A Cointegration Analysis of Investment and Uncertainty Factors:
South Africa, 1975 to 2005

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Abstract

Given that capital investment is critical in generating employment and in realizing social upliftment in South Africa, this paper examines survey data and hard economic data, arranged in time series spanning the period 1975 to 2005, in search of factors that may reflect or influence investor sentiment regarding the uncertainty of capital investment decision outcomes. It is then hypothesized that there are cointegrated relationships between investment, forecast investment, and these factors. The hypotheses are proved using the Johansen cointegration procedure to develop statistically significant econometric models which quantify the impact on investment, and on forecast investment, of factors reflecting or influencing domestic confidence, monetary policy and world sentiment.
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Glossary of Terms

ADF - Augmented Dickey-Fuller
ALSI - JSE All Share Index
AR(1) - Autoregressive Process of Order One
AUD - Australian Dollar
BCI - Business Confidence Index
BER - Bureau for Economic Research
BTOTE - Terms of Trade Index Excluding Gold
CAPM - Capital Asset Pricing Model
CPI - Consumer Price Index
DCF - Discounted Cash Flow
EINF - Inflation Rate – RSA
ER - Real Exchange Rate, e
FDI - Foreign Direct Investment
FSPI - S&P500 Index
I(1) - AR(1) process that can be rendered a Weakly Dependent I(0) process by differencing
IRR - Internal Rate of Return
JSE - JSE Securities Exchange South Africa
NGDFIA - Gross Fixed Capital Formation [constant] SAAR
NPV - Net Present Value
PMI - Purchasing Managers’ Index
RBAS - South African 90 Days Bankers Acceptance Rate
SAAR - South African Adjusted Rand adjusted to base year 2000
SAGB10 - RSA Government 10 Year Bond Yield
TOTVEH - Total Car and Commercial Vehicle Sales
USD - United States Dollar
USINF - Inflation Rate – USA
VAR - Vector Autoregressive
ZAR - South African Rand
1. Introduction to Area of Study

Capital investment decisions face uncertain outcomes. Therefore, organizations adopt a variety of strategies to minimize the risks of undesirable decision outcomes. Neoclassicist methods such as NPV, IRR and payback analysis require practitioners to commit to a number of assumptions underpinning likely scenarios outcomes. The Real Options and Monte Carlo frameworks further require practitioners to assign probabilities to various assumptions in order to determine a range of probable decision outcomes. However, these methods assume that practitioners have a degree of certainty as to the probability of various events occurring, thus converting the problem of analyzing uncertainty to one of analyzing systemic risk only. The inherent systemic risk is reflected in the required rate of return determined from the CAPM, which is used to determine probable outcomes of a capital investment decision.

However, practitioners also consider a wide variety of other strategic factors in deciding on investment, including the fact that they do not know all of the probable outcomes of a decision. The impact of factors reflecting or influencing investor sentiment regarding the uncertainty of decision outcomes is however seldom quantified in practice. A model quantifying the relationship between such factors and investment could be used by policymakers to determine changes that need to be effected in order to improve the investment climate.

In section 2, the problem of modeling investment and forecast investment is formally defined. Section 3 provides a review of literature on the topic of uncertainty of capital investment decision outcomes, on econometric models developed in the South African context, and on the motivation for and application of the Johansen procedure in econometric modeling. The relevance of the modeling problem is discussed in section 4, together with specific hypotheses to be tested during the modeling process. The methodology adopted in the modeling process is described in section 5, and the results generated by the process and from the testing of the hypotheses are presented in section 6. A number of conclusions drawn from the results are then discussed in section 7, together with some recommendations for future research.
2. Problem Statement

Four key problems are considered in this paper, namely:

1. The problem of identifying factors that may reflect or influence investor sentiment regarding the uncertainty of capital investment decision outcomes;
2. The problem of determining whether these factors are cointegrated with investment, and modeling any such cointegrating relationships;
3. The problem of determining whether these factors are cointegrated with forecast investment, and modeling any such cointegrating relationships;
4. The problem of interpreting the results obtained from the modeling exercises undertaken in terms of 2 and 3 above;

Data spanning the years 1975 to 2005 have been used, categorized as:

- **Survey Data**, meaning data that may have subjective content, such as the constitution and pricing of a basket of goods for the determination of the rate of inflation and the nature and interpretation of feedback received in constructing consumer or producer indexes.
- **Hard Data**, meaning data that is objective and reasonably easily measured, such as bond yields, sales figures, etc.
3. Literature Review

3.1. Uncertainty of Capital Investment Decision Outcomes

The review of literature on uncertainty is important in that it seeks evidence to suggest that there may be strategic factors that reflect or influence investor sentiment regarding the uncertainty of capital investment decision outcomes. This evidence is required to determine whether such sentiment influences investment, as opposed to the view that investment decisions are driven predominantly by findings generated using neo-classicist methods.

