoretically well grasped, but is extremely difficult to achieve in practice.

FIGURE 2 : OPTIMISING SHARE TIMING



Investor B also entered the market on 1 September 1998, but decides on a *passive strategy* of purchasing, holding and then selling at an ideal price level. The return generated by investor B on his initial R10,000 investment amounted to only R 21,000 (110%) for the same period.

According to Ambachtsheer and Farrell (In Streicher, 1994:45) the basic building blocks upon which successful active portfolio management can be based depends on the degree of valuation of the individual stock (under or overvalued), and the correlation between the valuation and the actual result. It goes without saying that the ability to predict correctly is the basis of active portfolio management.

2.5.10 Passive Portfolio Management

Bodie *et al.* (*In* Streicher, 1994:49) regards passive portfolio management as decisions based on the deliberate ignoring of any direct or indirect stock analysis. This may sound naive, but the forces of supply and demand in large capital markets have turned passive management into a reasonable choice for many investors.

The point can be illustrated by taking a well-diversified portfolio of ordinary stocks. Such a portfolio can be comprised such that it mirrors an index such as the 'Standard and Poor 500' or one of the indices of the Johannesburg Stock Exchange. No effort needs to be expended in stock analysis or the acquisition of information regarding an individual or a group of shares. The point of departure here is that there are so many active and knowledgeable managers operating in the market that most shares will be reasonably priced in any event.

2.5.11 Active vs Passive Portfolio Management

Active portfolio management is regarded as expensive due to the time and cost associated with the accumulation of information that enables optimal choices to be exercised. Active portfolio managers can only do an in depth analysis on a relatively small portion of the total market. Active portfolio management is a function of the perception and definition of the individual annalist as to what under and over valued means and to which degree the stock at question compares with that definition.

Cabot-Alletzhauser (1996) states that the followers of the Effective Market Hypothesis do not regard active portfolio management to be worth the time and cost incurred. They believe in a passive strategy in which no attempt is made at beating the market. This view is also held by Samuelson (1989:7) showing that only 0.1% of portfolio managers are able to beat the indices in which they are active over a long period.

2.5.12 Chapter Summary

The Johannesburg Stock Exchange has grown rapidly through the years and has of late been subjected to a number of significant changes that are destined to place South Africa on track as a global player. The Johannesburg Equities Trading System heralded the beginning of a new era of automated stock trading in South Africa. The implementation of the Totally

Electronic Trading System has now pathed the way for high capacity high speed trading abreast the best internationally.

The Johannesburg Stock Exchange has been innovative in restructuring its sectors to develop rising sectors such as the Development Capital Market and the Venture Capital Markets. These sectors are still young but emerging and the management of the stock exchange has been pro-active in marketing the advantages of listing in the Venture Capital and Development Capital Markets and has appropriately relaxed the listing requirements in these sectors to encourage growth through participation. The attractiveness of investing in Venture Capital firms lies in the fact that although at a higher risk, these companies are at the start of an exponential growth phase

It is understood that all investors aim at achieving profitable return on their investment, while at the same time minimising the risk associated with the particular investment. It was demonstrated that "risklessness" and "return" were in fact not synonymous concepts in the investment arena. Literature contains numerous methods and techniques with which the value of stocks can be determined. The most popular models and methods were researched to offer the reader an insight into methods used under fundamental analysis.

Two main approaches to analysis, i.e. technical and fundamental analysis of stocks were evaluated. The two methods were placed in comparison to each other in an attempt to establish which is the preferential instrument in the analysis of stocks. Although in conflict with the Efficient Market Hypothesis, a market survey into the choice exercises by modern portfolio managers in South Africa showed a preference for fundamental analysis.

CHAPTER 3

THEORETICAL BACKGROUND : FOURIER TRANSFORMS

"The person who knows 'how' will always have a job.
The person who know 'why' will always be his boss."
- - - Diane Ravitch

3.1 Introduction

The Fourier transform, a pervasive and versatile tool, is used in many fields of science as a mathematical or physical tool to alter a problem into one that can be more easily solved. Some scientists understand Fourier theory as a physical phenomenon, not simply as a mathematical tool. In some branches of science, the Fourier transform of one function may yield a physical function in another (Hoffman, 1999).

This section is aimed at creating a very broad and simple understanding of the theory of Fourier Transforms. The theory behind Fourier transform and digital signal processing is an extremely complex mathematical concept, and it is beyond the scope of this dissertation to become embedded in a detailed explanation of the topic. Having said this, it is however necessary to establish a basic understanding of how Fourier analysis works for it to have any value to the investor.

Secondly it will be pointed out that within the apparently cluttered appearance of stock market information, there may in fact be fundamental repetitive cycles lurking. Knowing the nature of these cycles, establishes an indication of when the next cycle is most likely to occur, and also creates a basis upon which further analytical tools can be employed to refine decisions regarding trading choices.

3.2 Jean Baptiste Joseph Fourier

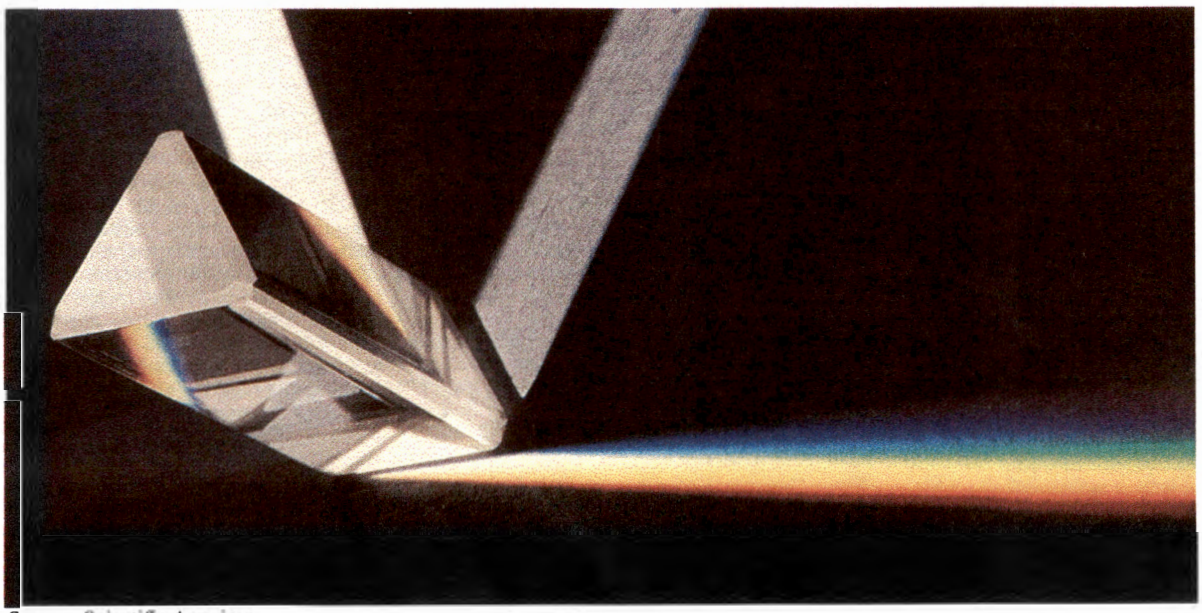
Fourier, Jean-Baptiste Joseph, (1768-1830) Baron and the father of the *Fourier Transform,* French mathematician, born in Auxerre and educated at the monastery of St-

Benoît-sur-Loire. He taught (1795) at the École Normale, where he had been a student, and at the École Polytechnique in Paris from 1795 to 1798, when he joined the campaign of Napoleon in Egypt. After returning to France in 1802, he published important material on Egyptian antiquities and was, until 1815, prefect of Isère département. He was bestowed a baron by Napoleon in 1808. In 1816 he was elected to the Academy of Sciences and in 1827 to the French Academy. His fame rests on his work in mathematics and mathematical physics. In his treatise *The Analytical Theory of Heat* (1822; trans. 1878), he employed a trigonometric series, usually called the Fourier series, by means of which discontinuous functions can be expressed as the sum of an infinite series of sines and cosines (Keston, 1999)

3.3 A Basic Analogy of a Mathematical Transform

Figure 3 depicts a physical analogy for a mathematical transform in an attempt to illustrate how the transformation process functions by showing how a ray sunlight is resolved into a spectrum when passed through a prism.

FIGURE 3 : SEPARATION OF SUNLIGHT THROUGH A PRISM.

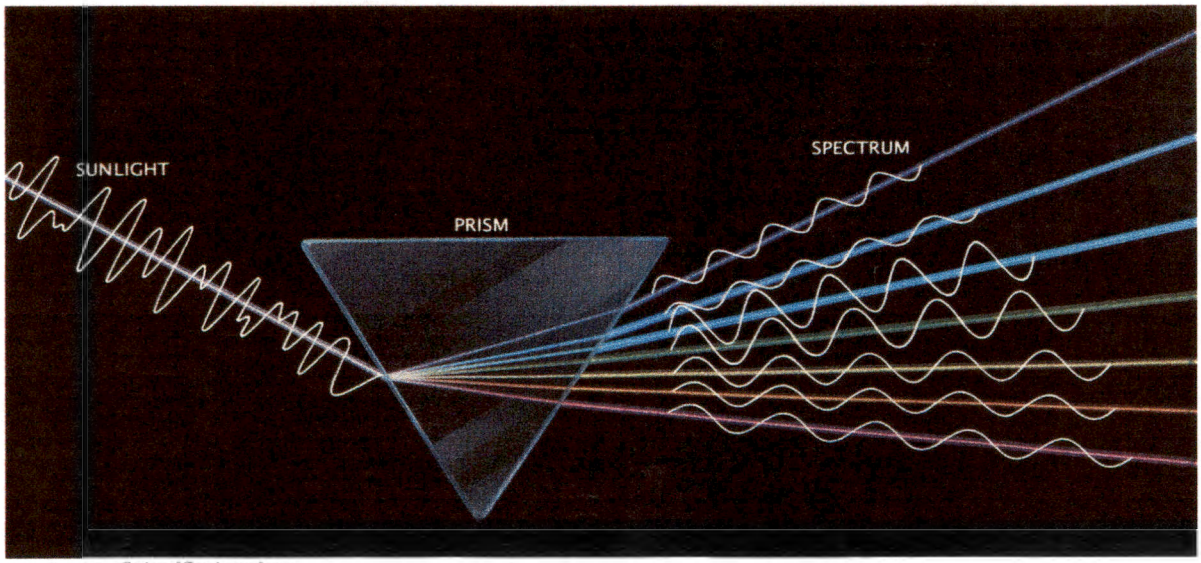


Source : Scientific American

In this application the incidence sunlight entering the prism varies in strength from moment to moment. The light leaving the prism has been separated in space into pure colours, or frequencies. The intensity of each colour implies an amplitude at each frequency.

Thus, a function of strength versus time has been transformed into a function of amplitude versus frequency. The Fourier Transform can represent a time-varying signal as a function of frequency and amplitude, but the transform also provides information about phase (Bracewell, 1989:63). Figure 4 is an excellent depiction of this concept.

FIGURE 4 : THE SPECTRUM OF WHITE light



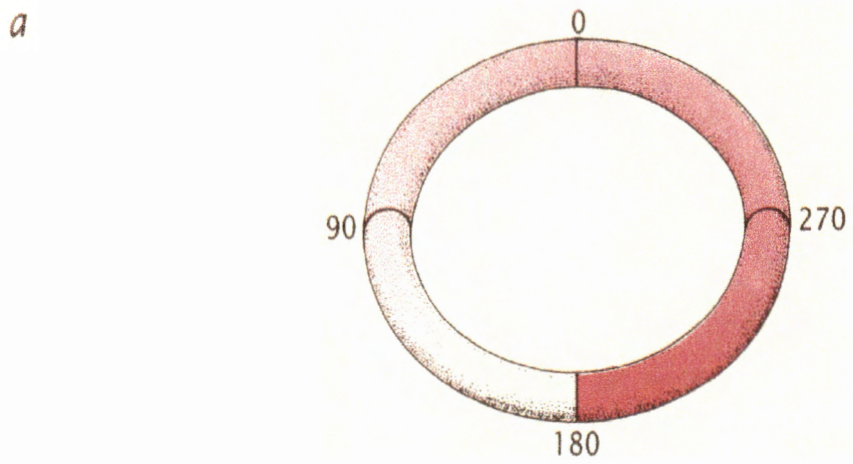
Source : Scientific American

3.4 Fourier Transforms - Basic Theory

In 1807 Fourier invented a mathematical technique to describe the conduction of heat in solid bodies. A simple illustration shall be used to avoid computational complications. If an iron ring is placed halfway into a fire, the section of the ring that is in the fire becomes red hot. The ring is withdrawn and before much heat is lost to the atmosphere, the ring is buried in fine, insulating sand, and the temperature around the outer curve is measured (Bracewell, 1989:62).

Initially the temperature distribution is irregular: part of the ring is uniformly cool, and part is uniformly hot; in between the temperature abruptly shifts. As heat is conducted from the hot region to the cool region, however, the distribution begins to smooth out. Soon the temperature distribution of the heat around the ring reaches a sinusoidal form; a plot of the temperature rises and falls evenly, like an S-curve, in exactly the same way sine and cosine functions vary. The sinusoid gradually flattens until the whole ring arrives at a constant temperature (Bracewell, 1989:62).

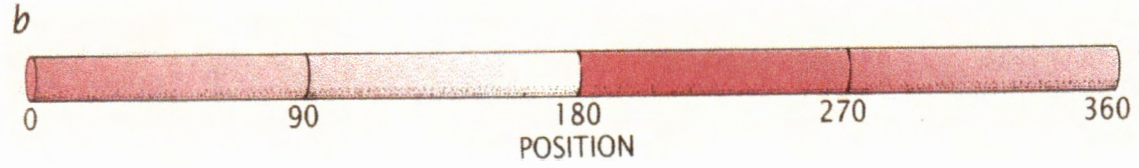
FIGURE 5 : TEMPERATURE OF AN IRON RING



The distribution of heat in the ring is shown in Figure 5. The brighter red represents the hotter area in the ring

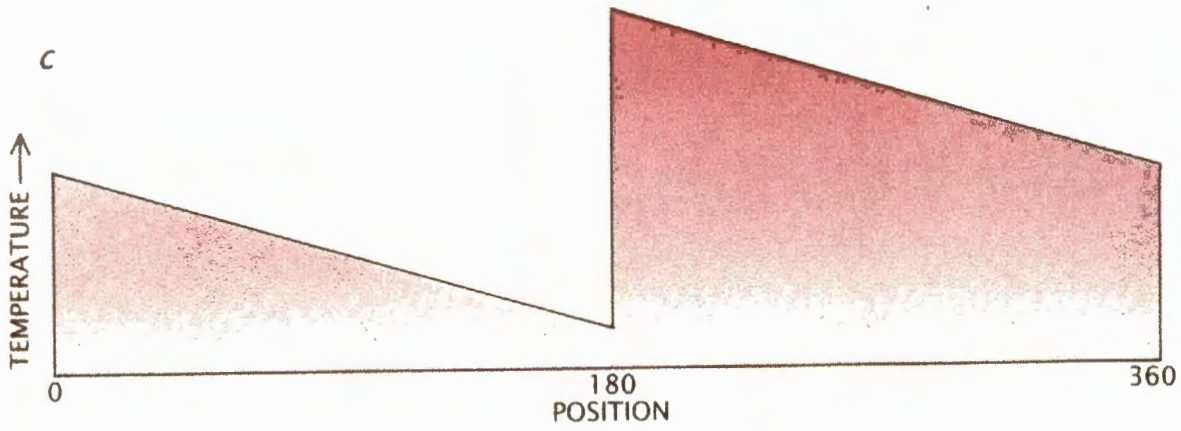
To begin the analysis the ring is hypothetically "uncoiled" and the temperature measured at each point on the circumference of the uncoiled rod as shown in Figure 6.

FIGURE 6 : UNCOILED RING



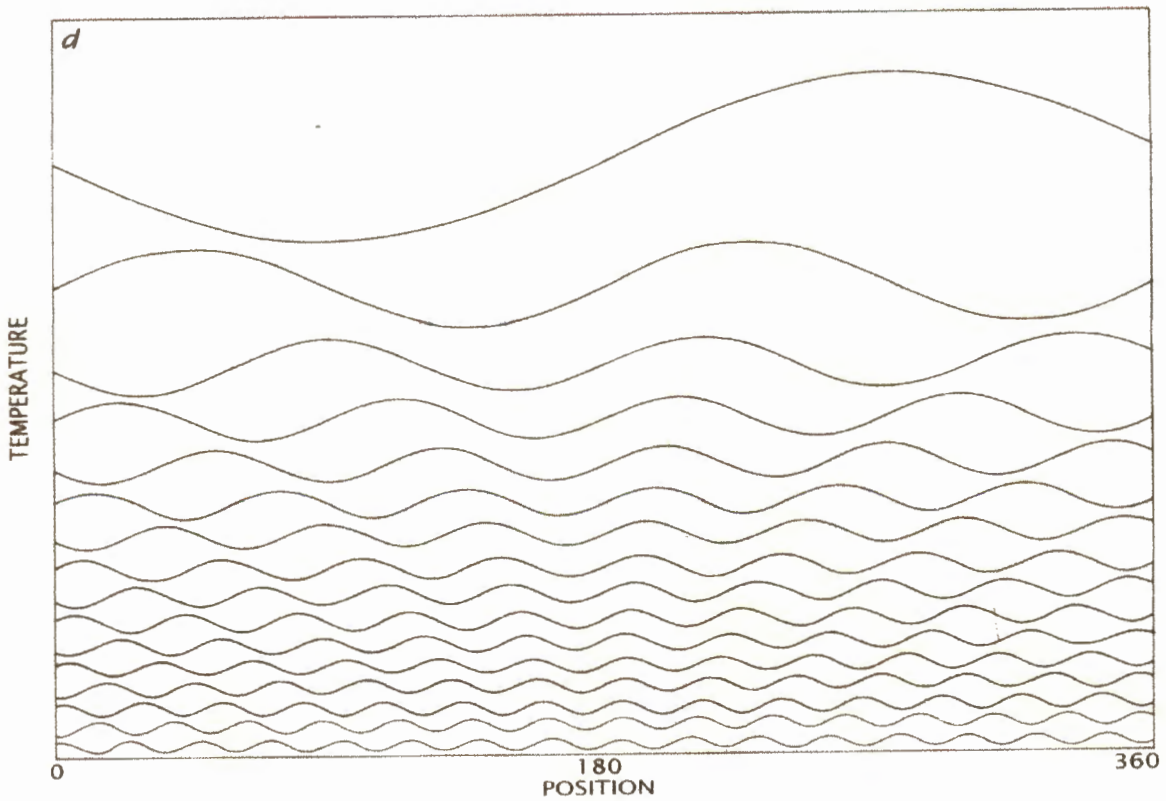
Each point on the circumference yields a temperature distribution as depicted in Figure 7. Fourier proposes that the initial irregular distribution could be broken down into many simple sinusoids that have their own maximum temperature and phase, that is, relative position around the ring.

FIGURE 7 : CIRCUMFERENTIAL TEMPERATURE DISTRIBUTION



Each sinusoidal component varies from maximum to minimum and back an integral number of times in a single rotation around the ring. The one cycle variation is known as the fundamental harmonic, whereas the two, three or more cycles in a single rotation are known as the second, third and higher harmonics as depicted in Figure 8.

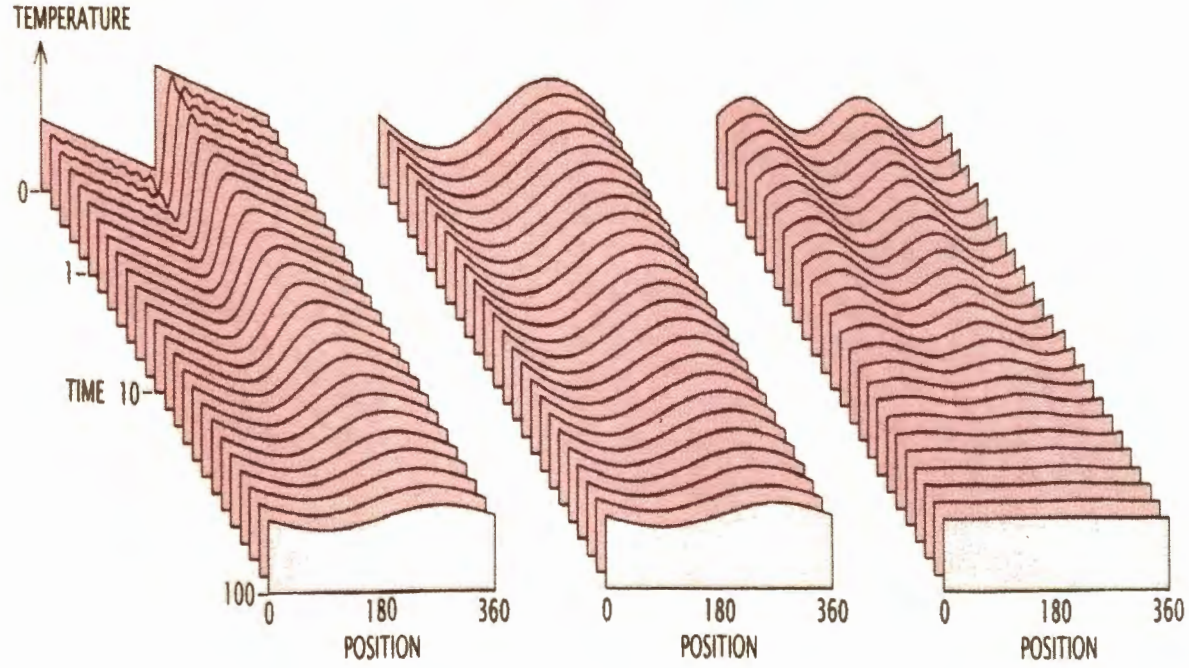
FIGURE 8 : FUNDAMENTAL AND HARMONICS



The temperature distribution is thus decomposed into many sinusoidal curves having one, two, three or more harmonics. The first harmonic persists the longest and therefore the temperature distribution approaches the sinusoidal shape of the first harmonic. One can follow the reasoning of the relationship between the fundamental and second harmonic by understanding that the temperature of the second harmonic varies from hot to cool twice around the circumference of the ring, where the fundamental varies only once. Therefor, the distance the heat must travel from hot peak to cold trough is only half as far as for the fundamental as for the second harmonic. Together with this the temperature gradient of the second harmonic is twice as steep as it is in the fundamental variation (Bracewell, 1989:64).

This phenomenon is well illustrated by the sinusoidal waves in Figure 9. The one-cycle distribution, or first harmonic is displayed in the middle, while the two-cycle distribution, or second harmonic is shown on the right. Bracewell, (1989:64) states that the second harmonic will decay four times faster than the first harmonic, and higher harmonics will decay even faster.

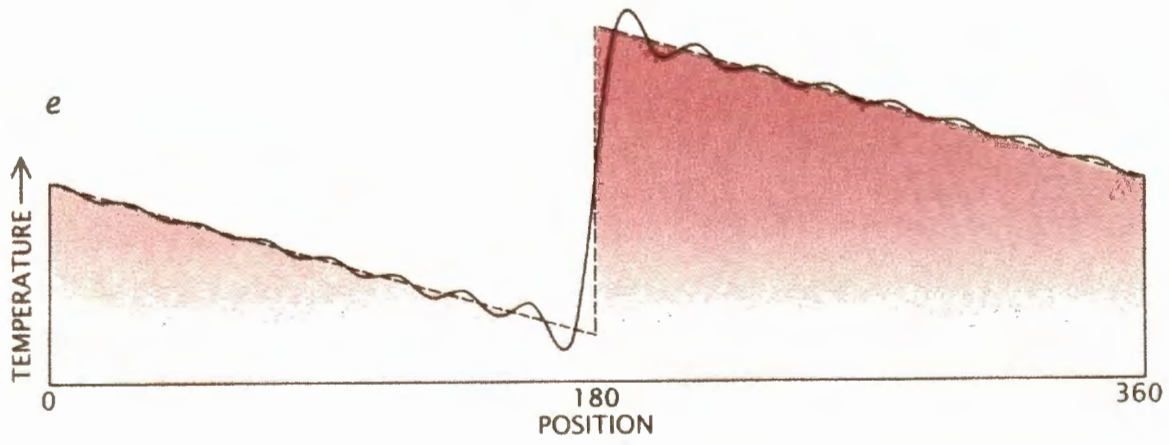
FIGURE 9 : EVOLUTION OF TEMPERATURE DISTRIBUTION



Source : Scientific American

When all the curves are simply added together, (solid line in Figure 10), they yield a good approximation of the original temperature distribution (broken line in Figure 10).

FIGURE 10 : FFT APPROXIMATING THE ORIGINAL TEMPERATURE



The mathematical function that describes the maximum temperature and position, or phase, for each of the harmonics is the Fourier transform of the temperature distribution. In simple terms, the original temperature distribution is traded for a more manageable series of full-period sine and cosine functions. The beauty of this being that when added together, they make up the original distribution (Bracewell, (1989:64).

In pure mathematical terms the Fourier transform of *f(x)* is defined as:

$$f(x)=\int_{-\infty}^{\infty}\left[\int_{-\infty}^{\infty} f(x)\exp(-i\,2\pi xs)\,dx\right]\exp(i2\pi xs)\,ds$$

3.5 Fast Fourier Transform

Because a digital computer works only with discrete data, numerical computation of the Fourier transform requires *discrete* sample values. This is particularly useful in stock market application since all values contained in the database are discrete values. Since the original function provides a value for each real number, it is decomposed into all sinusoidal functions at all frequencies. It is thus a frequency dependant list of amplitudes and phases which appear in the Fourier series.

The complete Fourier analysis concept is called spectral analysis. Fast Fourier Transform is an abbreviated calculation that can be computed in a fraction of the time, since it saves time by decreasing the number of multiplication's required to analyse a curve. The fast Fourier transforms is in fact a *Discrete Fourier Transform* algorithm which reduces the number of computations by sacrificing phase relationships and concentrates only on cycle length and amplitude (Hoffman, 1999).

A difficulty occurs when applying Fast Fourier Transform analysis to security prices, because fast Fourier transforms were designed to be applied to non-trending, periodic data. The fact that security prices are often trending is overcome by *detrending* the data using either a linear regression trendline or a moving average. To adjust for the fact that security data is not truly periodic, since securities are not traded on weekends and some holidays, the prices are passed through a smoothing function called a *Hamming window*.

3.6 General Applications of Fourier Transforms

Fourier transforms are applied widely in fields content with fluctuating phenomena. It is a valuable tool in plasma physics, semiconductor physics, acoustics, seismography, oceanography, radar mapping and medical imaging. A few popular applications are:

i. By electrical engineers to displaying graphs of the frequency content of electrical signals.

ii. To determine the frequency of a note played in recorded music. It is often used by bird watchers to recognise different kinds of birds or insects from field recordings.

iii. The fast Fourier transforms is also useful for image processing (using a two-dimensional version of the fast Fourier transforms).

iv. The fast Fourier transforms has numerous scientific/statistical applications, one such application is trying to detect periodic fluctuations in animal or human (squatter) populations.

v. Fast Fourier transforms are also used in analysing seismographic information to take "sonograms" of the inside of the Earth.

vi. Fourier methods have more recently become used to analyse Deoxyribose Nucleic Acid (DNA) sequences. The double helix form of DNA was discovered through X-ray diffraction techniques and Fourier analysis.

3.7 Application of fast Fourier transforms to Stock Market Data

Stock market data is made up of a number of points (daily closing price) which vary in amplitude (price constantly changes) over a period of time to represent a cyclical pattern. We have learned from the theory that any signal can be presented as a combination of sine and cosine waves at different frequencies and amplitudes. The time record of the stock is taken and converted into a number of different frequencies

The Fourier transform applied to the stock data in Chapter 5 shall indicate the predominate cycle lengths, as well as the relative strength of a number of harmonics. The duration of each of the cycles indicates the prominence of the value of that cycle. Once the predominate cycle length is known, this length can be used as a base parameter for the application of other indicators

3.8 Advantages of Applying Fast Fourier Transforms to Stock Data

The following advantages are envisaged in the application of fast Fourier transforms to stock data:

i. To search for rhythms, patterns and cycles which are hidden in the volatile fluctuations of the market. To identify, project and interpret these in an attempt to realise more consistent and reliable profits for investors and traders.

ii. To transform the primary data (stock data) from the time domain in which it appears highly complex, to the frequency domain to search for interpretable signals.

iii. The ability to extract the predominate cycle(s) from the security's data array (closing prices in this instance). The most prominent frequencies are filtered out of the data spectrum and when used in combination with each other, the frequencies can expose patterns of behaviour in the data array.

iv. With the predominate cycle exposed, a number of other indicators can be applied simultaneously to the stock data to indicate future trends, and signal buying and selling points.

v. Fast Fourier transform is a spectral analysis which utilises an abbreviated method of calculation and computes in seconds rather that minutes or hours. This advantage is particularly beneficial to real time on-line traders.

vi. The Fourier transform mimics the brain's most powerful ability, that of pattern recognition. The indicator seeks for the occurrence of certain patterns (frequencies) and distinguishes between their characteristics.

vii. It is a learning system. As new daily data is added to the database of the stock, so new patterns are created. The Fourier transform seeks, finds and reflects these new patterns and in this respect updates and modifies itself.

viii. Only if the length of the predominate cycle of a stock is known, can meaningful application of indicators such as moving averages be applied to the data array. Each stock has unique characteristics that are fundamental to that stock. The same parameters cannot simply be applied to each stock without knowing its most unique characteristic. Joubert (1995:18) is of the opinion that the best way to determine there pattern is by trail and error. The author of this disagrees and will show in Chapter 6 that the application of fast Fourier transforms can indeed identify which frequency is most prominent and should be applied when using a moving average. Using FFT assists in selecting the optimal moving average and replaces the traditional trail and error process with scientific logic.

ix. Fast Fourier transforms bypasses a very important negative characteristic of the moving average in that the last half of the moving average has no associated average

and is phase shifted. This happens to be the most important part of the trend sought (e.g. the last ten days of a twenty-day moving average). The result of this is that the predicted trend is in fact delayed with respect to the real change in price. Modern technical analysis software packages do attempt to rectify this phenomena by the application of a *right justification average* of the data.

x. Using fast Fourier transforms to expose regularity in underlying patterns enables one to act on the observation. Other than in fundamental analysis, the *reason* for the specific behaviour is not the concern of the analyst.

3.9 Chapter Summary

Although a complex mathematical tool, the chapter aimed at created a broad understanding of the theory of Fourier Transforms. Since stock market data is known to be cluttered, it is possible that certain frequencies may be of a repetitive nature. Fourier transforms are particularly suited to finding cyclical phenomena.

CHAPTER 4

A MODEL FOR FAST FOURIER TRANSFORMS AS AN ANALYSIS TOOL

"There are two times in a man's life when he should not speculate:
when he can't afford it, and when he can."
--- Mark Twain, 1897

4.1 Introduction

No market operates in a vacuum. In our boundryless, inter-connected world, the smallest tremor can detonate an earthquake and the smallest spark can ignite a wildfire. Markets react, speedily and unpredictably, to rumours of war, slips of the tongue, Presidential aches and pains, the vagaries of phenomena such as El Nino, and the almost mystical sway of public sentiment and opinion. Whichever way the wind blows, prices can rise as quickly as they fall, confounding the best-laid plans of some industries while rescuing others from the brink of disaster. These random forces - the 'Great Unknowns' - combine with the everyday law of supply and demand, and the cyclical nature of business itself, to shape the peaks and valleys of a dynamically shifting market. You may not be able to predict these forces, but by analysing and understanding them, you will be better equipped to weather the lows as you wait for the tide of fortune to turn (Haugen, 1997:4).

We have seen from the literature study that beneath the fluctuations of the market lie rhythms, patterns and cycles that can be identified, projected and interpreted. The composite data stream characterising each stock shall be analysed to identify and separate recognisable cyclical patterns. From this the most likely future direction the wave is likely to follow can be determined based on historical behaviour. It is the focus of this chapter to describe the construction of a fast Fourier transform and to describe how the resultant indicator can be applied in the selection of stock.

4.2 Methodology with respect to the Empirical Study

Since it is unpractical to analyse all the stocks on the market, or even those listed in the venture capital sector in the detail called for, an analysis was performed by means of descriptive inferential statistics. Inferential statistics is popularly used to deduce the likely overall behaviour of the random variable (specific stock) under study, based on the sample findings (Wegner, 1993: 168).

4.2.1 Population

The population at question consisted of all forty-nine stocks contained in the venture capital sector of the Johannesburg Stock Exchange as on 30 July 1999. This list is contained in Appendix E. A confidence level of 95% at a level of reliability of 98% was considered adequate upon which to base decision making. These levels could be achieved by the selection of ten stocks from the population.

4.2.2 Sample

Simple random probability sampling was found to be most applicable to the application intended for. This method of sampling ensures impartiality and justifies the use of the probability theory. Each stock chosen was thus selected purely on a random basis, and each had an equal chance of being selected. The stocks were numbered and selection was performed in accordance with random numbers generated. Only the sampled observations were analysed and used as a basis for decision making.

4.3 Construction of a Fast Fourier Transforms Indicator

Knowing which of the stocks were to be analysed led to the construction of a method by which each of the ten stocks in the sample could be analysed. Paragraph 4.3 firstly details each step taken in the conversion and analysis process to establish a sound understanding of the methodology. Thereafter each stock comprising the sample shall be analysed individually within a template. For purposes of convenience only the important steps in the conversion process shall be displayed.

Financial markets present data in the form of a time series. The data can be obtained in the form of daily, hourly, or tick-by-tick stock prices. Our economic concern is to predict the value of the stock at some point in the future. Thus we need to extract as much information as possible from historical data with the hope of learning the underlying behaviour. The information however is extremely *noisy*. In the words of Magon-Ismail *et al* (1998:2184), the challenge to information processing of financial data entails the extraction of only the relevant information from the overwhelming noise.

But the noise generated within the financial data is not the only nuisance that complicates the processing of financial data, noise plays a role as a tradable commodity in its own right. Magon-Ismail *et al* (1998:1284) are of the opinion that being able to predict the changes in noise level in financial time series is of critical importance, as these changes are directly reflected in the stock price changes. This then is an important reason for using fast Fourier transforms in stock data analysis as great improvement in the spectral signal-to-noise ratio can be achieved.

During the following analysis process, the assumption that the price at various times has a deterministic dependence on the past will be studied. A search shall be conducted for order or regularity in the history of the price, which may enable one to use the present to make assumptions about the future. This will be achieved by transforming the time domain data into the frequency domain, manipulating it, and then transforming it back to the time domain for further processing.

4.4 Manipulation of Data Base

Using the Progressive Systems Download Facility enabled the accumulation of the stock history of the stocks at question. The raw data as recorded daily by the Johannesburg Stock Exchange was imported into Metastock from which the data was converted to an ASCII file via Excel. The ASCII file was then imported into the digital signal-processing programme *DADiSP* for manipulation of the data series. Application of the FFT algorithm enabled a spectral analysis to be conducted on the waves to determine the nature of the noise, biases and harmonics within the data series.

With the assistance of Smart (1999) the following basic steps were decided upon in manipulation of the data series:

- A least squares fit was applied to the original data to determine the fundamental trend of the data. (In electrical terms - The direct current (DC) offset as a function of time). This is done as stock markets in particular are prone to offset and noise which is super-imposed on the series output of the stock data.
- From the polynomial fit a polygraph was constructed to represent the non-cyclical data. The non-cyclical data represents those components that offset and bias the data series, and can be referred to as the fundamental trend underlying the stock.
- The non-cyclical information was then removed from the original data to offer only the relevant information. The new series produced presented the alternating current (AC) component of the original series. Since noise was still present in the waveform, it was necessary to remove some of the high frequency components from the series.
- A fast Fourier transform was then performed on the relevant data to transform the time domain data into the frequency domain. The transform presents the opportunity to extract the unwanted frequencies (noise and harmonics) from the signal and to retain only the meaningful frequencies.
- A new series was then produced from the transformed data containing only the relevant information.
- An inverse fast Fourier transform was then applied to the modified signal to move back to the time domain. The resultant waveform was thus comprised of a filtered version of the original wave without the noise components.
- Finally the analysis was completed by superimposing the filtered FFT onto the original wave. By also super-imposing a second indicator onto this wave, the level of accuracy offered by utilising FFT as an indicator can be determined.

The manipulation process described above will be elaborated on by graphically depicting the steps performed.

4.5 Transforming Between the Time and Frequency Domains

Figure 11 shows the basic share data (daily closing price) as a function of time. The data is very noisy due to the interaction of the stock with the general market forces. No patterns of regularity are identifiable at face value and mathematically the chance that the next point on the curve will be positively inclined compared to the last data point recorded is 50%.

FIGURE 11 : ORIGINAL STOCK DATA

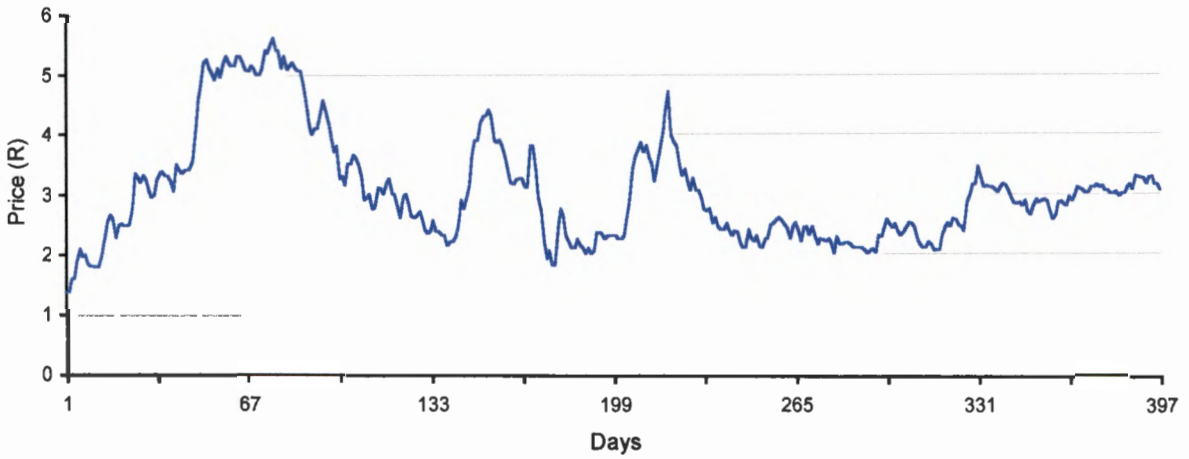


Figure 12 shows a polygraph of the non-cyclical data comprising the data array. This is the "fundamental" trend underlying the stock data and represents those components responsible for off-setting the actual cyclical trends within the data.

FIGURE 12 : POLYGRAPH OF NON-CYCLICAL DATA

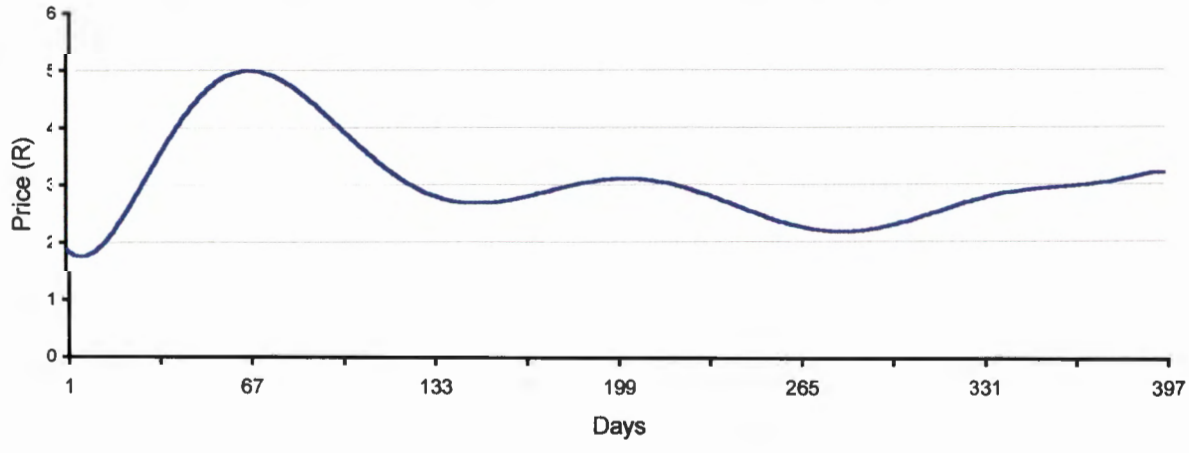


Figure 13 shows the resultant wave after the fundamental trend (DC component) was removed from the original signal, leaving only the AC component of the signal. The data is still in the time domain.

FIGURE 13 : CYCLICAL TREND

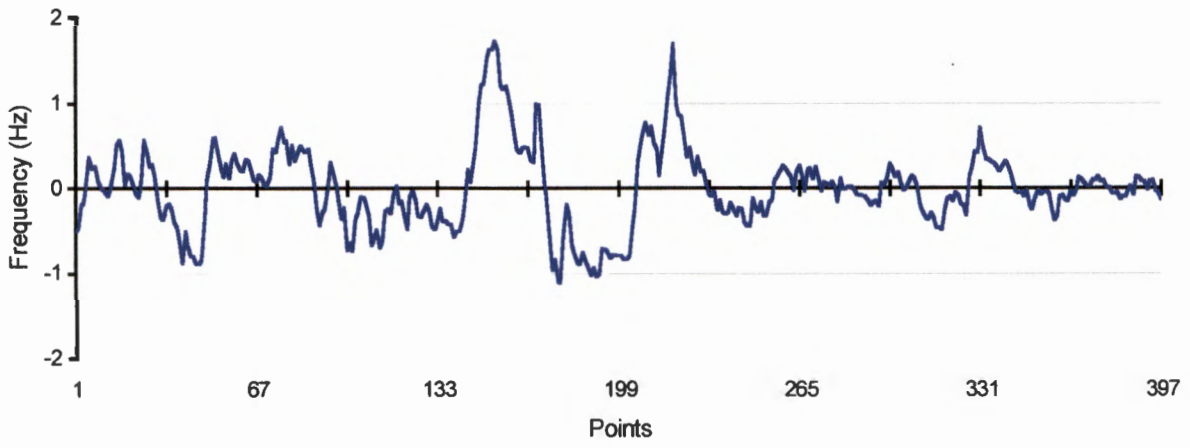


Figure 14 depicts data which has been converted to the frequency domain. A fast Fourier transform was applied to the data stream from Figure 13 to identify the most prominent cyclical trends contained within the signal. These trends present themselves as high frequency components and can be seen at the ends of the graph. Also present in the data is a number of high frequency components which are not wanted. Typical examples of unwanted high frequency components are:

- The one (1) day spectrum which gives a prominent peak caused by the sampling rate of one day, and
- The seven (7) day spectrum which gives a prominent peak caused by the share price being static over weekends.

The most significant frequencies are selected from this plot and the unwanted frequencies are filtered out to leave only the more relevant signals for manipulation. Note also that the number of points on the x-axis has doubled. With the conversion to the frequency domain, an imaginary component associated with each data point is generated increasing the length of the data stream.

FIGURE 14 : FAST FOURIER TRANSFORM

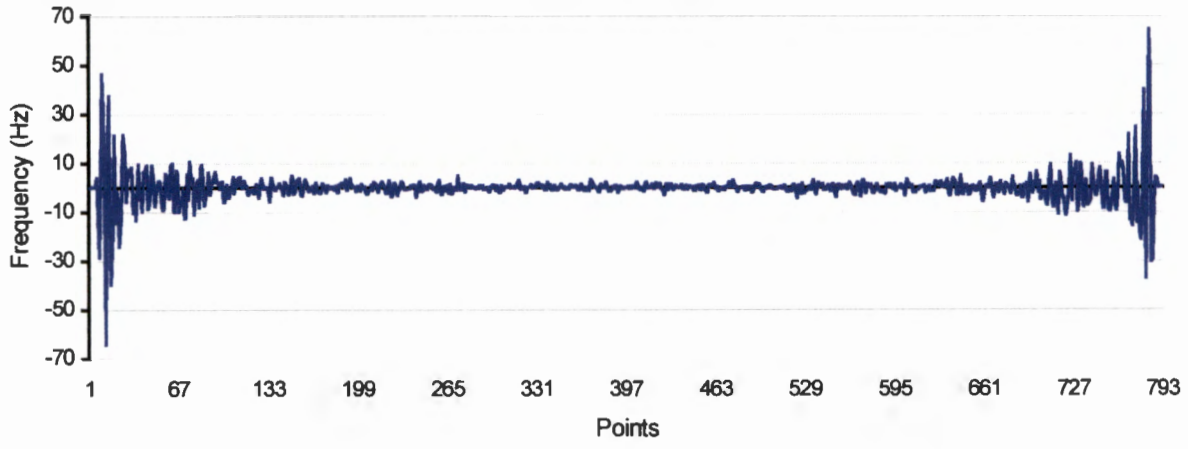
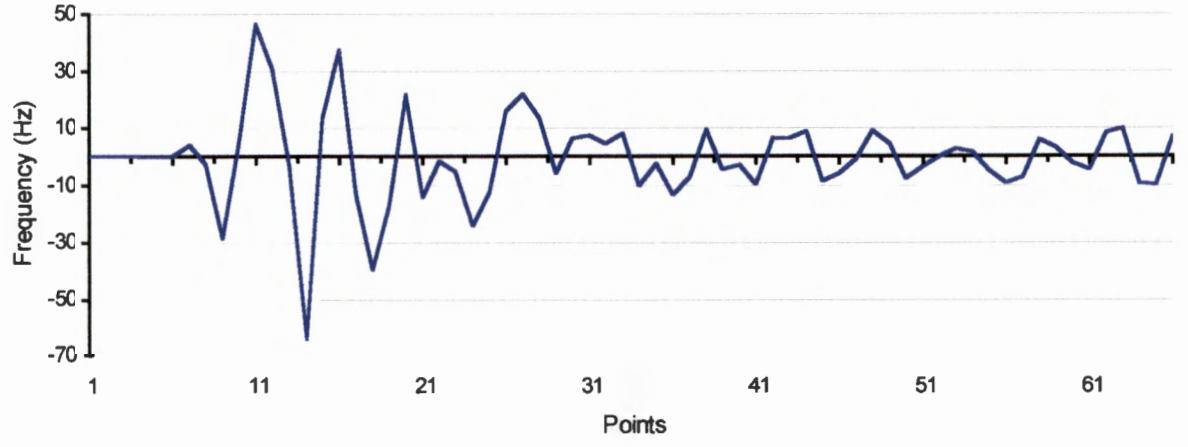


Figure 15 depicts the resultant waveform after the unwanted frequencies were filtered out of the wave in Figure 14. These are the most prominent frequencies that show significant cyclical occurrence in the data stream and the frequencies that are most likely to repeat themselves in future. Note that the data stream has been significantly reduced after removal of the unwanted frequencies. The original data stream length will be made up by padding the latter part of the signal with zero's.

FIGURE 15 : NOISE FILTERED SIGNAL



At this point in the construction of the indicator, the investor has three choices. The first is to

inverse the fast Fourier transform and move the data back to the time domain, to add the offset and then to impose the inverse function onto the original wave and to use it as an indicator in its own right for stock analysis. The second option is to use the inverse Fourier transform as an indicator by monitoring the point of zero crossing with the x-axis to produce signals. The third option is to stop after the relevant frequencies have been extracted and to employ those frequencies unveiled as a baseline for other indicators, such as moving averages and oscillators,

The author of this is of the opinion that the second option offers more scope of use, and shall in fact use option two in analysing the sample in paragraph 4.6. The construction of the fast Fourier transform indicator shall however be continued in the interest of investors in preference of option one.

Figure 16 shows the inverse fast Fourier transform which was obtained from transforming the noise extracted fast Fourier transform (Figure 15) back to the time domain. This wave is now a filtered version of the waveform depicted in Figure 13, but without the noise components. Figure 16 depicts the inverse Fourier transform as an indicator as described in option two.

FIGURE 16 : INVERSE FFT

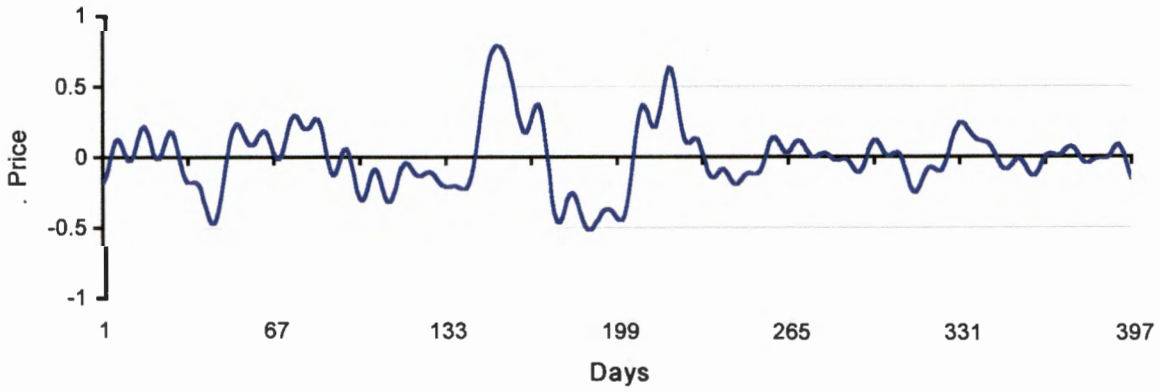
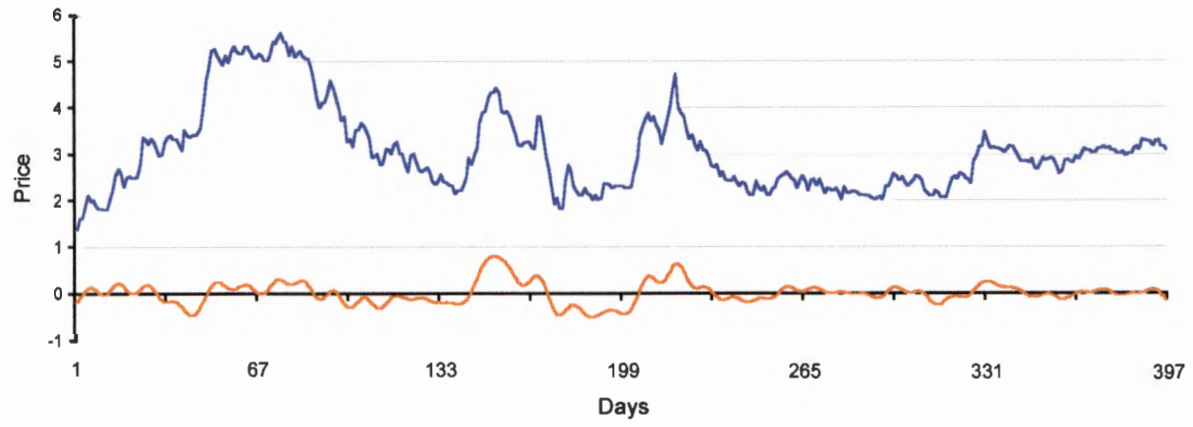


Figure 17 depicts the original wave, to which the inverse fast Fourier transform was added. The inverse fast Fourier transform oscillates around the x-axis and produces buy signals every time the slope is positive and the wave crosses the x-axis (zero crossing), in the same fashion sell signals can be derived when the slope is negative and a point of zero crossing is detected.

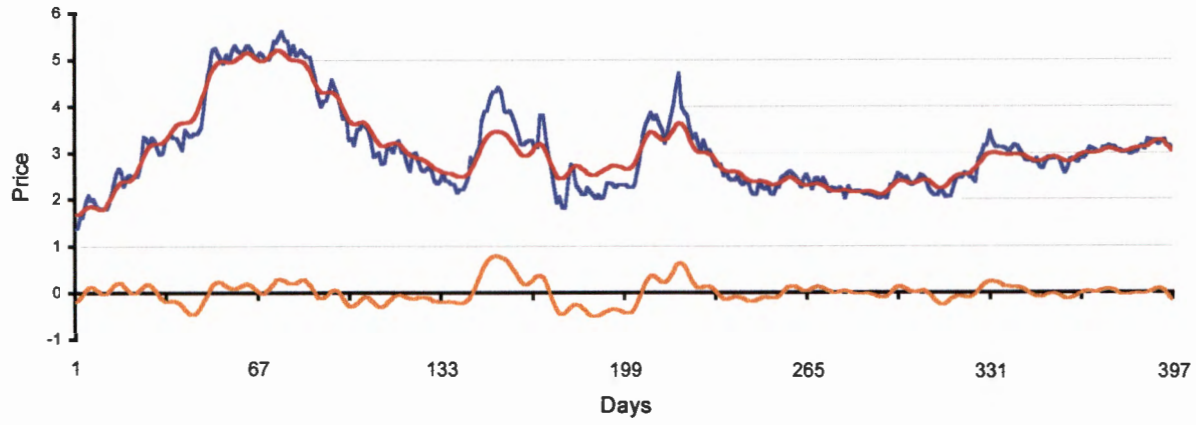
FIGURE 17 : IFFT AND ORIGINAL SIGNAL



To enable any analysis to be conducted, the zero crossing points of the inverse function *(orange line)* have to be projected up to the original wave *(blue line)*. This is inconvenient, and therefore a method was devised whereby the two waves could be seen on the same plot.

Figure 18 is comprised of the original wave *(blue line)*, upon which inverse fast Fourier transform *(orange line)* has been overlaid. This was achieved by adding the fundamental wave (Figure 12) to the inverse fast Fourier transform (Figure 16), and superimposing the resultant wave *(red line)* onto the original wave. From the graph it can be seen that the zero crossing points generated by the inverse FFT without the offset *(orange line)* are in fact the same points where the offset inverse FFT *(orange line)* intercepts with the original data series *(red line)*.

FIGURE 18 : IFFT IMPOSED ONTO ORIGINAL SERIES



The data is now data back in the time domain, and the fundamental known, further analysis can be performed on the data series to fine-tune the prediction. This form of further analysis is a highly personal matter and a magnitude of indicators can be applied to the data to predict future buy and sell signals.

4.6 Chapter Summary

Each stock has its own unique cyclical character which is moulded by the forces of supply and demand. These tendencies appear to obey an inner clock in that they repeat themselves with respect to certain frequencies and amplitudes. These cyclical tendencies have to be extracted and made visible to the investor to equip him such that a scientific investment strategy can be adopted.

CHAPTER 5

RESULTS, CONCLUSIONS AND RECOMMENDATIONS

"I believe the future is only the past again, entered through another gate."

---Sir Arthur Wing Pinero, 1893

5.1 Introduction

The effectiveness of the model designed in Chapter 4 will be determined by the application of the model to the sample chosen. The performance achieved by buying and selling shares on the recommendation of the fast Fourier transform indicator in combination with a moving average will be determined. The result will be benchmarked against the growth achieved in the Venture Capital Sector Index, and also the Johannesburg Stock Exchange Overall Index.

5.2 Analysis Strategy

The analysing strategy shall be based on the use of those prominent frequencies extracted from the Fourier analysis in the form of the inverse Fourier transform. Figure 19 will be used to depict the analysis strategy described in this section. A bias of 5% shall be applied to the baseline of the Fourier transform to mechanically filter small fluctuations which appear around the x-axis. This bias is implemented to preventing unnecessary buying and selling from taking against the general trend. The bias line is indicated as a Magenta dotted line in Figure 19h. Once the indicator breaks through both the baseline and the bias line, a fair indication is given that the tendency is increasingly positive (see Figure 19). In the same fashion the sell indicator can be applied. Once the indicator turns negative and breaks through the 5% bias a sell signal is indicated (see Figure 19).

The author prefers not to employ the sell signal generated by the fast Fourier indicator or any other indicator. Instead the proven technique of utilising a stop-loss strategy will be employed for the analysis. The stop-loss will be set at 7% after any high has been achieved. Stop-loss selling points are indicated in Figure 19 and indicate that the price of the stock has fallen by at least 7% from the previous high.

The predominate frequency shall also be transferred to the moving average indicator which will be super-imposed over the original graph as a complimentary indicator to support the decision. The moving average is indicated by the red line in Figure 19.

Point (Ba) indicates the first buy signal where the Fourier indicator crosses the bias line. Note that the buy signal is supported by the moving average at the point where the moving average intercepts the stock line (blue line).

Although the Fourier indicator turned negative and indicated a sell signal at point (b), this signal is ignore as it the stock price has not fallen by the 7% set as a stop-loss. This decision is supported by the moving average which has had no interception with the stock line at this point. This process is repeated for points (c) (d) and (e). At point (Sa) on the top graph of Figure 19 the stock price turns and falls through the 7% stop-loss level. The stock is immediately sold. This decision is supported by the moving average where an interception with the stock line is seen at point (Sa).

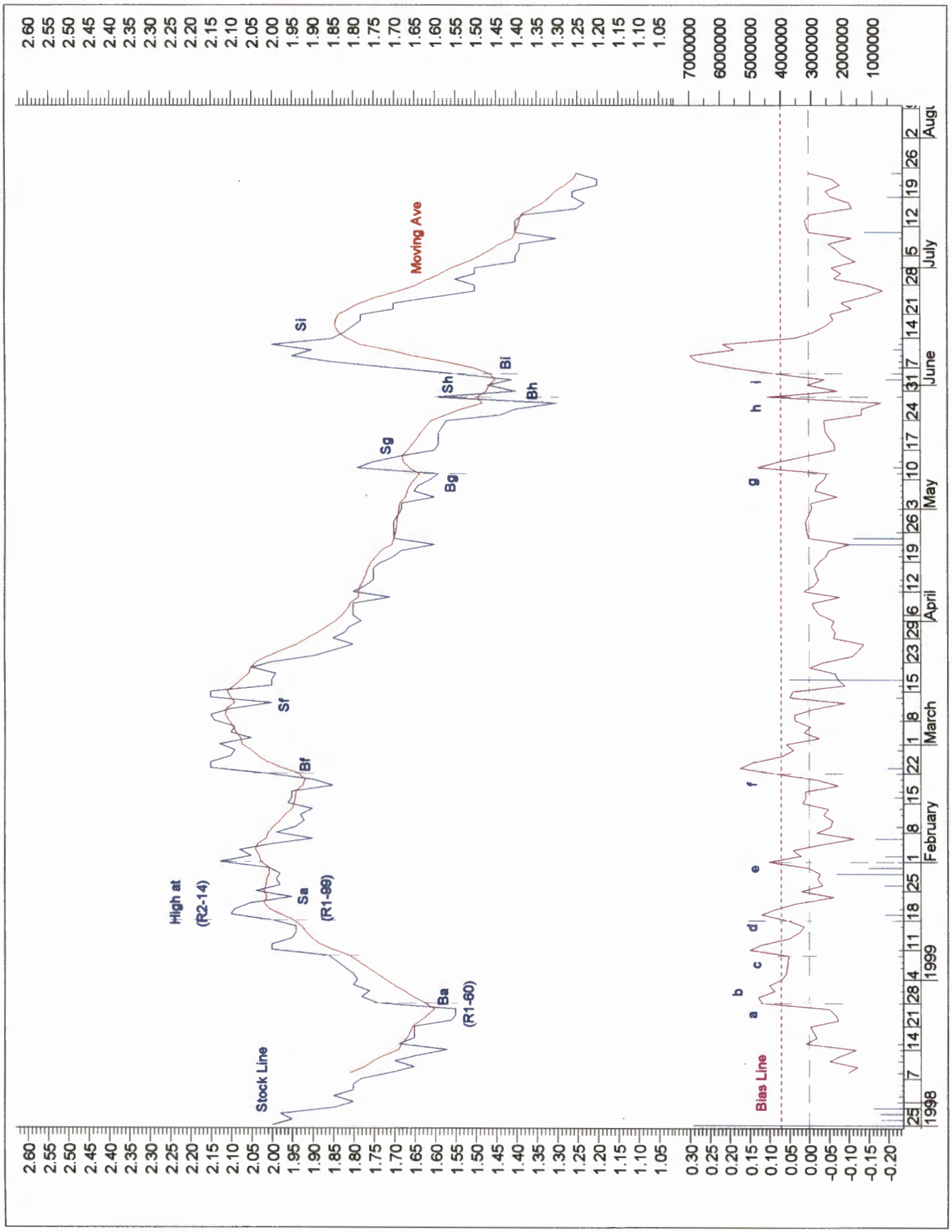
The same process is repeated for points (Bf), (Bg), (Bh) and (Bi) in Figure 19, as well as for the analysis of the stocks comprising the selected sample.

The results of the conversion of the sample is contained in Appendix A. The template created in DADiSP was used to analyse each stock in a similar fashion. Since the template takes the stock data through sixteen steps to arrive at the inverse function, only the steps of significance are displayed. Shown in the appendix is the original data, the non-cyclical data and the resultant trend with the offset removed. Then the Fourier transform is shown, the portion that is filtered and finally the inverse Fourier function in the time domain is shown.

Appendix B contains graphs of the ten stock fully analysed. Each buy and sell point is indicated on the graph. A vertical line also projects the interception point between bias line and Fourier indicator up to the stock graph to establish how this point synchronises with the interception between moving average and stock line. In all the stocks analysed, the synchronisation was excellent.

For each stock in the sample a table is generated to display the prominent frequencies found. The buy and sell points and the resultant gain/loss generated are also tabulated.

FIGURE 19 : METHOD OF ANALYSIS



5.3 Discussion of the Results

Table 3 offers a concise summary of the calculations done and the results obtained on conclusion of the analysis. Shown in the table is the stock frequency, the converted cycle in days (periods) and the parameter used to set up the moving average which is half the length of the period of the most prominent frequency extracted from the fast Fourier transform.

The predominate cycle length can be seen to be rather short, and averages out at 28 days for all the stocks contained in the sample. The reason for this is found in the fact that the Venture Capital Sector in South Africa is still a young and emerging sector.

TABLE 3 : FOURIER ANALYSIS SUMMARY

Stock	**Frequency (Hz)**	**Period (Days)**	**Moving Average (Days)**
Secdata	0.04907	20	10
Aplitec	0.04121	24	12
Refcorp	0.02451	40	20
Zenith	0.01560	64	32
Gilboa	0.04929	20	10
Edata	0.02083	48	24
Penny	0.19047	5	2
Bryant	0.05263	19	10
Legven	0.02192	45	22
Pentacom	0.03846	26	13
Average	**0.03571**	**28**	**14**

Table 4 summarises the original stock data showing the first date of listing until the date on which the stock data was extracted for analysis purpose, which was 23rd July 1999. The stocks under analysis could thus not be subjected to an equal period of analysis and the comparison was therefore conducted on the performance of the Venture Capital Index and the Overall Index over the last 381 days and ending on 23rd July 1999. The figure of 381 days is the average listing period for all the stocks comprising the sample (see listing period column in Table 4). This period is substantially less than the 5 year term initially focussed at in the literature study conducted.

The gain/loss column reflects the natural gain or loss achieved by the stock over the period of its existence, and is the difference between its listing price and last recorded price on 23rd July 1999. The overwhelming losses shown in 80% of the stocks points at the two phases of downturn which the economy has experienced of late and which obviously influenced the younger stocks more.

TABLE 4 : STOCK DATA SUMMARY

Stock	**Listing Date**	**Listing Period (Days)**	**Listing Price (R)**	**Last Price (R)**	**Gain / Loss %**
Secdata	25/11/98	163	R2-00	R1-25	(37.50)
Aplitec	10/12/97	397	R1-37	R3-05	122.63
Refcorp	25/11/97	408	R0-37	R0-11	(70.27)
Zenith	29/05/95	1025	R0-50	R0-04	(92.00)
Gilboa	05/02/96	852	R0-20	R0-06	(70.00)
Edata	06/08/96	240	R4-70	R3-20	(31.91)
Penny	25/05/99	42	R2-15	R2-15	(0.00)
Bryant	01/07/98	266	R1-30	R0-50	(61.54)
Legven	25/08/98	228	R1-80	R2-70	50.00
Pentacom	13/10/98	194	R0-64	R0-25	(60.94)
	Average	**381**		**Net Loss**	**(25.15%)**

From the performance achieved through the use of the Fourier indicator as summarised in Table 5, the model may indeed be regarded as a viable analysis tool in the toolkit of the investor. Table 5 contains the individual results for each stock as well as the performance of the Venture Capital Sector Index and the Overall Index of the Johannesburg Stock Exchange. The effectiveness of the indicator is proven by the net profit of 47.38% generated through the use of fast Fourier transforms compared to the net loss of 25.15% through natural growth (decline) of the stocks. Although the sector chosen proved to be an extremely complex sector to conduct analysis upon, the model still offered profitable return over the same period.

TABLE 5 : INDICATOR PERFORMANCE SUMMARY

Stock/Sector	**Listing Period (Days)**	**Gain / Loss %**
Secdata	163	12.31
Aplitec	397	25.81
Refcorp	408	100.07
Zenith	1025	101.08
Gilboa	852	92.68
Edata	240	32.75
Penny	42	1.01
Bryant	266	71.34
Legven	228	25.48
Pentacom	194	11.45
Average	**381**	**47.38**
Venture Capital Index	**381**	**(2.63)**
Overall Index	**381**	**17.42**

Figure 20 has been included to offer an understanding of the degree of difficulty experienced by the Venture Capital sector during the periods of economic decline in South Africa. The Venture Capital Sector Index *(blue)* has been superimposed onto the Overall Index *(red)* to show the sharp contrast in the ability of this young sector to withstand market forces as opposed to the more mature sectors. Only the latter 381 days is shown, as this was the applicable period of the analysis.

FIGURE 20 : VENTURE CAPITAL SECTOR vs OVERALL INDEX

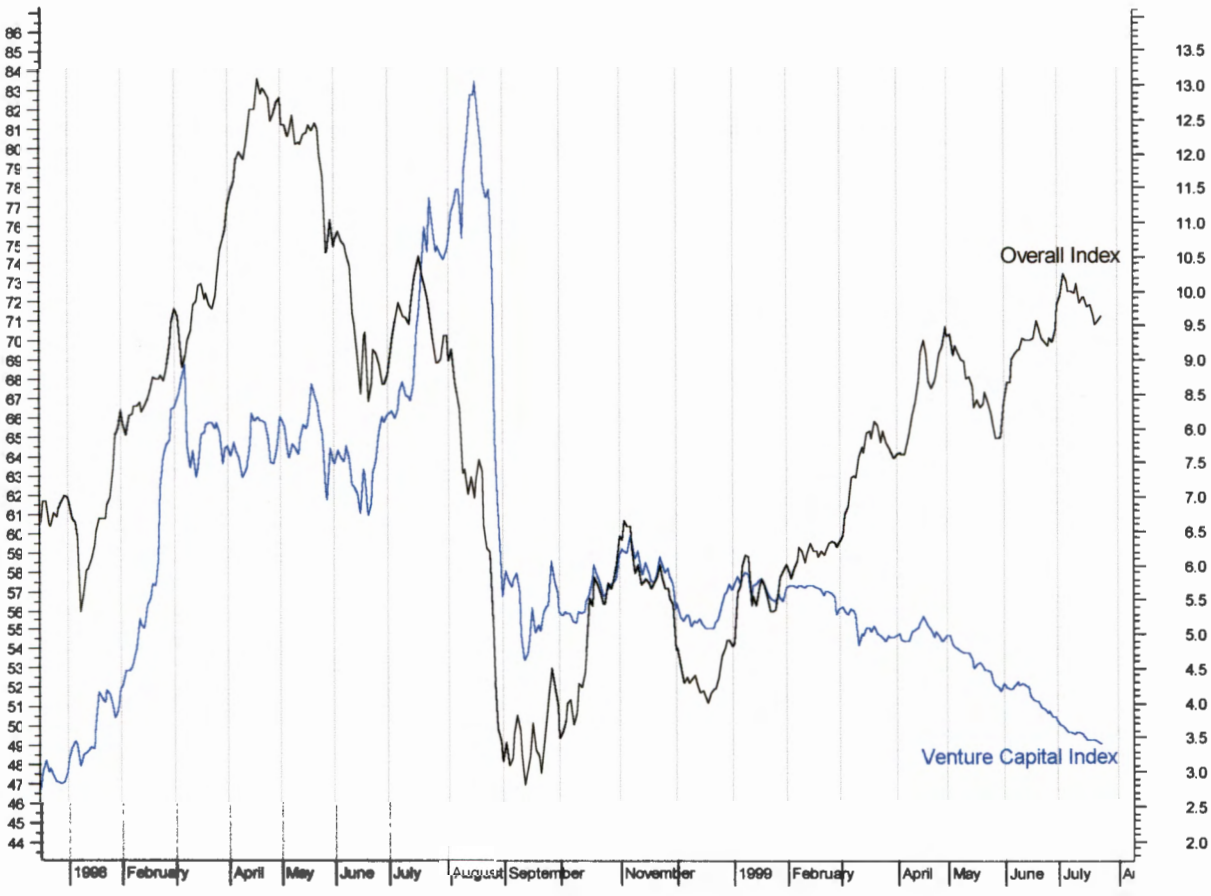
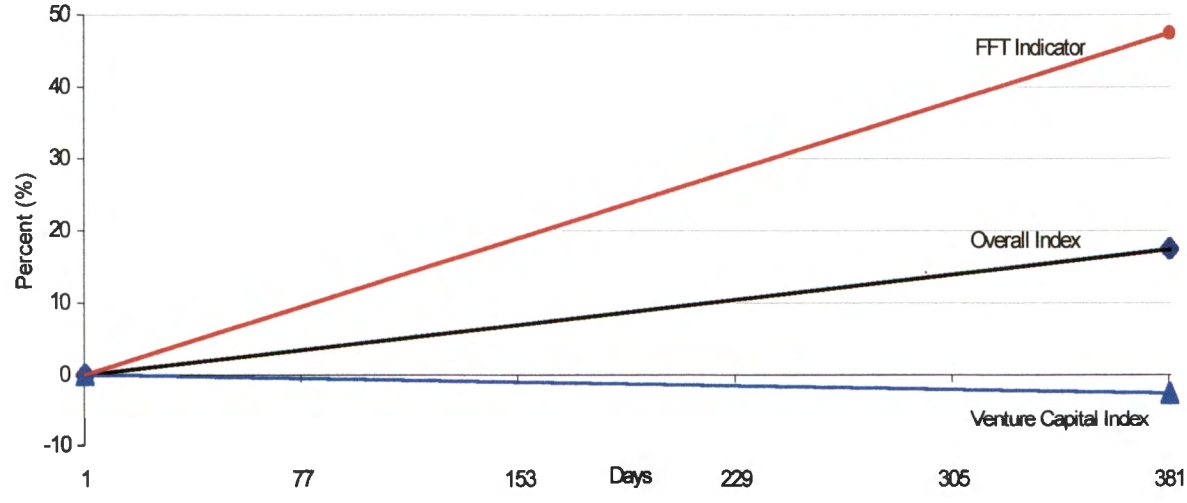


Figure 21 depicts the last 381 days of the Venture Capital Index *(blue)*, the Overall Index *(black)* as well as line FFT Indicator *(red)* which have all been overlaid on the same chart. This offers a year and a half of data, from 8th January 1998 to 23rd July 1999. The FFT line represents the average gain of all the stocks contained in the sample over the average period of 381 days. The figure has the intention of offering a visual impression of the natural performance achieved by the Indices as opposed to the using the fast Fourier Indicator.

FIGURE 21 : FFT vs INDEX PERFORMANCE



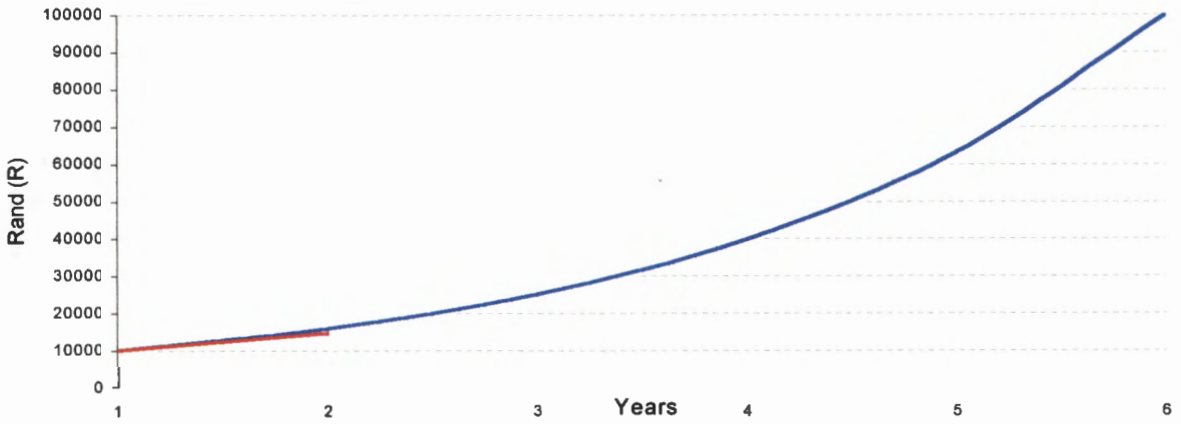
5.4 Chapter Summary

The results obtained by applying fast Fourier transforms as an analysis tool to a sample of randomly selected stocks from the Venture Capital sector proved to perform well. The average percentage profit generated through the use of the fast Fourier indicator to identify positive purchasing signals amounted to 47.38% as opposed to the -2.63% achieved by the Venture Capital Index and the 17.42% produced by the Overall Index. It must also be kept in mind that taking the average of ten stocks is already diversifying the portfolio. The performance could in fact be much higher (or lower) if the stock are seen in isolation, or if the portfolio size is reduced (see Table 5 for individual performance).

Two factors had a profound impact on the Venture Capital sector in particular, and thus influenced the analysis process as well. The first was the fact that stock analysis was confined to short periods of analysis as the venture capital sector is very young. The second was the two successive bear markets caused by the downturn in economic activity in the country, which hit the venture capital sector particularly hard.

In conclusion, the performance of the fast Fourier indicator must be placed in comparison to the performance required of investment in venture capital stocks. In Chapter 2 it was stated by Bukula (1996:18), that an investment in venture capital should appreciate at least ten times by the end of the investment period, which is approximately five years. If an investment of R10 000 is made initially, it should thus appreciate to R100 000 in a five-year period. Figure 31 presents this theoretical growth graphically *(blue line)*. The performance

FIGURE 22 : GROWTH COMPARISON



of the venture capital stocks selected tracks the required performance as suggested by Bukula well as can be seen from the red line in Figure 22.

CHAPTER 6

SUMMARY AND EVALUATION OF THE STUDY

"For things come not back: the spoken word, the spent arrow, the past, and the neglected opportunity."

-.-.-.Omar Idn Al-Halif

6.1 Problem Statement

Investors who follow a technical approach to investment, are faced with two key issues when considering to invest in a company. Firstly *which* shares to buy, and secondly *when* to buy or sell these shares. Venture Capital shares can offer extremely high return on investment if the investor is able to accurately and timely access and withdraw from the market. Due to the volatile nature of venture capital shares it is difficult to predict their future trends.

Many analysis tools are available to the investor. No analysis tool however is concerned with identifying the predominate cycle in a data array. Through the empirical research it was found that the cycle length used by investors when applying indicators such as moving averages are chosen on a trail and error basis.

Fourier transforms were specifically designed to illuminate the predominate cycle in data. It was thus regarded as most appropriate to examine whether fast Fourier transforms could be employed as an analysis tool to illuminate the underlying cycles in a scientific manner. In doing so the investor could be assisted in optimising his stock selection, and thus reducing his investment risk.

6.2 Purpose of the Study

The main purpose of this dissertation was to determine the degree of accuracy with which fast Fourier transforms could be applied as an analysis tool in the selection of venture capital stock.

6.3 Methodology and Measurement Instrument

A fast Fourier transform indicator was developed by removing the unwanted noise and biases from the data series. Depending on the point at which the transformation process was interrupted, offered the investor three choices of application of the indicator as a stock selection tool. For the analysis of the sample selected for this study, the inverse function of the fast Fourier transform was chosen, and the biased points of zero crossing used as trigger points. These points were confirmed by the application of the most prominent frequency to a moving average. The moving average was superimposed onto the original wave and the points of intersection between the two waves used as trigger points.

The quantitative analysis established that the random sample of stocks taken from the venture capital sector could indeed be analysed with a high degree of accuracy and reliability. The application of the fast Fourier transforms to the basic data offered substantially higher returns than that offered by the indices.

6.4 Results and Conclusions

The results obtained by applying fast Fourier transforms as an analysis tool to the sample proved to perform well. The average percentage profit generated through the use of the fast Fourier indicator to identify positive purchasing points amounted to 47.38% as opposed to the -2.63% achieved by the Venture Capital Index and the 17.42% produced by the Overall Index.

It can be concluded that fast Fourier transform can indeed be applied as an analysis tool and can vastly assist the investor in stock selection. Using other supporting indicators together with the fast Fourier transform compliments the investment decision and should be part of the investment strategy. The choice and combination of indicators is a highly personalised matter and one the investor must feel comfortable with.

The use of a moving average derived from the predominate frequency as supplied by the Fourier transform, in combination with the fast Fourier indicator for detecting the points of zero crossing proved to be a valuable combination for timing the investment decision.

6.5 Critical Evaluation of the Study

Two factors had a profound impact on the venture capital sector in particular, and thus influenced the analysis process as well. The first was the fact that stock analysis was confined to short periods of analysis as the venture capital sector is still young. The second was the two successive bear markets caused by the downturn in economic activity in the country and hit the venture capital sector particularly hard.

The investigation was limited to the stocks contained in the venture capital sector and although there is no technical reason why the indicator should not perform equally well for all the sectors, this cannot simply be deducted.

Use was only made of daily closing price data, and inter-day analysis was not considered since investment in venture capital stock is intended over a period of three to seven years.

Fourier analysis is a complex mathematical phenomena and one that requires background and feel for the subject. The analysis was further facilitated by an advanced and expensive software package, something the ordinary investor shall not have access too.

The largest limitation of Fourier is determined by how close the cycles of the various periods are compared to the ideal sine wave. This can be a problem, as it is well known that the maximum point in a cycle does shift its position relative to the minima in response to the overall trend in the price. While the trend is upward, the maximum will fall to the right of the centre point between the minima, it will be closer to the end of the cycle.

During an overall downturn, the maximum falls earlier in the cycle period, closer to the start of the cycle. A shift like this can distort the sine form of the cycle sufficiently to introduce 'false' cycles into the results of the Fourier analysis.

6.6 Recommendations for Further Research

The extraction of the underlying cycles that constitute the real character of the wave under analysis is a complex process. The investor will experience difficulty in managing a data series in accordance with the approach followed in chapter 5. A routine or a template which

converts the original stock array, performs the fast Fourier analysis and transform the data back to the time domain automatically is required. The investor is then provided with a resultant wave and frequency range which will vastly assist with the selection and investment decision.

The fast Fourier transform indicator was applied with relative success to the Venture Capital sector. Since the application and functioning of Fourier is not sector dependant, but an analysis method, the indicator should be well suited to the analysis of any stock. As this aspect cannot simply be accepted, the suitability of the indicator to other sectors and the entire population of stock comprising the Johannesburg Stock Exchange shall have to be determined.

The sensitivity of the fast Fourier transform indicator to detect the point of zero crossing can be adjusted by the introduction of an offset line. In the analysis strategy applied to the sample of stocks in this study, 5% was chosen as a random figure. There is no scientific evidence to support the choice. The figure was chosen purely on the experience of the author from his numerous analyses of stock. The research of this factor shall contribute to the effectiveness of the indicator.

It is common practice to employ at least two, and preferably not more than four indicators in an investment strategy (Anon, 1995:8). The use of multiple indicators serves as a method of complimenting or supporting one another in the quest to predict future behaviour. In the strategy employed in chapter 5 the fast Fourier transform indicator was supported by a moving average indicator. Once more there is no scientific evidence to support this choice and was chosen randomly, and for its ease of use and understanding. The optimal combination of indicators for stock selection may present an investment strategy offering higher returns.

6.7 Concluding Remarks

The development of Fourier as an analysis tool may assist the public at large to become more involved in the functioning of the financial markets. With greater involvement by the public in the stock market, the market becomes more liquid and a liquid market is to the benefit of all involved.

The wide use of Fourier's method and related analytical techniques makes what Lord Kelvin said in 1867 just as true today:

"Fourier's theorem is not only one of the most beautiful results of modern analysis,

but it may be said to furnish an indispensable instrument in the treatment

of nearly recondite questions in modern physics."

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APPENDIX A

RESULTS OF TEMPLATE ANALYSIS

A1 Analysis of Secdata

Figure 19a : Original Data

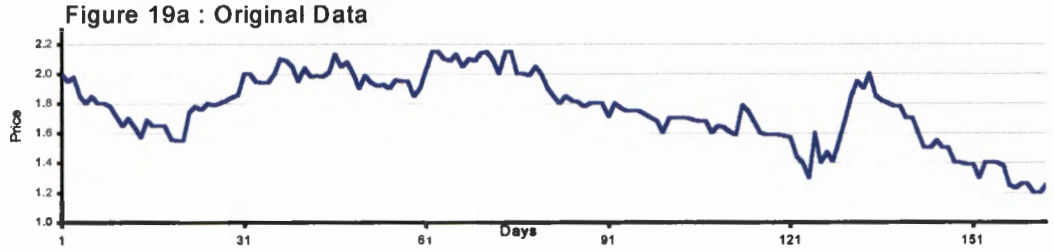


Figure 19b : Polygraph

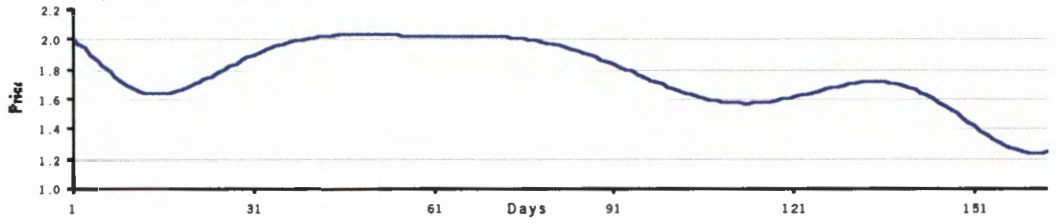


Figure 19c : Cyclical Trend

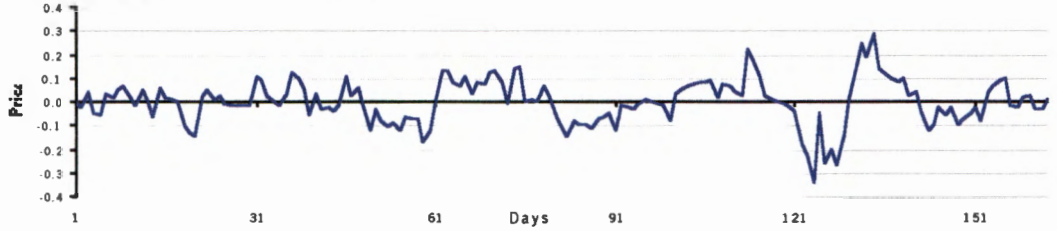


Figure 19d : Fast Fourier Transform

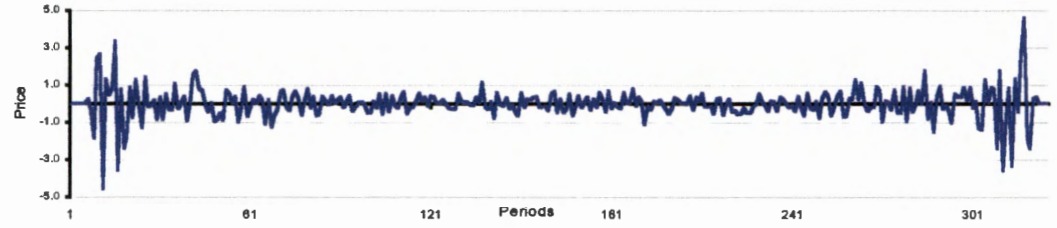


Figure 19e : FFT Extract

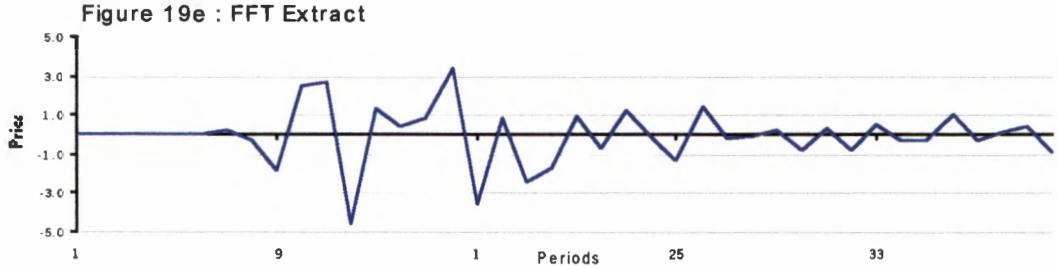


Figure 19f : Concat

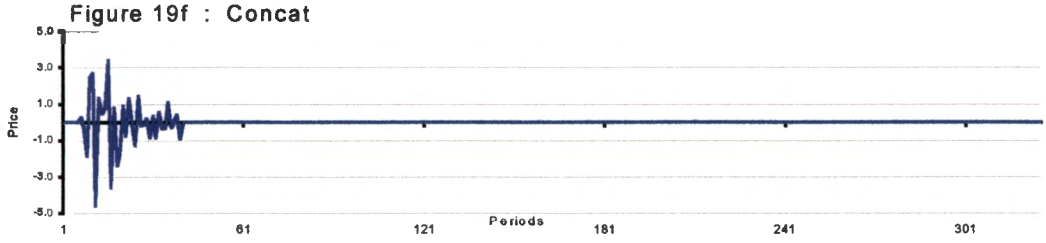
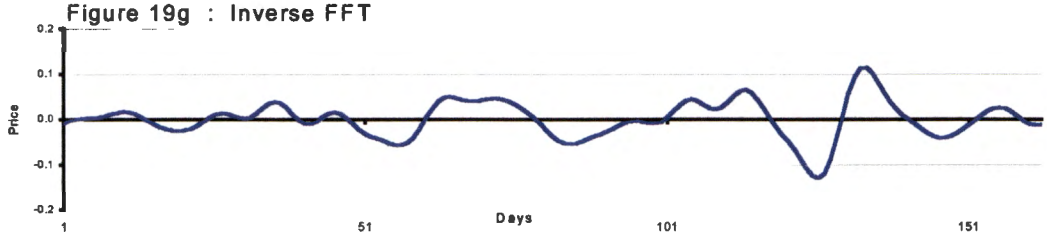


Figure 19g : Inverse FFT



A2 Analysis of Aplitec

Figure 20a : Original Wave

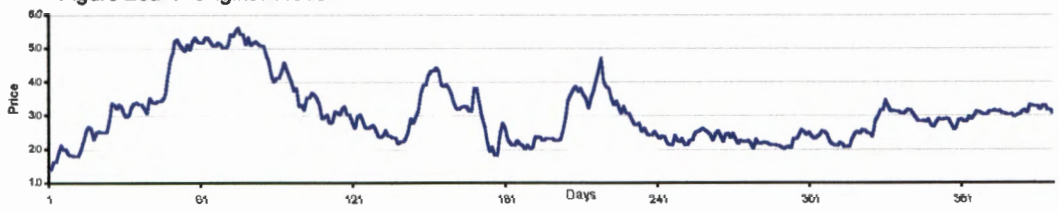


Figure 20b : Polygraph

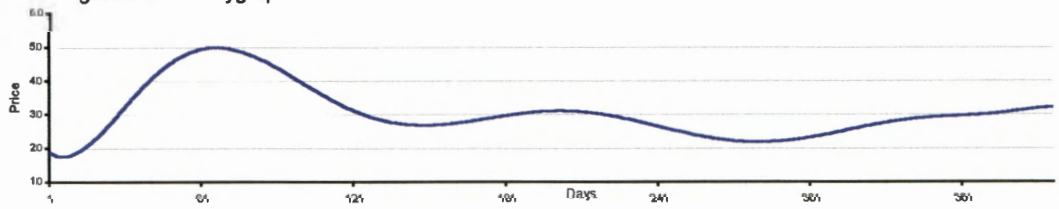


Figure 20c : Cyclical Trend

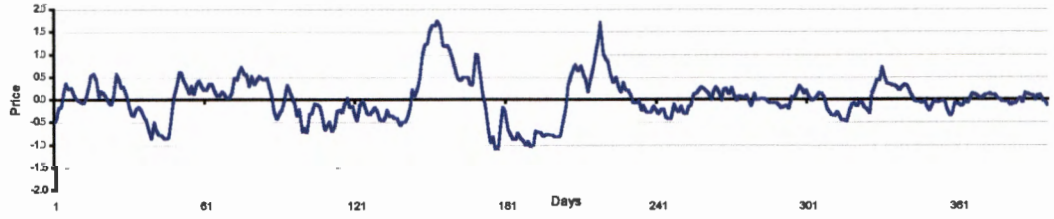


Figure 20d : Fast Fourier Transform

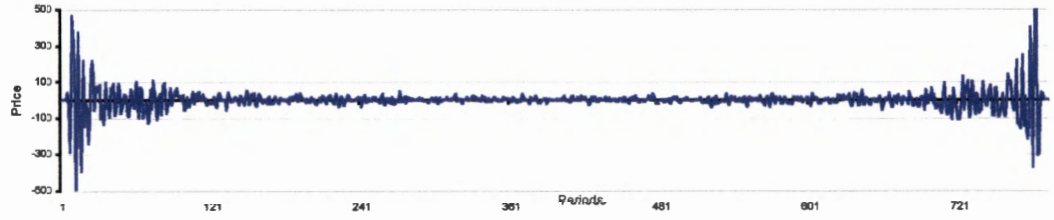


Figure 20e : FFT Extract

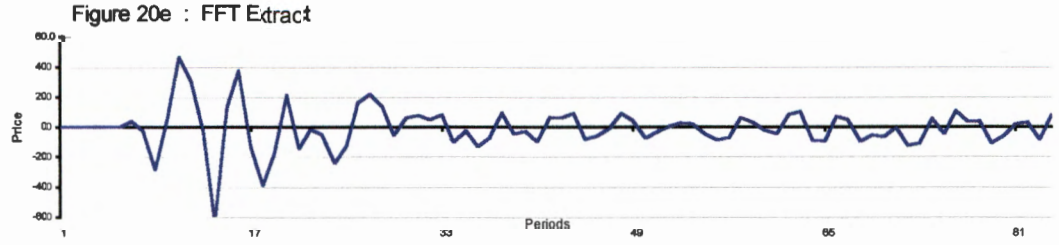


Figure 20f : Concat

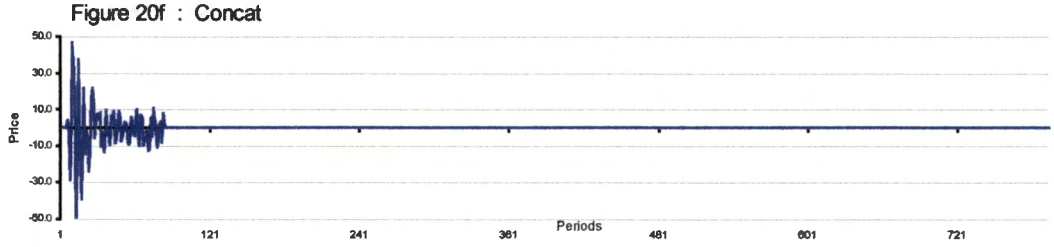
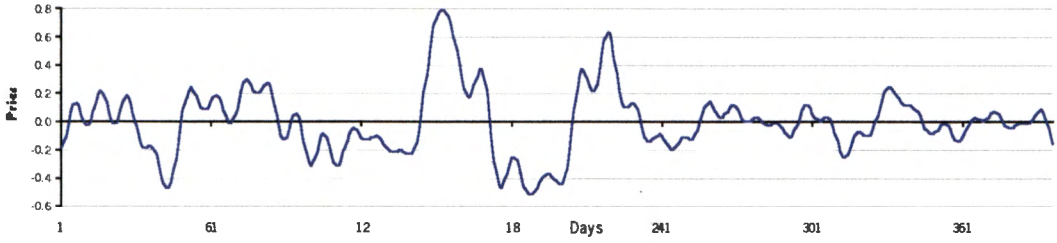


Figure 20g : Inverse FFT



A3 Analysis of Refcorp

Figure 21a : Original Data

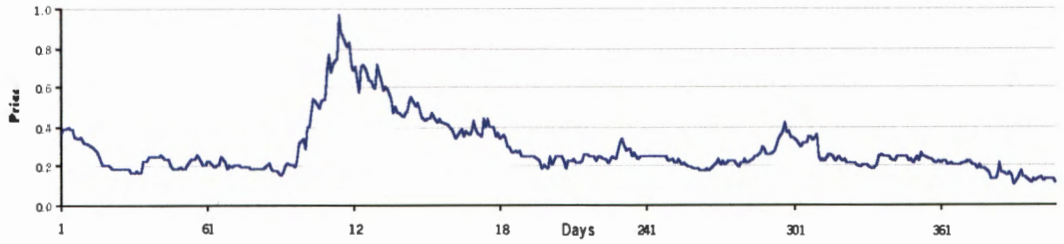


Figure 21b : Polygraph

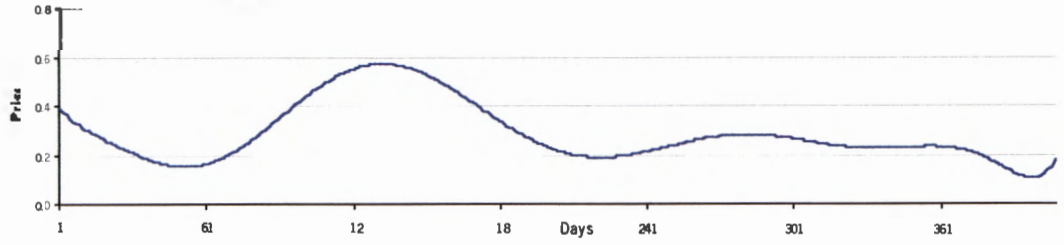


Figure 21c : Cyclical Trend

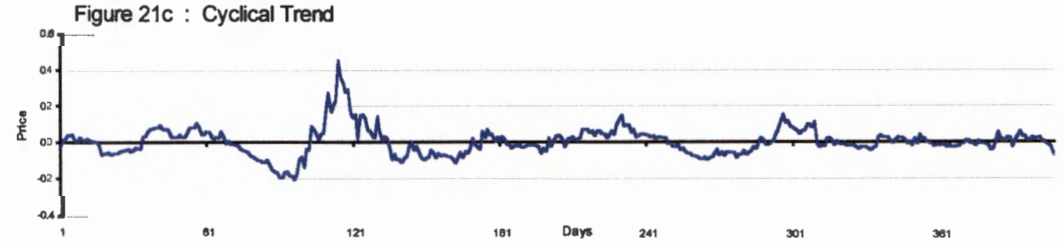


Figure 21d : Fast Fourier Transform

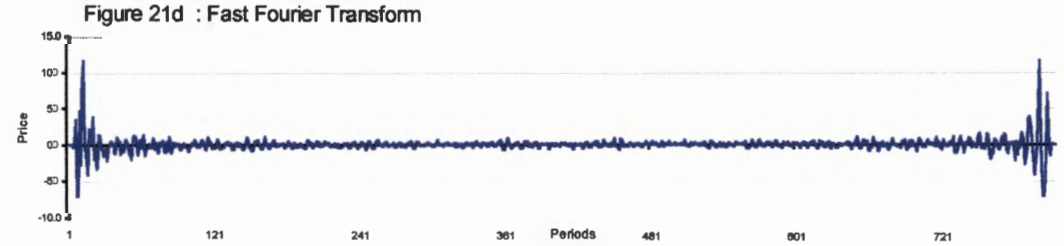


Figure 21e : FFT Extract

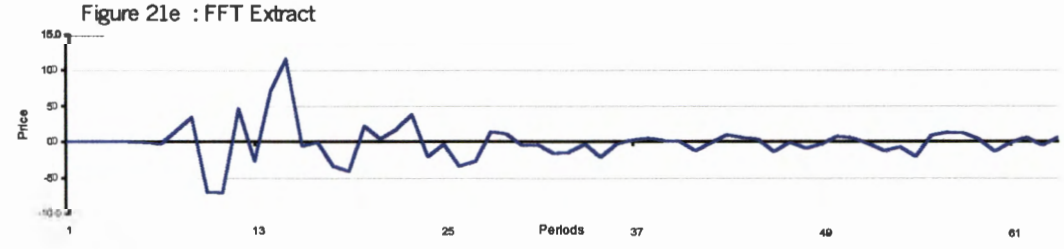


Figure 21f : Concat

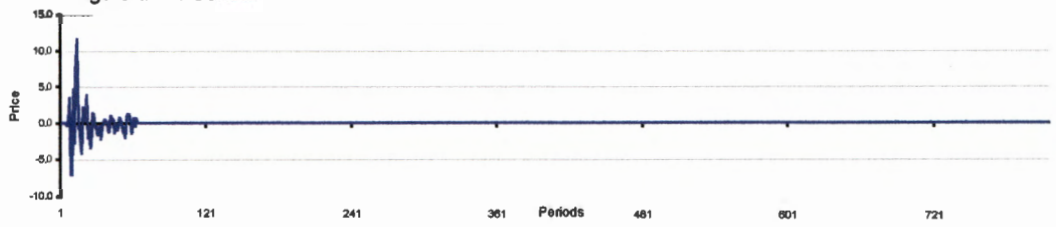
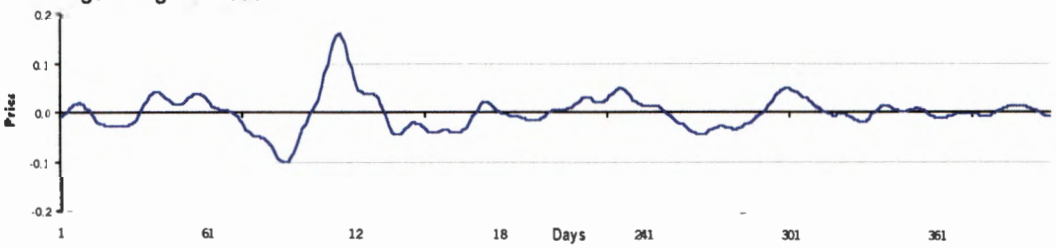


Figure 21g : Inverse FFT



A4 Analysis of Zenith

Figure 22a : Original Data

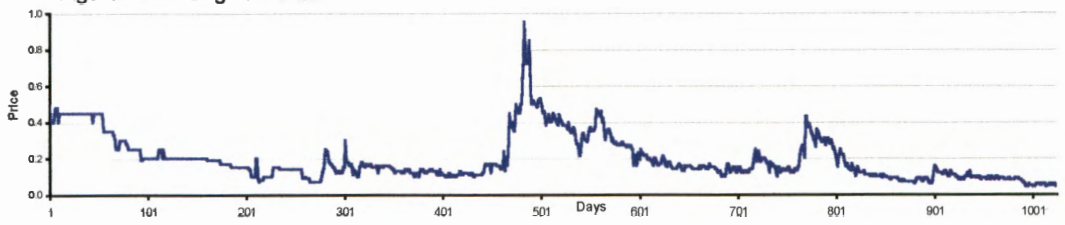


Figure 22b : Polygraph

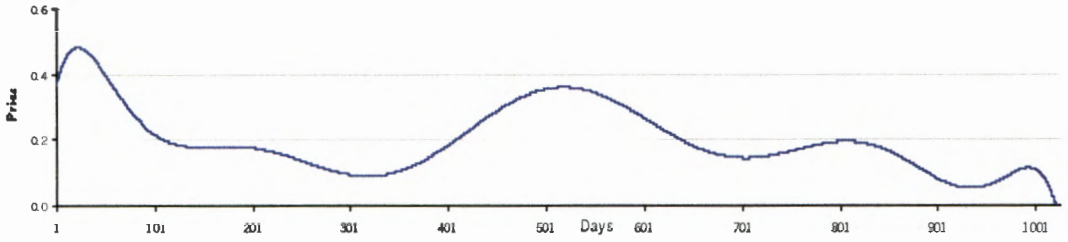


Figure 22c : Cyclical Trend

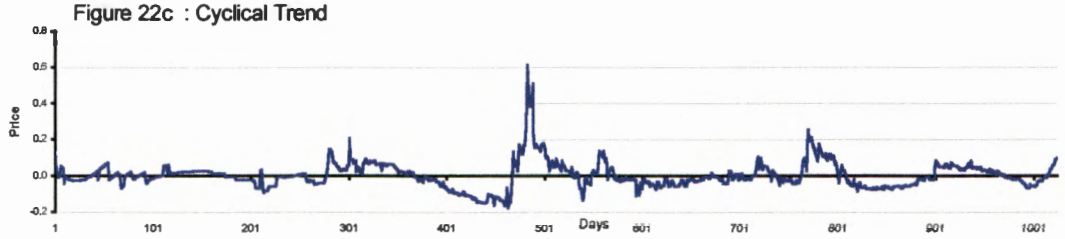


Figure 22d : Fast Fourier Transform

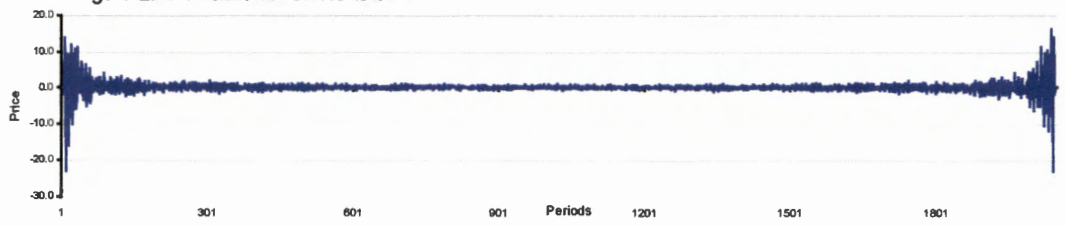


Figure 22e : FFT Extract

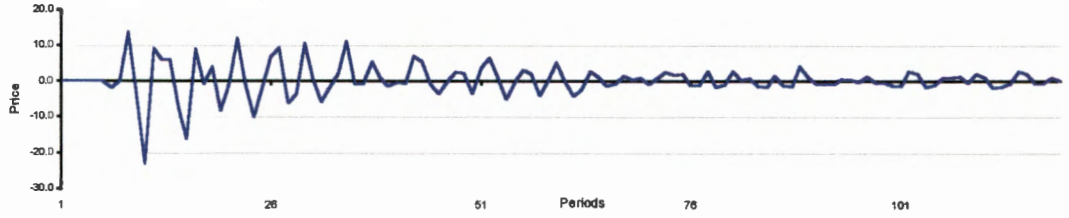


Figure 22f : Concat

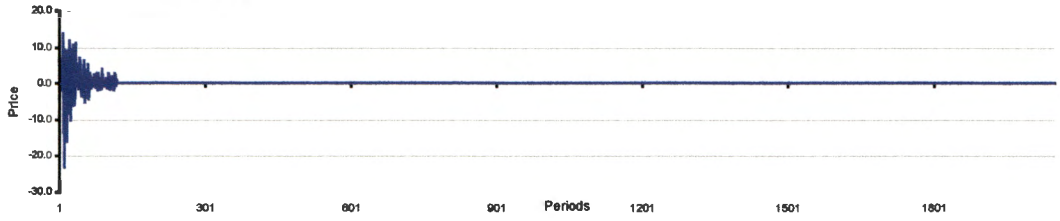
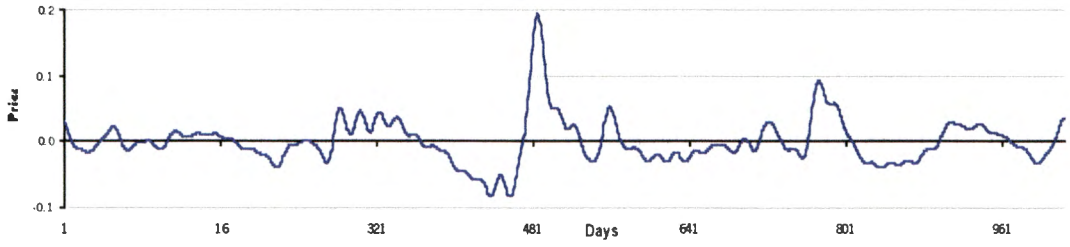


Figure 22g : Inverse FFT



A5 Analysis of Gilboa

Figure 23a : Original Data

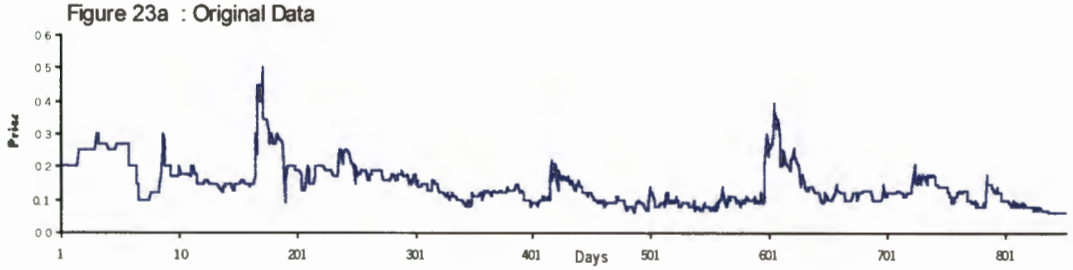


Figure 23b : Polygraph

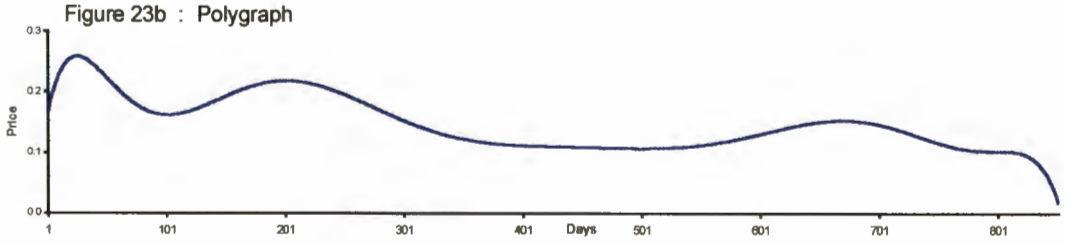


Figure 23c : Cyclical Trend

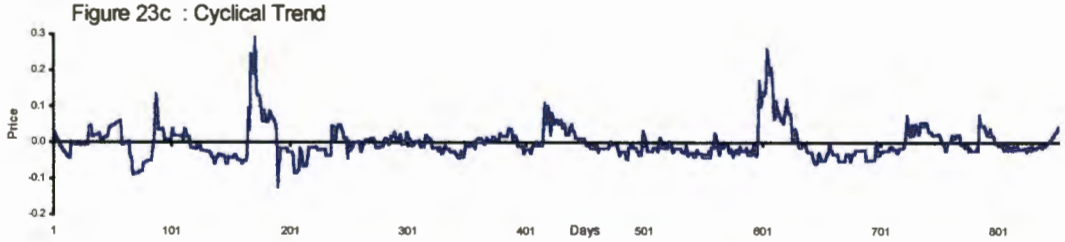


Figure 23d : Fast Fourier Transform

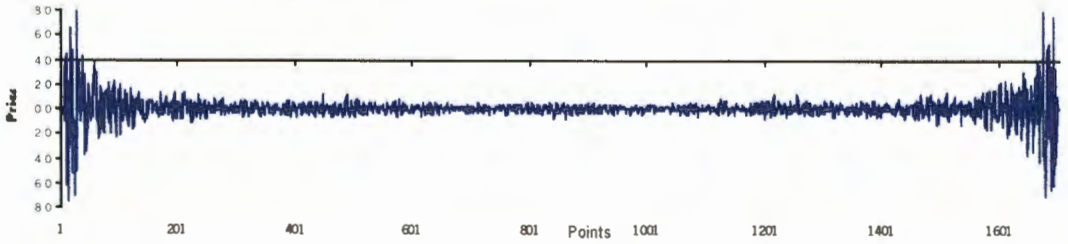


Figure 23e : FFT Extract

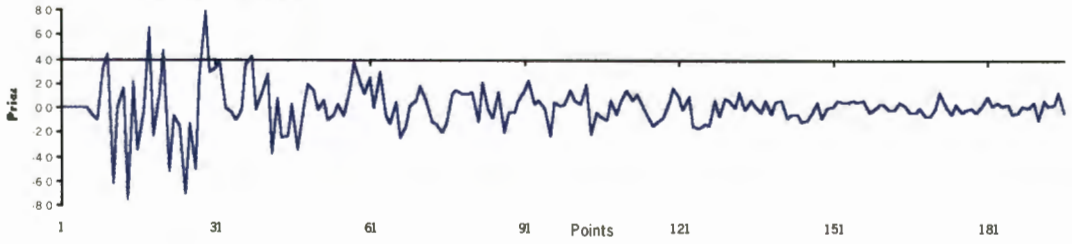


Figure 23f : Concat

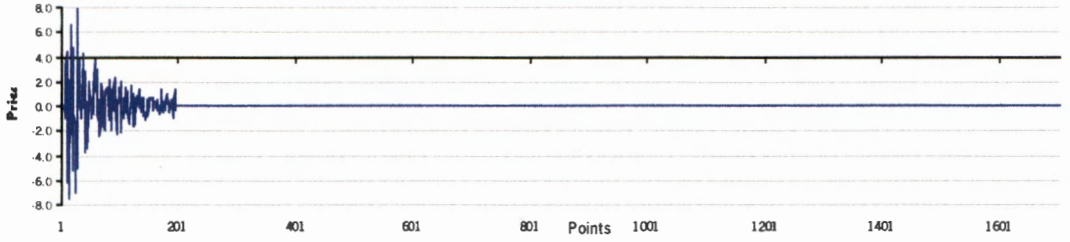
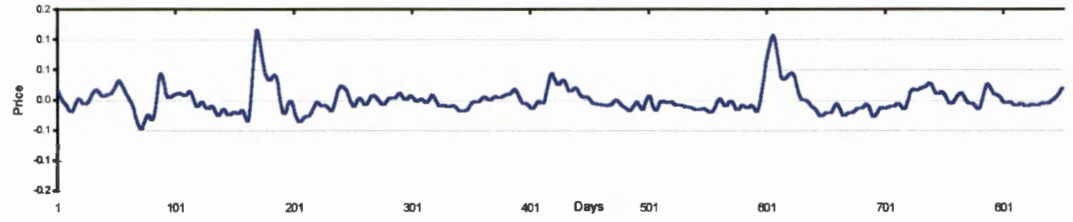


Figure 23f : Inverse FFT



A6 Analysis of Edata

Figure 24a : Original Data

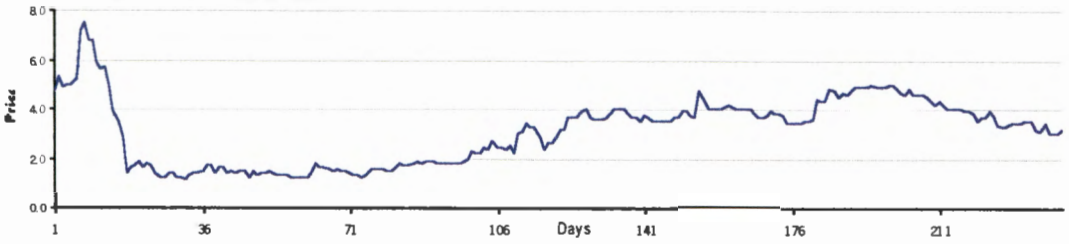


Figure 24b : Polygraph

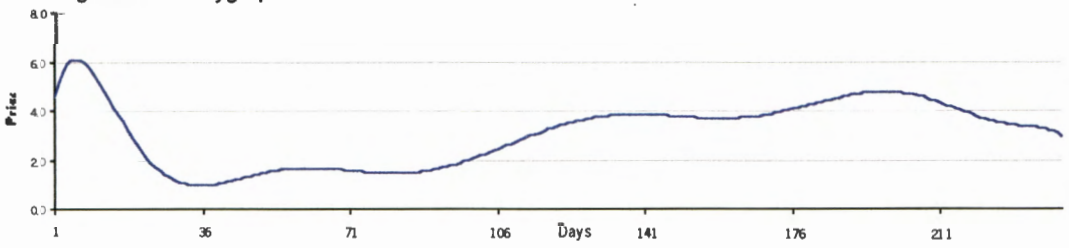


Figure 24c : Cyclical Trend

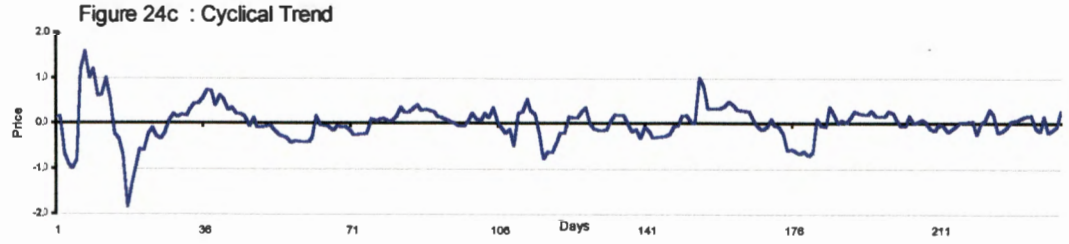


Figure 24d : Fast Fourier Transform

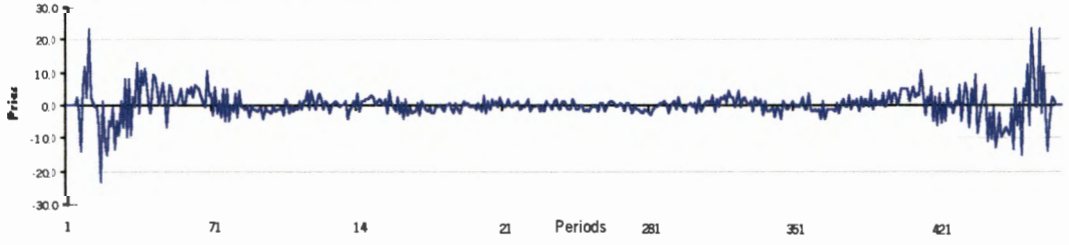


Figure 24e : FFT Extract

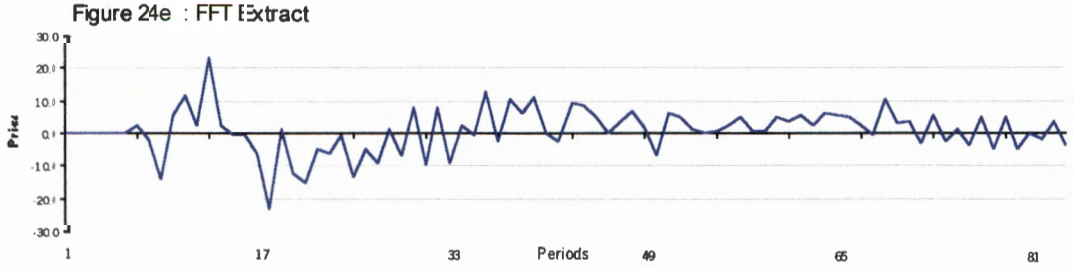


Figure 24f : Concat

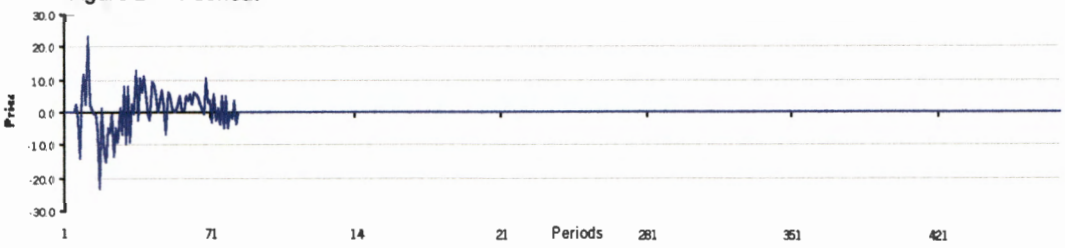
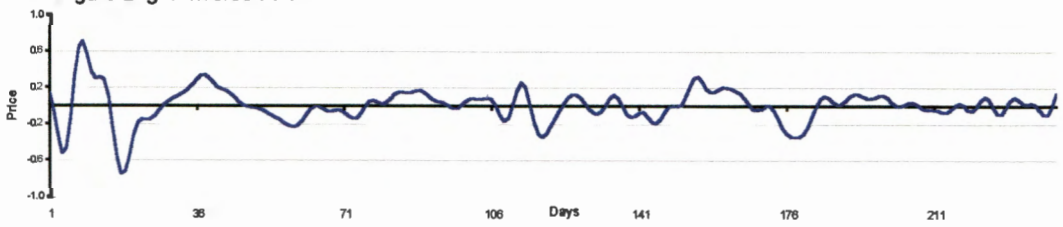


Figure 24g : Inverse FFT



A7 Analysis of Penny

Figure 25a : Original Data

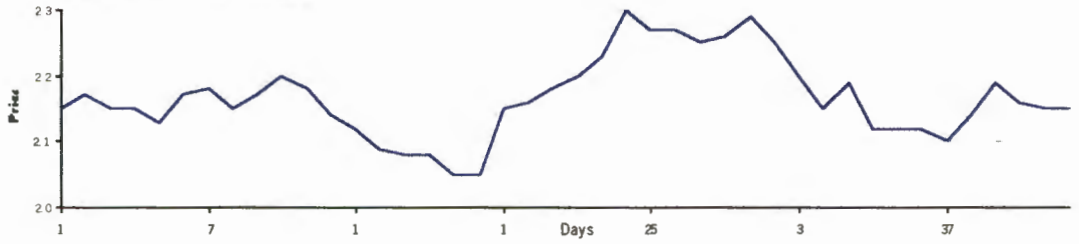


Figure 25b : Polygraph

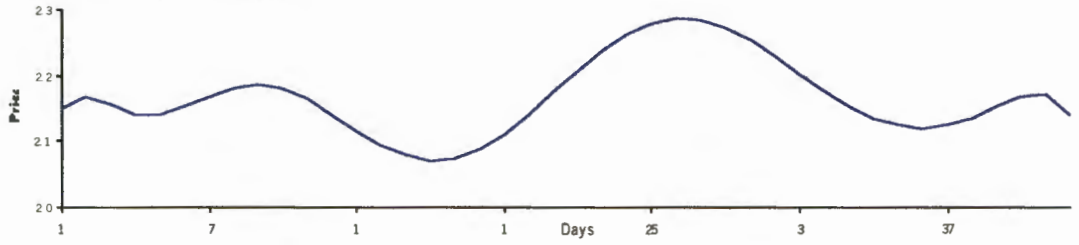


Figure 25c : Cyclical Trend

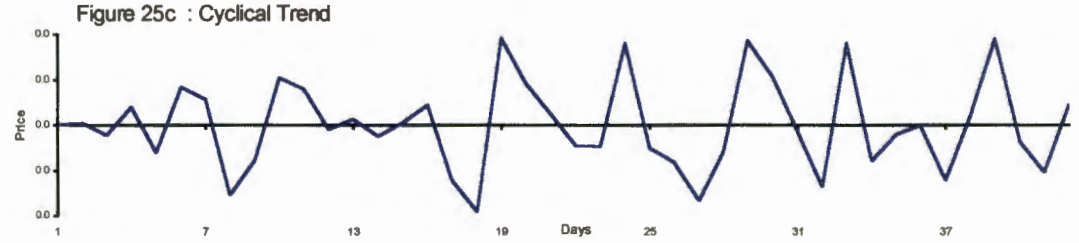


Figure 25d : Fast Fourier Transform

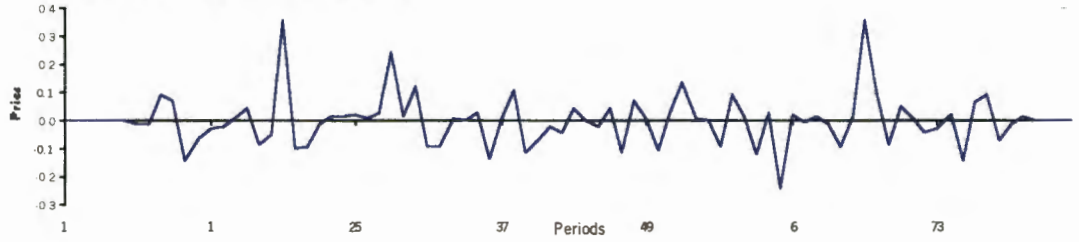


Figure 25e : FFT Extract

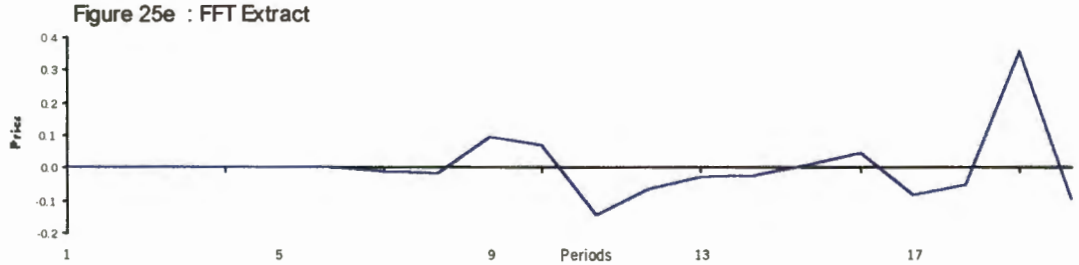


Figure 25f : Concat

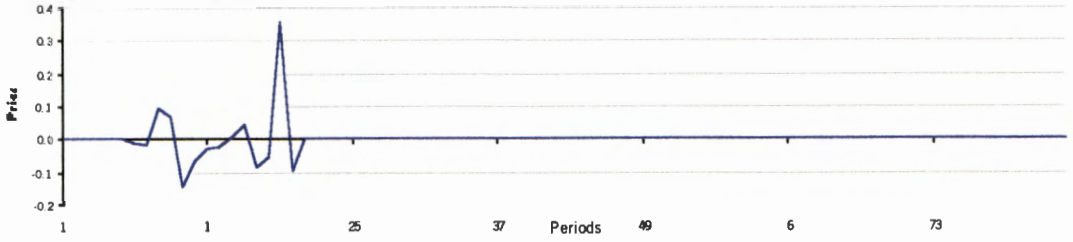
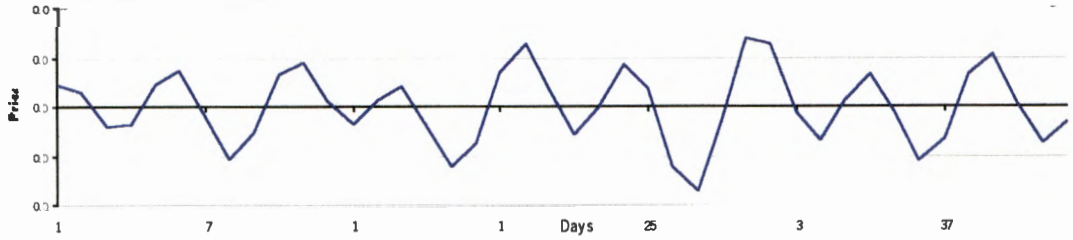


Figure 25g : Inverse FFT



A8 Analysis of Bryant

Figure 26a : Original Data

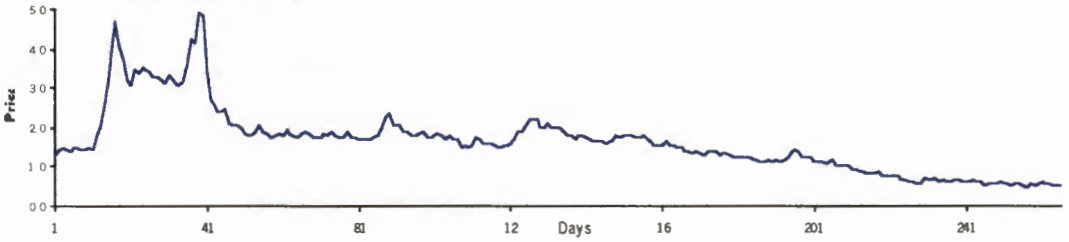


Figure 26b : Polygraph

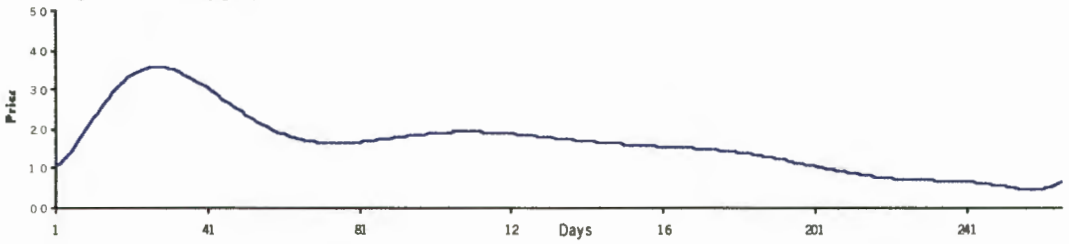


Figure 26c : Cyclical Trend

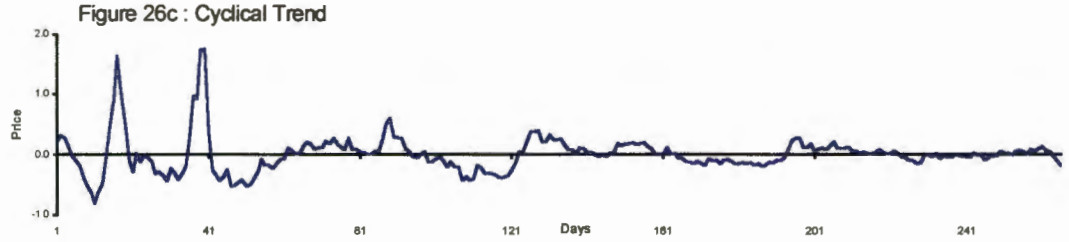


Figure 26d : Fast Fourier Transform

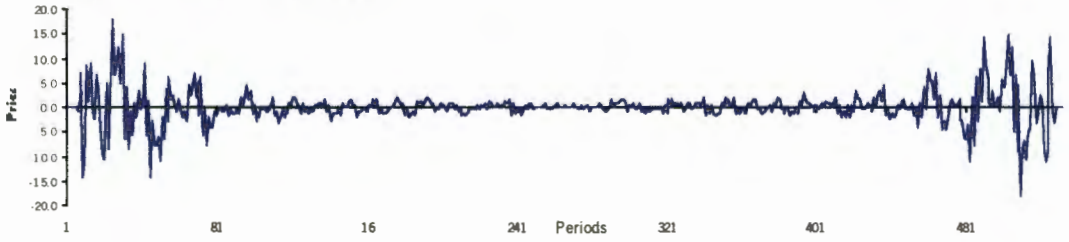


Figure 26e : FFT Extract

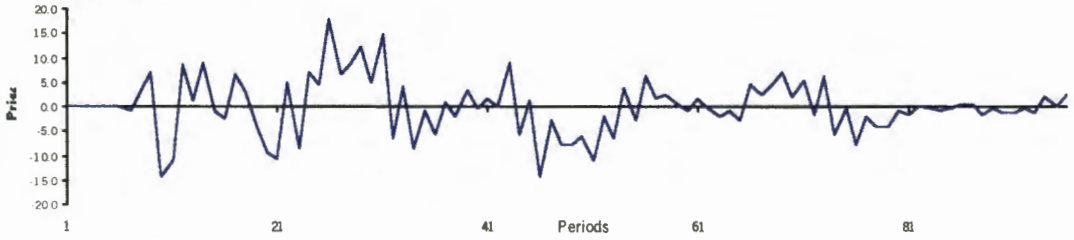


Figure 26f : Concat

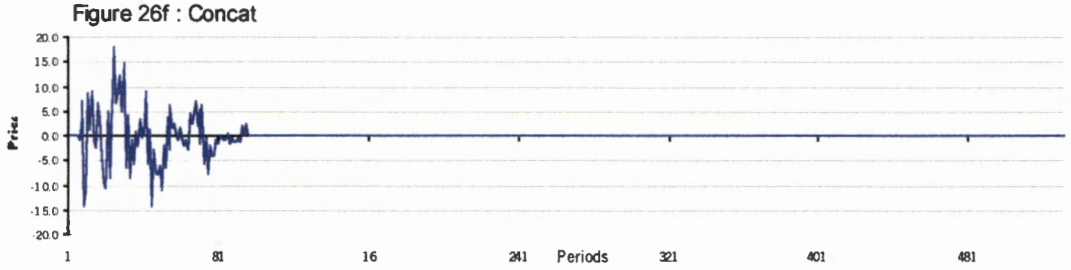
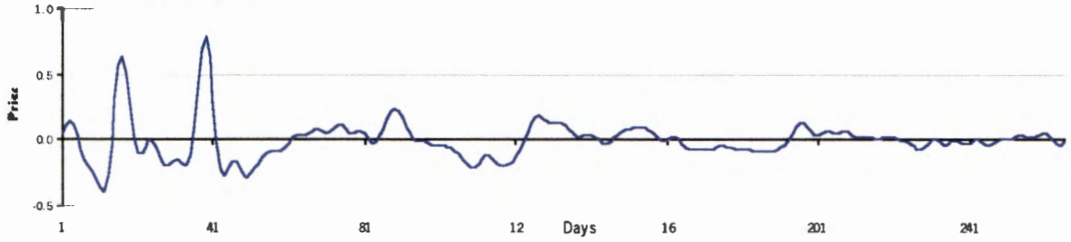


Figure 26g : Inverse FFT



A9 Analysis of Legven

Figure 27a : Original Data

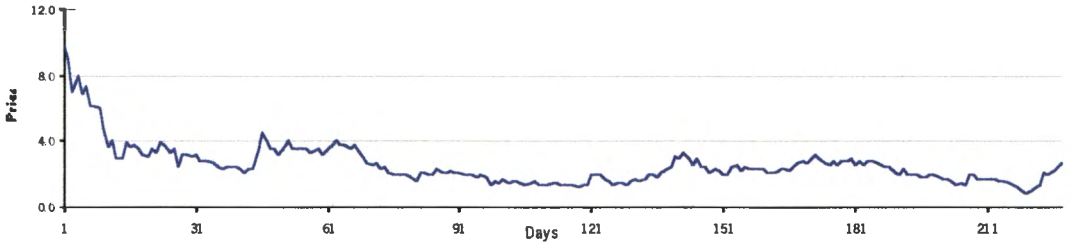


Figure 27b : Polygraph

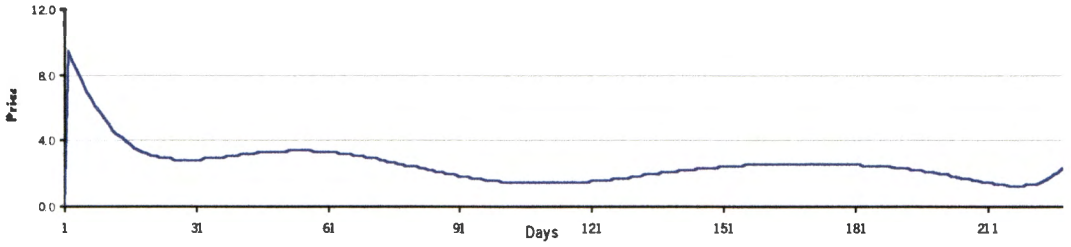


Figure 27c : Cyclical Trend

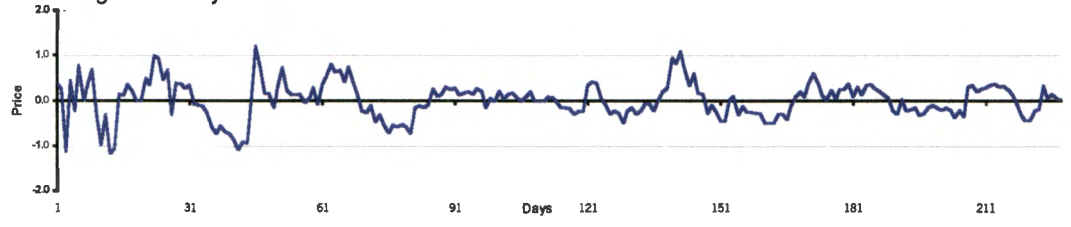


Figure 27d : Fast Fourier Transform

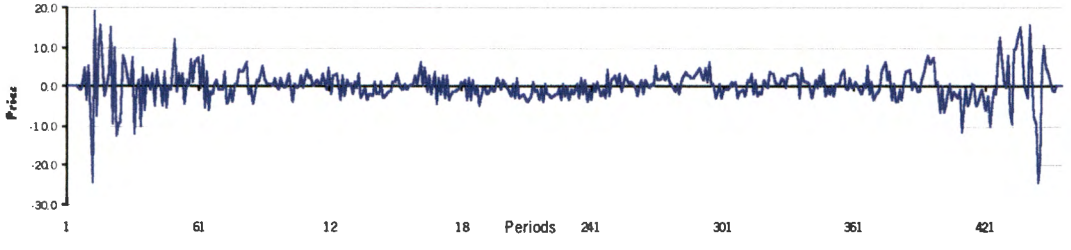


Figure 27e : FFT Extract

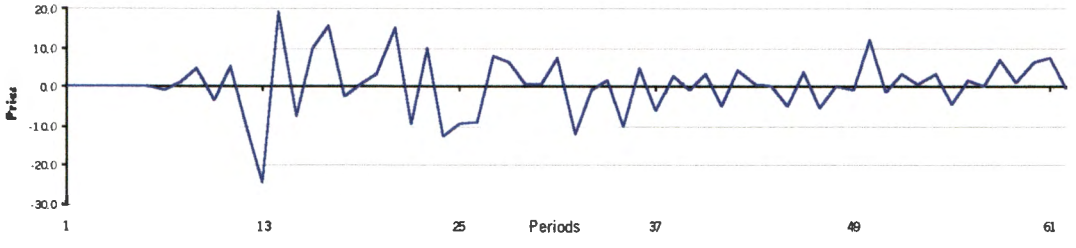


Figure 27f : Concat

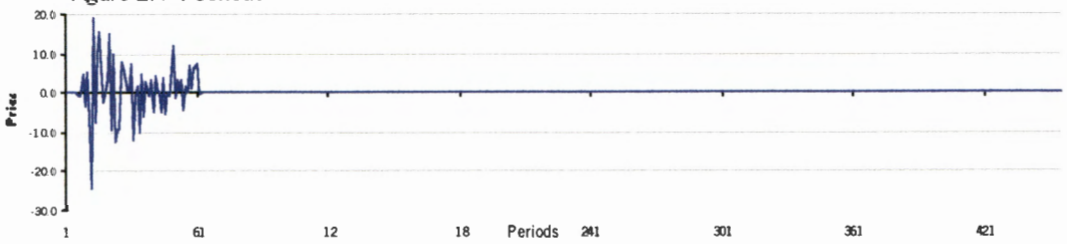
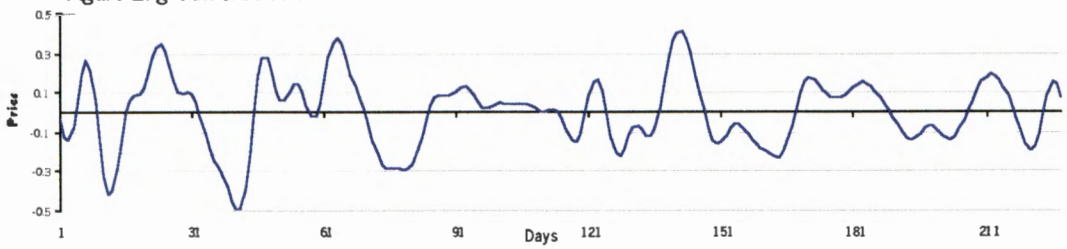


Figure 27g : Inverse FFT



A10 Analysis of Pentacom

Figure 28a : Original Data

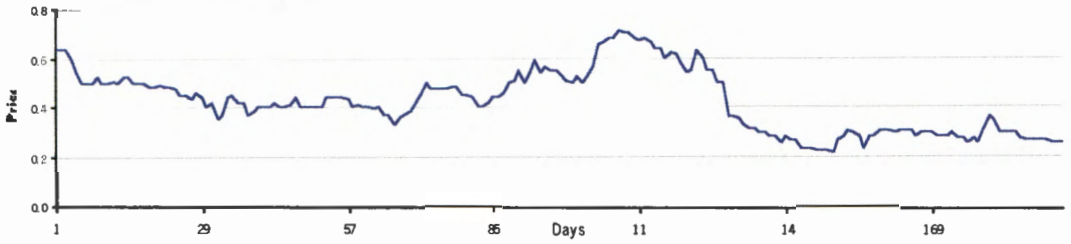


Figure 28b : Polygraph

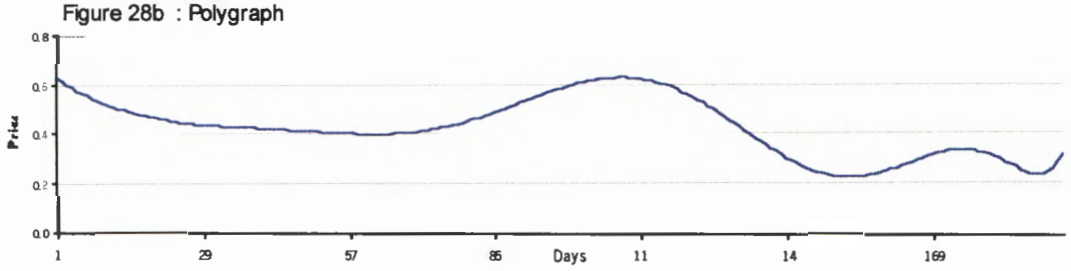


Figure 28c : Cyclical Trend

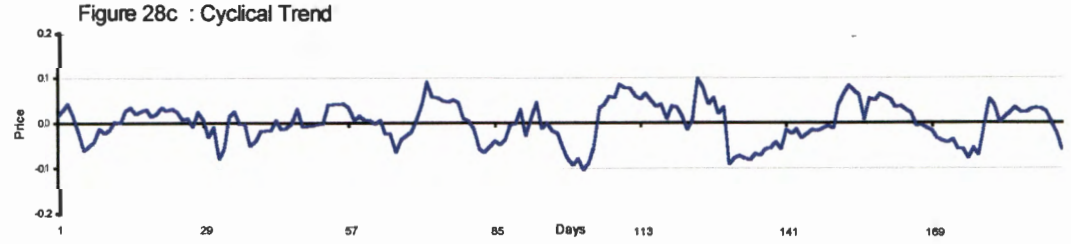


Figure 28d : Fast Fourier Transform

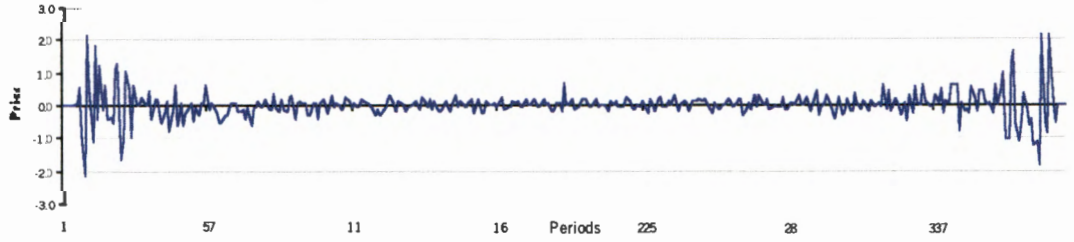


Figure 28e : FFT Exract

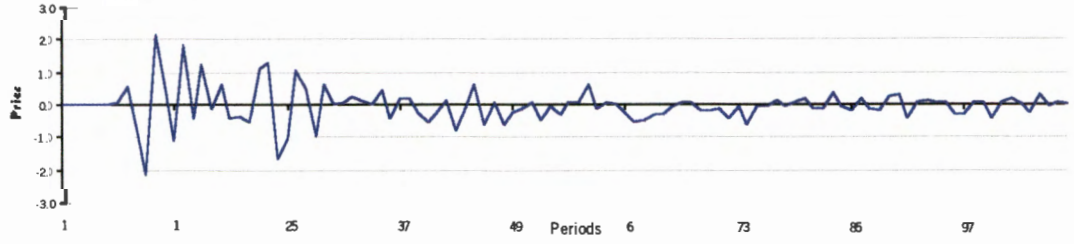


Figure 28f : Concat

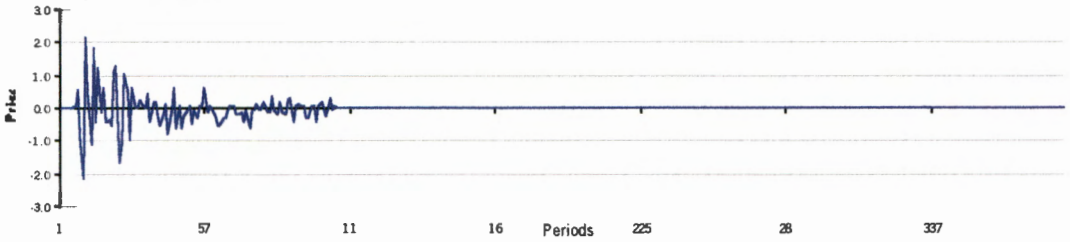
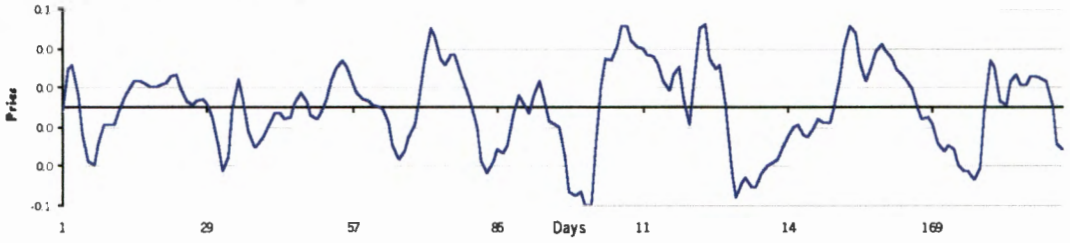


Figure 28g : Inverse FFT



APPENDIX B

FINAL GRAPHICAL RESULTS OF STOCK ANALYSIS

FIGURE B1 : SECDATA FINAL RESULT

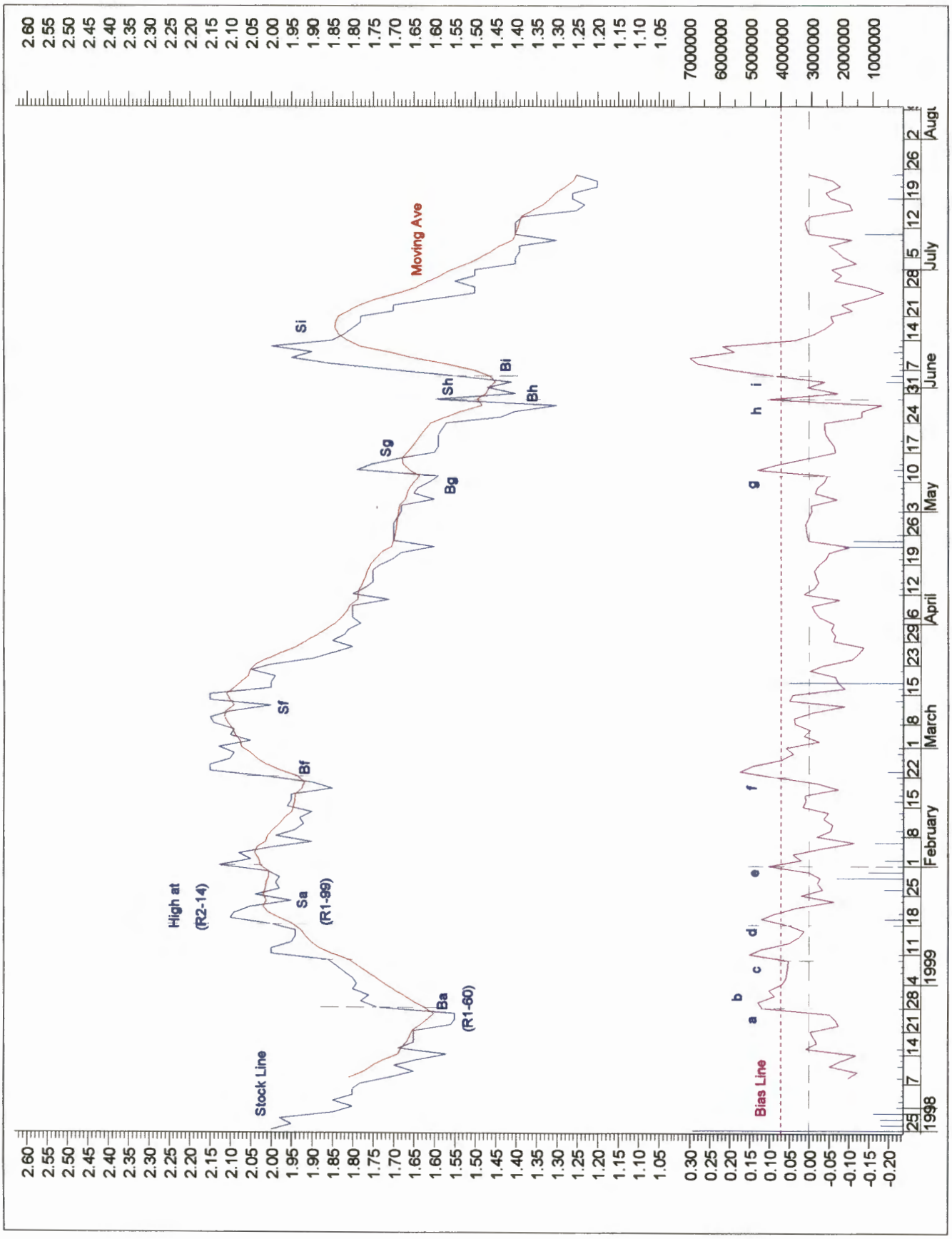


FIGURE B2 : APLITEC FINAL RESULT

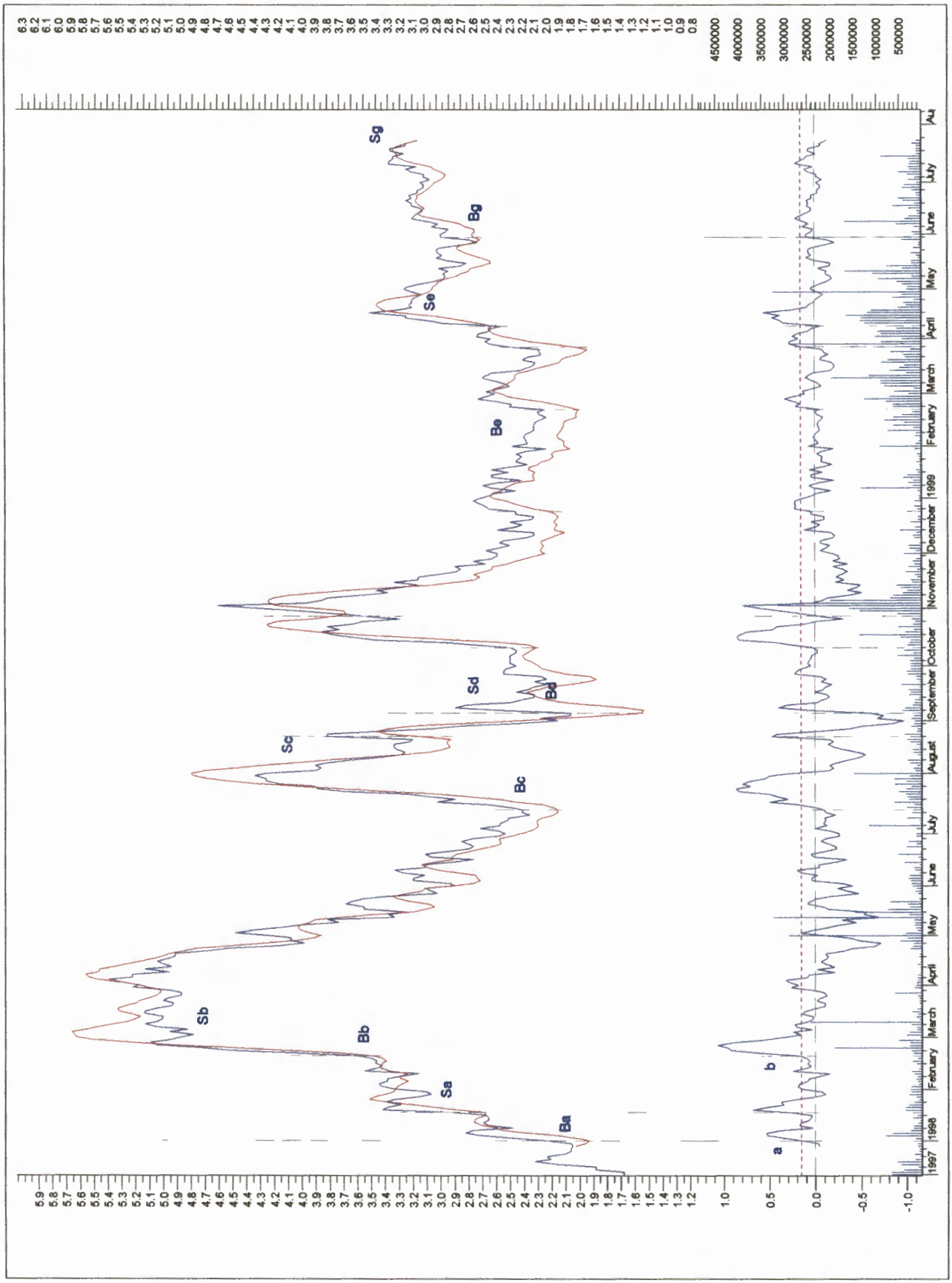


FIGURE B3 : REFCORP FINAL RESULT

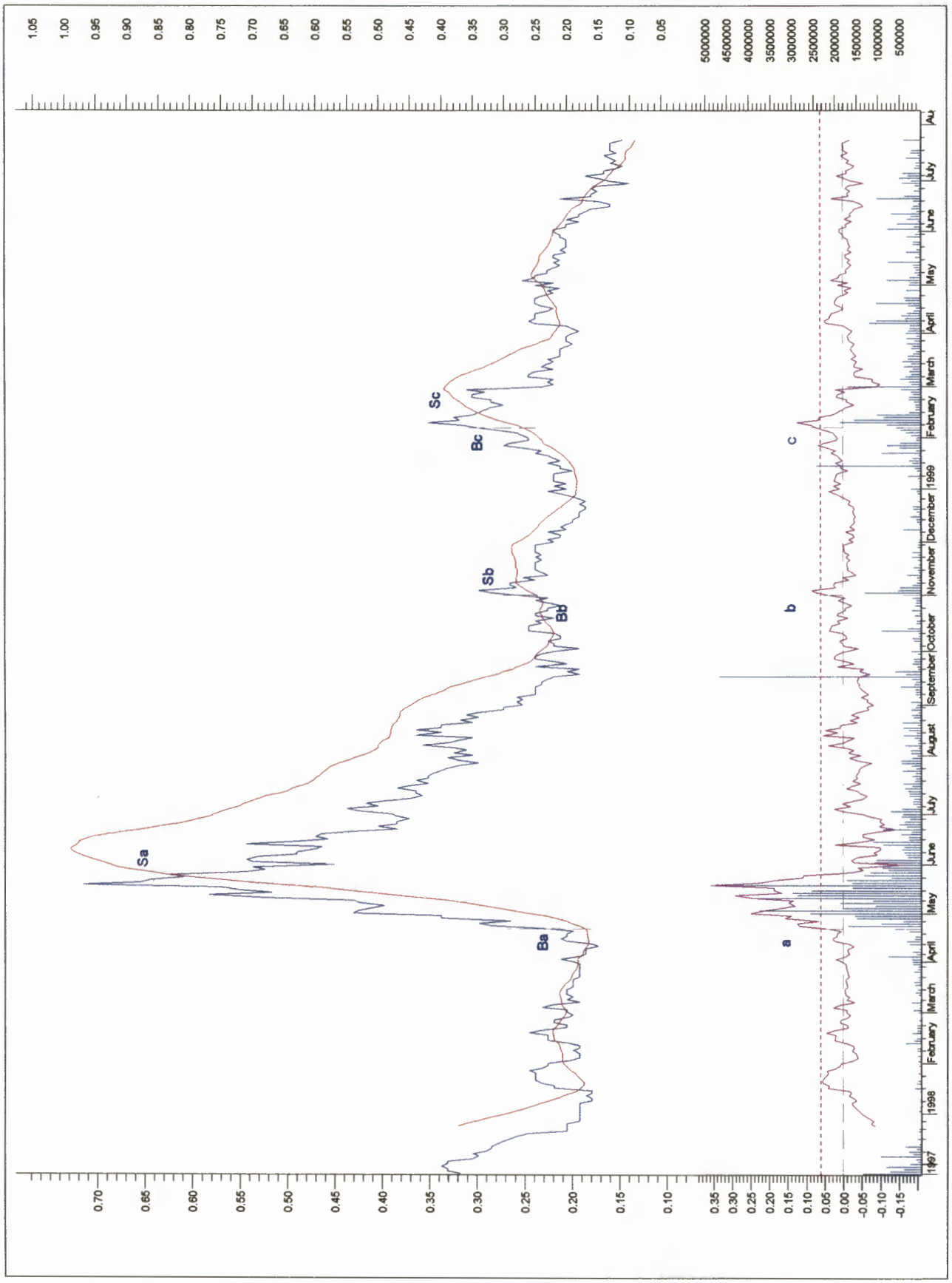


FIGURE B4 : ZENITH FINAL RESULT

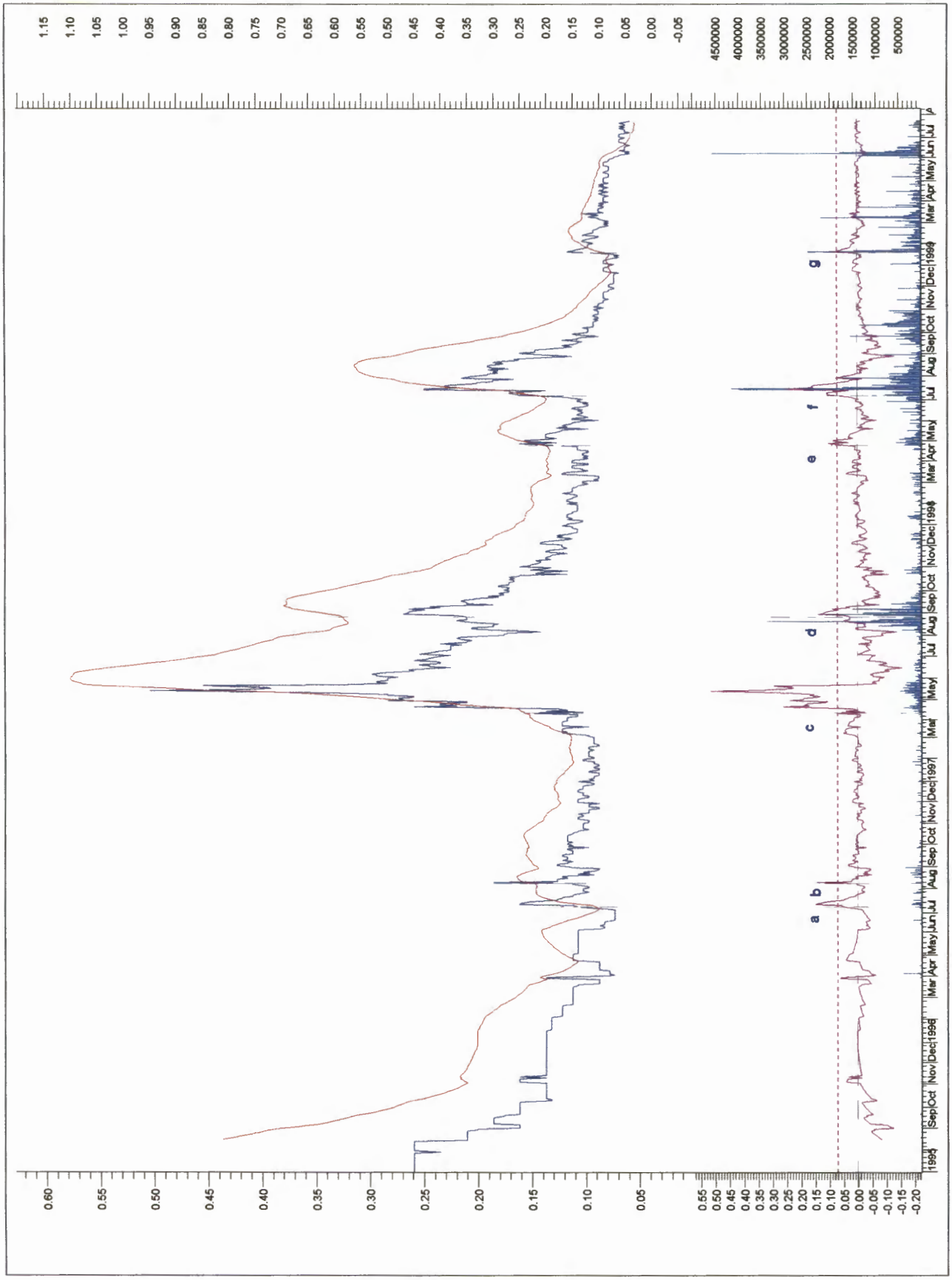


FIGURE B5 : GILBOA FINAL RESULT

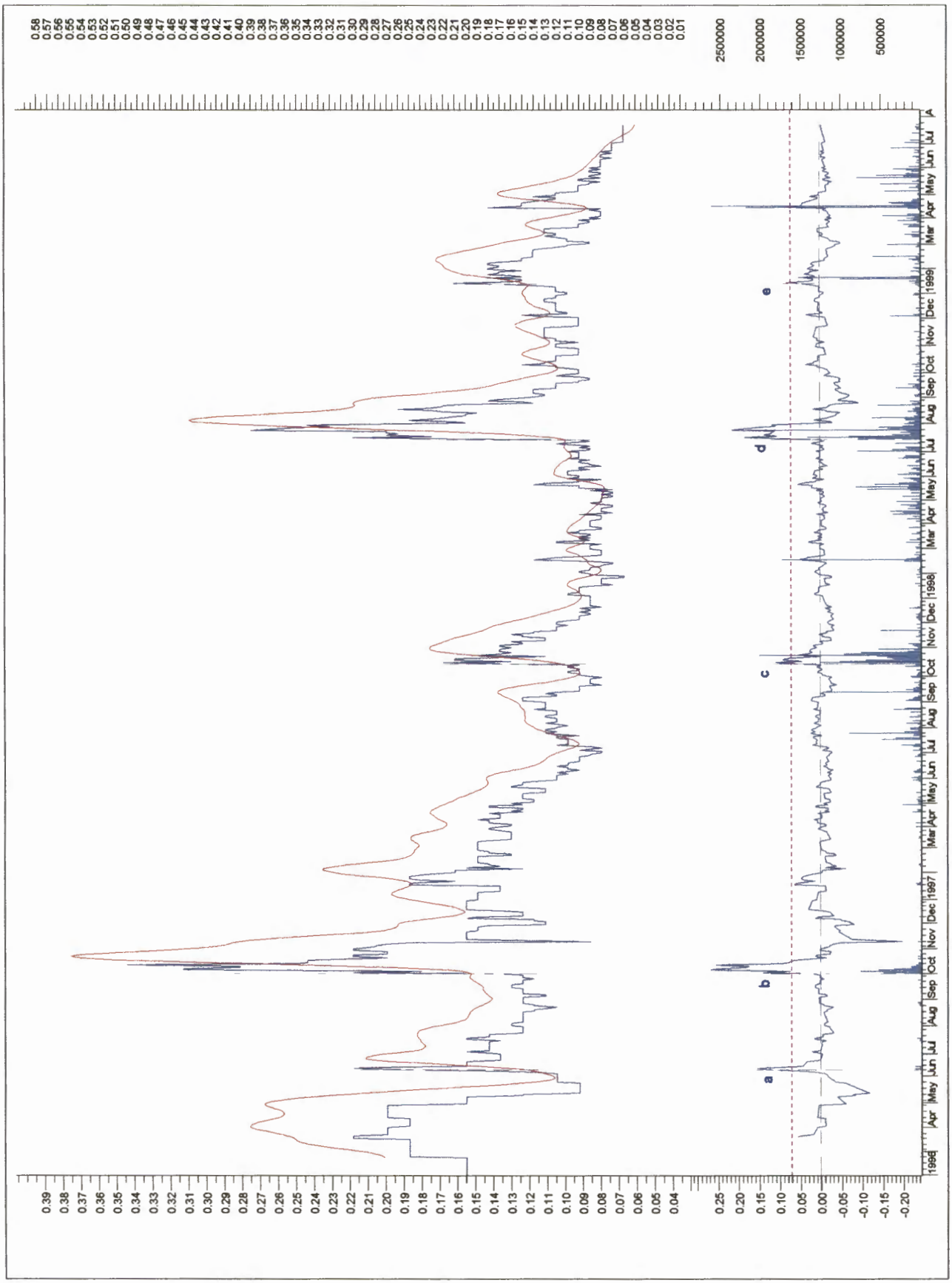


FIGURE B6 : EDATA FINAL RESULT

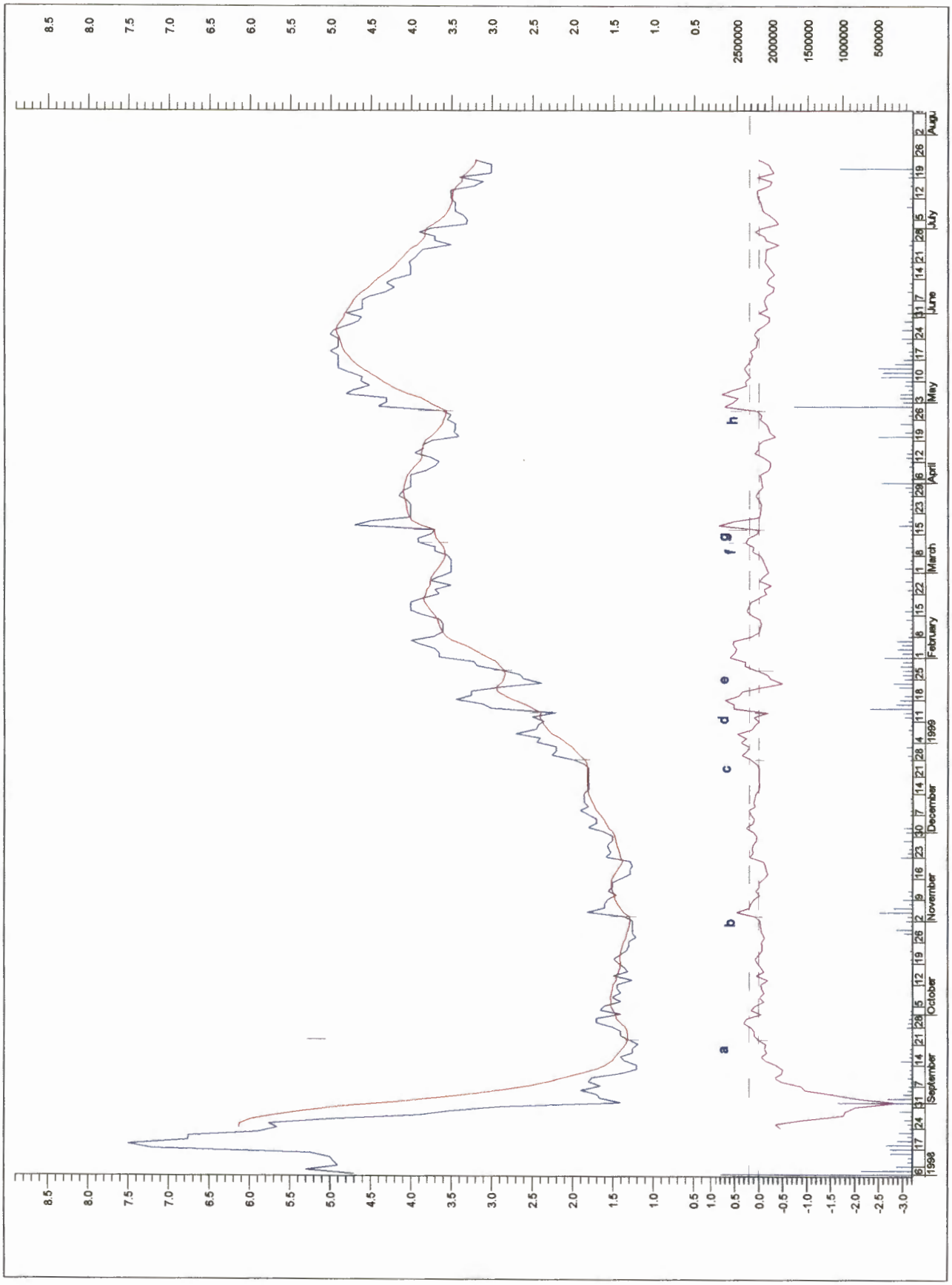


FIGURE B7 : PENNY FINAL RESULT

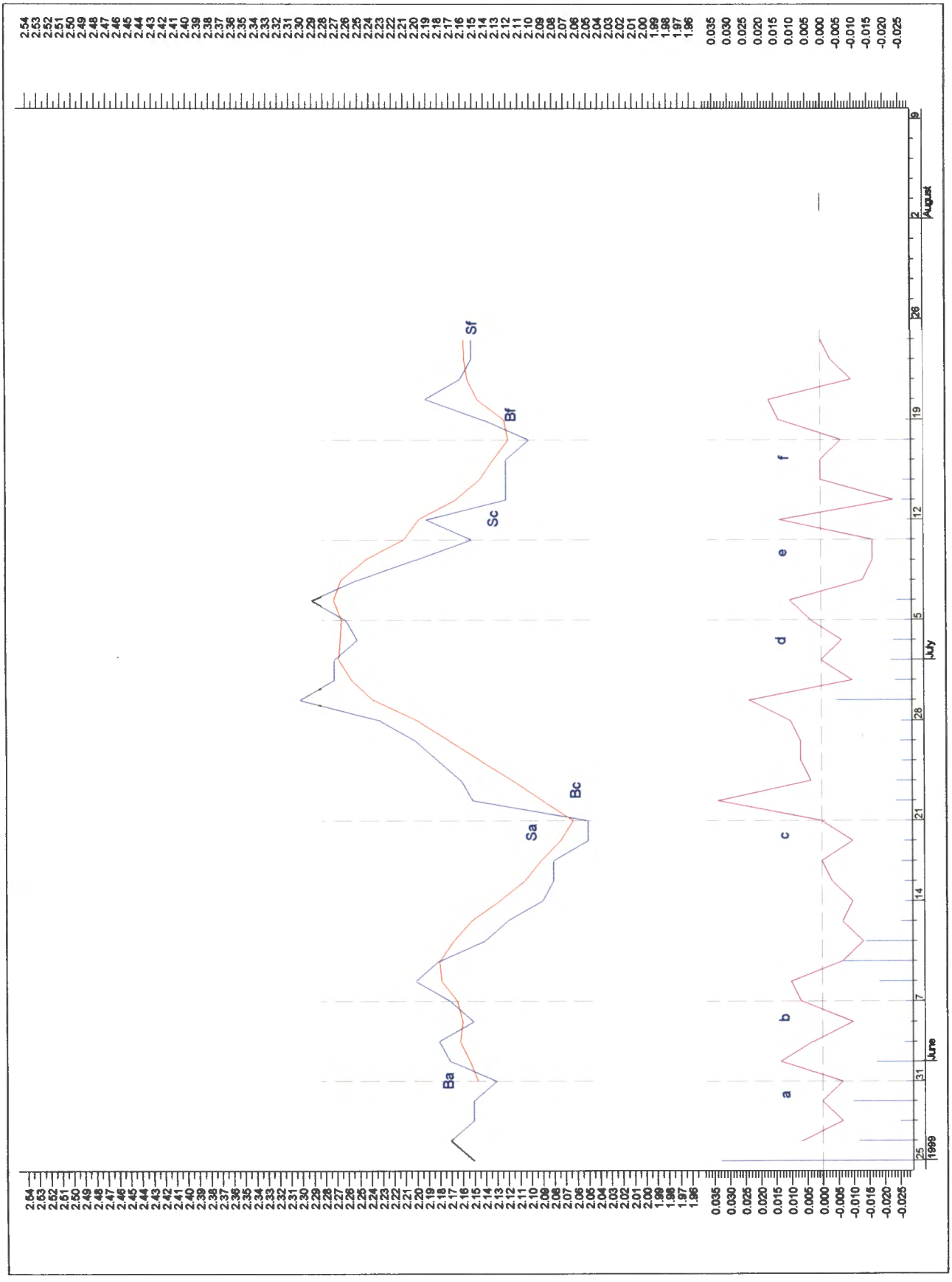


FIGURE B8 : BRYANT FINAL RESULT

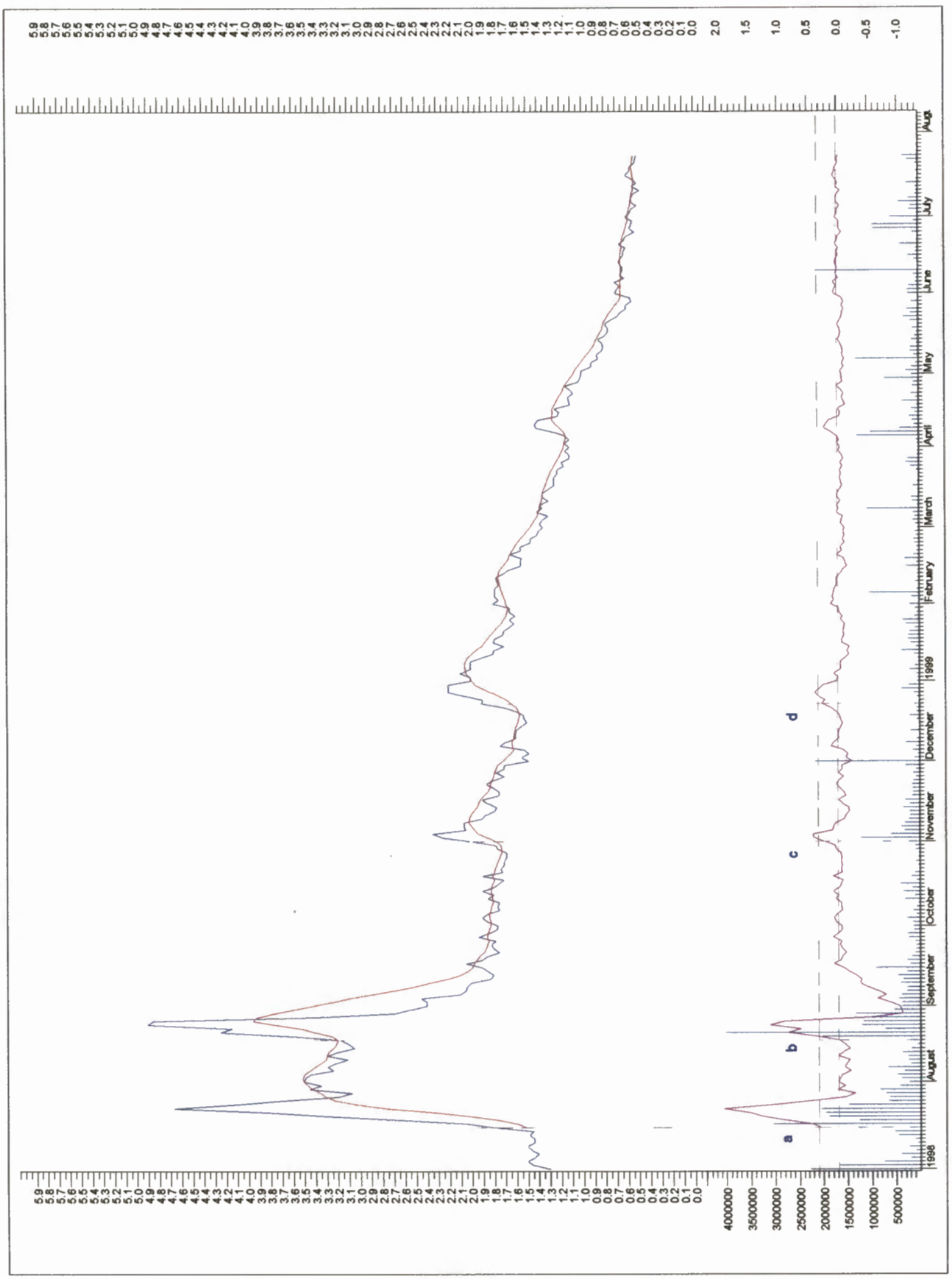


FIGURE B9 : LEGVEN FINAL RESULT

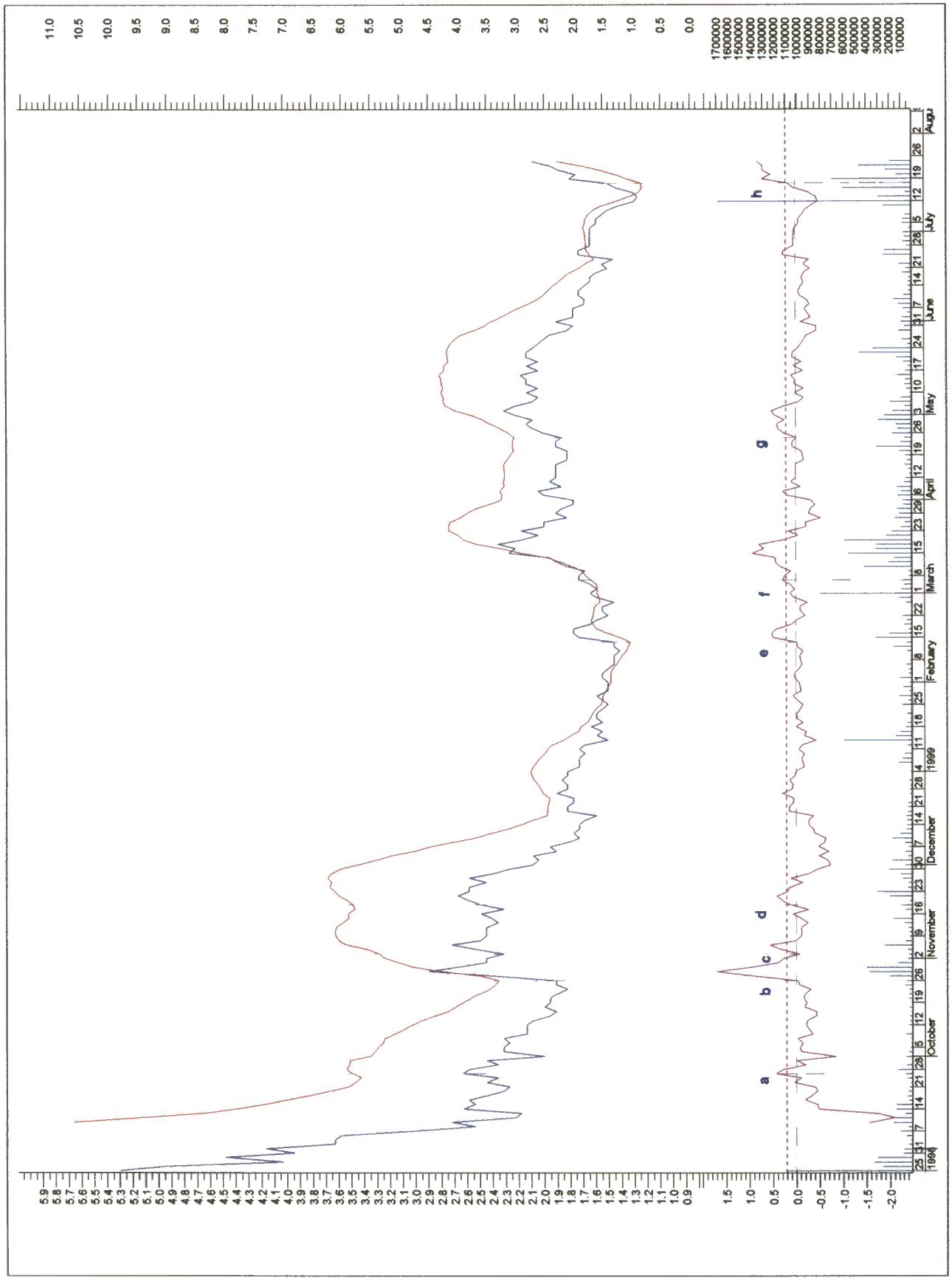
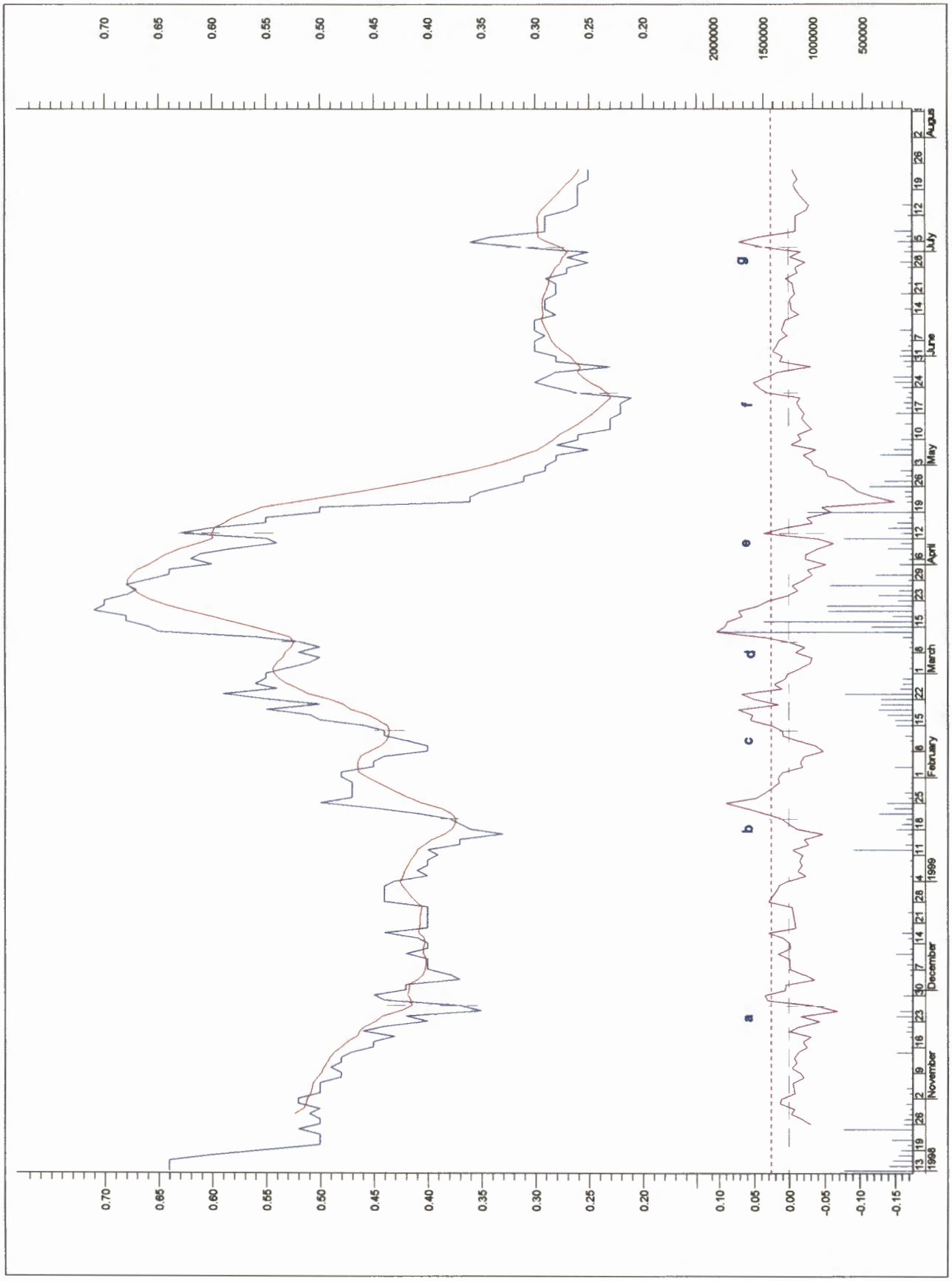


FIGURE B10 : PENTACOM FINAL RESULT



APPENDIX C

FREQUENCIES EXTRACTED

C1 Frequency Analysis

The following frequencies were extracted from the fast Fourier analysis. The asterisk (*) indicates the predominate frequency which shall be used in the analysis of the stock. The one day and seven day frequencies listed in Table C1 were ignored as these are functions of the sampling intervals used. The twenty day cycle proved to be the most predominate cycle and thus a ten day moving average was used in conjunction with the fast Fourier indicator to analyse the stock.

This process was repeated for all the stock contained in the sample and will not again be repeated in this Appendix. The frequencies extracted will be tabulated to highlight the most prominent frequencies, and the predominate cycle for each stock.

TABLE C1 : SECDATA FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.02453	40
0.04907 *	**20**
0.06134	14
0.01226	7
1.10022	1

TABLE C2 : APLITEC FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.01007	100
0.01511	66
0.04121 *	**24**
0.08222	12
0.14202	7

TABLE C3 : REFCORP FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.00980	102
0.01476	68
0.09607	50
0.02451 *	**40**
0.06372	15

TABLE C4 : ZENITH FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.00390	256
0.00170	85
0.01560 *	**64**
0.04195	24
0.05463	18

TABLE C5 : GILBOA FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.01052	95
0.01525	65
0.02584	38
0.04929	**20**
0.11384	8

TABLE C6 : EDATA FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.02083 *	**48**
0.03750	26
0.08333	12
0.13752	7
0.85416	1

TABLE C7 : PENNY FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.19047 *	**5**
0.76190	1

TABLE C8 : BRYANT FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.01879	53
0.03759	26
0.05263 *	**19**
0.09992	10

TABLE C9 : LEGVEN FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.02192 *	**45**
0.03071	32
0.07456	13
0.13157	7

TABLE C10 : PENTACOM FREQUENCIES

Frequency (Hz)	Cycle Length (Days)
0.02061	48
0.02577	39
0.03846 *	**26**
0.10309	10
0.13917	7

APPENDIX D

TABLES OF PERFORMANCE

The moving average *(red line on main graph)* was programmed with half the value of the predominate cycle as extracted from the FFT. A 5% bias was applied to the Fourier function and is displayed as the magenta dotted line in the bottom section of the graph. Point (a) is the first buy signal generated by the oscillator. The point is confirmed by the intersection between the moving average and share line at R1-60. Buy signals at (b) and (c) were ignored, since the share was still rising and the slight fall between (b) and (c) was not enough to trigger the stop loss strategy. After point (c) a high of R2-14 was achieved and the share then declined to below R1-99 which was the 7% stop loss level. The share was thus sold at the stop loss of R1-99. The next positive break-through on the oscillator occurred.

The buy strategy was applied every time positive break-through was witnessed on the Fourier indicator and the intersection between the moving average and the share was then used to confirm the decision. The sell strategy was constantly linked to the stop loss principal.

The investment amount was set as close to R10 000, depending on the number of shares (to the nearest hundred) that could be purchased for the amount. The amount was kept constant at the initial investment amount, and the profit/loss from the previous transaction was not considered for re-investment. For purposes of convenience, no transaction fees and taxation was brought into the equation. Table D1 reflects the results of the trading strategy.

TABLE D1 : SECDATA PERFORMANCE

Serial	**Buy (R)**	**Amount (R)**	**No Shares**	**Sell (R)**	**Amount (R)**	**Profit/Loss %**
Ba – Sa	1-55	9 920	6 400	1-95	12 480	25.81
Be – Se	1-95	9 945	5 100	1-99	10 149	2.05
Bf – Sf	1-59	9 858	6 200	1-64	10 168	3.14
Bg – Sg	1-35	9 990	7 400	1-48	10 952	9.63
Bh – Sh	1-55	9 920	6 400	1-86	11 904	20.0
		49 633			**55 653**	**12.13 %**

TABLE D2 : APLITEC PERFORMANCE

Serial	Buy (R)	Amount (R)	No Shares	Sell (R)	Amount (R)	Profit/Loss %
Ba – Sa	2-00	9 890	4 300	3-11	15 394	55.65
Bb – Sb	3-45	9 660	2 800	4-37	12 236	26.67
Bc – Sc	2-25	9 900	4 400	2-41	10 604	7.11
Bd – Sd	2-00	10 000	5 000	2-38	11 900	19.00
Be – Se	2-29	9 847	4 300	3-20	13 760	39.74
Bg – Sg	2-85	9 975	3 500	3-05	10 675	7.02
		59 272			**74 569**	**25.81 %**

The Fourier indicator crosses the bias line *(magenta dotted line)* at point (a) indicating a purchase signal. The projected stock price is R2-00 at point (Ba). The moving average indicator *(red line)* is unable to support the purchase signal given by the FFT indicator due to phase shift. The stock price continues to increase to a high of R2-80, then turns and declines. The investor now has to be cautious and waits for a sell signal when the stock price falls below the 7% stop loss level which is calculated at R2-60. The caution is emphasised by the FFT indicator which crosses the bias line signalling a sell. The stock bottoms out at R2-70 and again experiences upward momentum. It was thus not necessary to sell, as the decline was only 3.57% and well within the 7% stop loss and proves the strategy to be effective

The stock reaches a new high just before point (Sa) before declining again. A new stop loss is calculated based on the high of R3-34 and set at R3-11. When the stock declines through this level it is sold and the investor waits for the next upward crossing of the FFT indicator and the bias line. This occurs at point (b) and the process repeats itself.

This entire process is repeated for each of the stocks in the sample and shall not be repeated in this Appendix. Only the results of the analysis shall be tabulated to indicate individual stock profit or loss results.

TABLE D3 : REFCORP PERFORMANCE

Serial	Buy (R)	Amount (R)	No Shares	Sell (R)	Amount (R)	Profit/Loss %
Ba – Sa	0-23	9 982	43 400	0-88	38 192	282.61
Bb – Sb	0-28	9 996	35 700	0-33	11 781	17.86
Bc – Sc	0-34	9 996	29 400	0-34	9 996	0.00
		29 974			**59 969**	**100.07%**

TABLE D4 : ZENITH PERFORMANCE

Serial	Buy (R)	Amount (R)	No Shares	Sell (R)	Amount (R)	Profit/Loss %
Ba – Sa	0-07	9 996	142 800	0-14	19 992	100.00
Bb – Sb	0-11	9 999	90 900	0-17	15 453	54.54
Bc – Sc	0-10	10 000	100 000	0-47	47 000	370.00
Bd – Sd	0-22	9 988	45 400	0-24	10 896	9.09
Be – Se	0-11	9 999	90 900	0-15	13 635	36.36
Bf – Sf	0-11	9 999	90 900	0-23	20 906	109.08
Bg – Sg	0-07	9 996	142 800	0-09	12 852	28.57
		69 989			**140 734**	**101.08%**

TABLE D5 : GILBOA PERFORMANCE

Serial	Buy (R)	Amount (R)	No Shares	Sell (R)	Amount (R)	Profit/Loss %
Ba – Sa	0-12	9 996	83 300	0-20	16 660	66.67
Bb – Sb	0-12	9 996	83 300	0-32	26 656	166.67
Bc – Sc	0-09	9 999	111 100	0-16	17 776	77.78
Bd – Sd	0-11	9 999	90 900	0-25	22 725	127.27
Be – Se	0-12	9 996	83 300	0-15	12 495	25.00
		49 986			**96 312**	**92.68%**

TABLE D6 : EDATA PERFORMANCE

Serial	Buy (R)	Amount (R)	No Shares	Sell (R)	Amount (R)	Profit/Loss %
Ba – Sa	1-30	9 880	7 600	1-70	12 920	30.77
Bb – Sb	1-35	9 990	7 400	1-85	13 690	37.04
Bc – Sc	2-00	10 000	5 000	2-70	13 500	35.00
Bd – Sd	2-20	9 900	4 500	3-40	15 300	54.55
Be – Se	2-89	9 826	3 400	4-00	13 600	38.41
Bf – Sf	3-90	9 750	2 500	3-90	9 750	0.00
Bg – Sg	3-70	9 990	2 700	4-70	12 690	27.03
Bh – Sh	3-60	9 720	2 700	5-00	13 500	38.89
		79 056			**104 950**	**32.75 %**

TABLE D7 : PENNY PERFORMANCE

Serial	Buy (R)	Amount (R)	No Shares	Sell (R)	Amount (R)	Profit/Loss %
Ba – Sa	2-13	9 798	4 600	2-05	9 430	-3.76
Bc – Sc	2-05	9 840	4 800	2-14	10 272	4.39
Bf – Sf	2-10	9 870	4 700	2-15	10 105	2.38
		29 508			**29 807**	**1.01 %**

TABLE D8 : BRYANT PERFORMANCE

Serial	Buy (R)	Amount (R)	No Shares	Sell (R)	Amount (R)	Profit/Loss %
Ba – Sa	1-45	9 860	6 800	4-34	29 512	199.31
Bb – Sb	3-18	9 858	3 100	4-64	14 384	45.91
Bc – Sc	1-78	9 968	5 600	2-28	12 768	28.09
Bd – Sd	1-90	9 880	5 200	2-14	11 128	12.63
		39 566			**67 792**	**71.34%**

TABLE D9 : LEGVEN PERFORMANCE

Serial	Buy (R)	Amount (R)	No Shares	Sell (R)	Amount (R)	Profit/Loss %
Ba – Sa	3-90	9 750	2 500	3-63	9 075	(6.92)
Bb – Sb	2-30	9 890	4 300	4-19	18 017	82.17
Bc – Sc	3-20	9 920	3 100	3-81	11 811	19.06
Bd – Sd	3-60	9 720	2 700	3-72	10 044	3.33
Be – Se	1-30	9 880	7 600	1-58	12 008	21.54
Bf – Sf	1-70	9 860	5 800	2-23	12 934	31.18
Bg – Sg	1-90	9 880	5 200	2-14	11 128	12.63
Bh – Sh	1-50	9 900	6 600	2-10	13 860	40.00
		78 800			**98 877**	**25.48%**

TABLE D10 : PENTACOM PERFORMANCE

Serial	Buy (R)	Amount (R)	No Shares	Sell (R)	Amount (R)	Profit/Loss %
Ba – Sa	0-37	9 990	27 000	0-42	11 340	13.51
Bb – Sb	0-38	9 994	26 300	0-46	12 098	21.05
Bc – Sc	0-44	9 988	22 700	0-51	11 577	25.00
Bd – Sd	0-52	9 984	19 200	0-66	12 672	26.92
Be – Se	0-66	9 966	15 100	0-61	9 211	(7.58)
Bf – Sf	0-26	9 984	38 400	0-27	10 368	3.85
Bg – Sg	0-31	9 982	32 200	0-33	10 626	6.45
		69 888			**77 892**	**11.45%**

APPENDIX E

COMPANIES LISTED IN THE VENTURE CAPITAL SECTOR OF THE JSE

COMPANY	CODE
ALL JOY FOODS LTD	ALJ
NET 1 APPLIED TECHNOLOGY	APL
AROMA LIQUOR HLDGS LTD	ARM
BRAINWARE LTD	BRW
BRYANT TECHNOLOGY LTD	BRY
DECTRONIC LTD	DTR
E-DATA HOLDINGS LTD	EDT
ENTERPRISE OUTSOURCING H	EOH
GILBOA PROPERTIES LTD	GLB
INTEGRATED HEALTH TECHN	HLT
ITI TECHNOLOGY HLDGS LTD	ITI
JEM TECHNOLOGY HOLDINGS	JMH
LEGACY VENTURES LTD	LGV
MICROLOGIX LTD	MRX
MSI HOLDINGS LTD	MSH
MOULDED MEDICAL SUPPLIES	MUM
MAXTEL LTD -N-	MXN
MAXTEL LTD	MXT
PENTACOM HOLDINGS LTD	PNT
QALA GROUP LTD	QLA
RARE EARTH EXTRACTION CO	RCO

REF FIN & INVEST CORP LD	REF
SA MINERAL RESOURCES COR	SAM
SECUREDATA SOLUTIONS LTD	SDA
SKILLS ACCEL LTD	SKL
SOTTA SECURITISATION INT	SOT
TECHNOLOGY COMMUNICATION	TCM
TOP INFO TECHNOLOGY HLDG	TOT
VIKING INVST & ASSET MAN	VKG
VALUECOM HOLDINGS LTD	VLC
WORLD EDUCATIONAL TECHNO	WTC
WHETSTONE INDUS HLDGS LD	WTS
ZENITH CONCESSIONS ORD	ZNT
ZAPTRONIX LTD	ZPT

APPENDIX F

SECTOR LAYOUT OF JSE

Code	Sector Name	Note	Old Name
CI11	RESOURCES	NAME CHANGE	MINING PRODUCERS
CI10	MINING RESOURCES	NEW SECTOR	
IX02	COAL	NAME CHANGE	MINING – COAL
IX06	DIAMONDS	NAME CHANGE	MINING - DIAMONDS
IX14	GOLD	NAME CHANGE	MINING - GOLD - KLERKSDORP
IX24	PLATINUM	NAME CHANGE	MINING - METALS AND MINERALS - PLAT
IX28	METALS AND MINERALS	NAME CHANGE	MINING - METALS AND MINERALS - OTHER
IX32	MINING HOLDINGS, HOUSES	NAME CHANGE	MINING FINANCIAL - MINING HOUSES
IX35	MINING EXPLORATION	NAME CHANGE	MINING FIN - MINING EXPLORATION
IX04	JUNIOR MINING	NEW SECTOR	
IX19	CURTAILED OPERATIONS	NAME CHANGE	MINING - CURTAILED OPERATIONS
CI09	NON-MINING RESOURCES	NEW SECTOR	
IX56	CHEM, OILS AND PLASTICS	NAME CHANGE	IND - CHEMICALS, OILS & PLASTICS
IX73	PAPER	NAME CHANGE	INDUSTRIAL - PAPER
IX78	STEEL	NAME CHANGE	INDUSTRIAL - STEEL AND ALLIED
CI21	FINANCIAL & INDUSTRIAL		
CI24	FINANCIAL		
IX44	INVESTMENT TRUSTS	NAME CHANGE	FINANCIAL - INVESTMENT TRUSTS
IX39	PRIVATE EQUITY FUNDS	NEW SECTOR	
CI23	BANKS & FIN SERVICES	NEW SECTOR	
IX40	BANKS	NAME CHANGE	FINANCIAL - BANKS AND FIN SERVICES
IX41	FINANCIAL SERVICES	NEW SECTOR	
CI22	INSURANCE	NEW SECTOR	
IX42	LIFE ASSURANCE	NAME CHANGE	FINANCIAL - INSURANCE
IX43	SHORT TERM INSURANCE	NEW SECTOR	
CI27	INDUSTRIAL		

Code	Sector Name	Note	Old Name
IX54	BUILDING, CONST AND ENG	NAME CHANGE	INDUSTRIAL - BLDG, CONSTR & ALLIED
IX59	DEVELOPMENT STAGE	NAME CHANGE	INDUSTRIAL - DEVELOPMENT STAGE
IX50	DIVERSIFIED INDUSTRIAL	NAME CHANGE	INDUSTRIAL - INDUSTRIAL HOLDING
IX67	EDUCATION AND STAFFING	NEW SECTOR	
IX60	ELECTRONICS & ELECTRICAL	NAME CHANGE	INDUSTRIAL - ELECTRONICS & ELECTRICAL
IX74	HEALTHCARE	NAME CHANGE	INDUSTRIAL - PHAR AND MEDICAL
IX53	HOTELS AND LEISURE	NEW SECTOR	
IX61	INFORMATION TECHNOLOGY	NEW SECTOR	
IX69	MEDIA	NAME CHANGE	INDUSTRIAL - MEDIA
IX71	PACKAGING AND PRINTING	NAME CHANGE	INDUSTRIAL - PACKAGING AND PRINTING
IX51	SERVICE	NEW SECTOR	
IX63	TELECOMMUINICATIONS	NEW SECTOR	
IX86	TRANSPORT	NAME CHANGE	INDUSTRIAL - TRANSPORTATION
IX45	REDEVELOPMENT	NAME CHANGE	FINANCIAL - REDEVELOPMENT
CI26	INDUSTRIAL CONSUMER	NEW SECTOR	
IX52	BEVERAGES	NAME CHANGE	IND - BEVERAGES, HOTELS & LEISURE
IX58	CLOTHING AND TEXTILES	NAME CHANGE	IND-CLOTHING,FOOTWEAR & TEXTILES
IX66	FOOD	NAME CHANGE	INDUSTRIAL - FOOD
IX68	FURNITURE AND APPLIANCES	NAME CHANGE	INDUS - FURN, HOUSEHOLD & ALLIED
IX80	RETAIL	NAME CHANGE	INDUSTRIAL - STORES
CI70	REAL ESTATE	NEW SECTOR	
IX46	PROPERTY	NAME CHANGE	FINANCIAL - PROPERTY
IX49	PROPERTY LOAN STOCK	NAME CHANGE	FINANCIAL - PROPERTY LOAN STOCK
IX48	PROPERTY UNIT TRUSTS	NAME CHANGE	FINANCIAL - PROPERTY TRUST
IX87	CASH COMPANIES		
IX88	DEVELOPMENT CAPITAL		
IX89	VENTURE CAPITAL		
CI80	OTHER SECURITIES	NEW SECTOR	
IX90	DEBENTURES		
IX36	KRUGERRAND		
IX94	PREFERENCE	NAME CHANGE	PREFERENCE – INDUSTRIAL