3.1.1. Definitions and Measures of Uncertainty and Risk

“Knight (1921) is commonly credited for initially highlighting the now commonplace distinction between risk and uncertainty. He defined risk as a situation where the probabilities attaching to a range of potential outcomes are known, ex ante. Uncertainty, on the other hand, was the situation where these probabilities are not known.”17 (Gilbert, 1999:139). Uncertainty in this framework is the result of the existence of stochastic processes which determine the actual outcome of the economic system. However, given that these processes are either fixed, or change in a predictable way, uncertainty, while aleatory, is thus still equivalent to risk, as defined by Knight (1921).”17 (Gilbert, 1999:141).

Given the problems of definition outlined above, further clarity was sought from literature. Donald Schon is quoted in the Harvard Business Review as saying that “Risk has its place in a calculus of probabilities”, whilst a “situation is uncertain when it requires action but resists and analysis of risks”18 (Schon, 1985:10). Also, “According to Choi (1993) uncertainty is not the result of a lack of information about the future. Rather it is the result of the inability of individuals adequately to perceive a system of underlying causal relationships (which he terms a paradigm) which, from the point of view of the decision maker, will determine the outcome of the situation under consideration. Individuals therefore feel uncertain not because of the lack of information about the future but rather because they do not know how to turn
the information they have into knowledge using a form or structure which will provide them with an adequate basis for action ... Choi defines four possible sources of uncertainty: complexity of calculation; inherent unpredictability of the future; the interdependence of human actions; and finally, the nature of the mental processes of (cognitively limited) individuals.”17 (Gilbert, 1999:159)

Furthermore, in developing measures of uncertainty, it will be important to understand those factors that influence uncertainty. It is therefore be useful to consider Rogers’ “processes by which people learn about risk and choose among real life prospects with associated uncertainties, risks and benefits”43 (Rogers, 1997:745). A study comparing the USA and Russian credit card markets argues that “when actors face uncertainty and are unable to calculate risk, they rely on trust”19 (Guseva, et al, 2001:623), which implies a learning process. The learning hypothesis is further supported when “Choi argues that individuals, like scientists, will actively seek a paradigm (or explanation) to use. This is what Choi defines as learning. Choi argues that the individual will first attempt to stretch existing paradigms so that they might fit the problem, failing which, they will act in an uncoordinated fashion. The success or failure of this approach is determined through a trial and error process, either mentally (if possible) or through the actual use of potentially successful paradigms in the making of decisions, that is, motivating action. When, or if, a successful outcome is achieved, the search (or learning) process ends. ... Choi’s approach suggests that imitation will be a common form of behaviour.”17 (Gilbert, 1999:162).

3.1.2. The Role of Uncertainty in Capital Investment Decisions

Required rates of return on actual capital investment projects generally exceed the required returns determined using the CAPM.23 (Jagannathan, Meier, 2002; Olsen, Troughton, 2000).

Jagannathan and Meier claim to “provide an answer to this puzzle”, by adopting a neo-classicist view explaining the phenomenon within the Real Options framework23 (Jagannathan, Meier, 2002:55). In order to better
understand the utility and limitations of the Real Options framework, the case study prepared by Meulbroek where an “analysis of how to incorporate price and quantity uncertainty risk into a compound real option problem”\(^{38}\) (Meulbroek, 2001:1) is instructive.

However, Olsen and Troughton explain the phenomenon by adopting a more paradigmatic approach to the question of uncertainty, where they claim that “Current equilibrium models, such as the capital asset pricing model, tend to underestimate required returns because they do not contain any provision for ambiguity.”\(^{40}\) (Olsen, Troughton, 2000:28-29).

Courtney et al argue that “executives take a binary view: either they underestimate uncertainty to come up with the forecasts required by their companies' planning or capital-budging processes, or they overestimate it, abandon all analysis, and go with their gut instinct”. In developing a decision making framework under uncertainty, they make a “distinction among four discrete levels of uncertainty that any company might face” suggesting “three basic types of actions: big bets, options, and no-regrets moves”\(^8\) (Courtney, et al, 1997:201). These four levels of uncertainty, namely “Level 1. Clear Enough Future”, “Level 2. Alternate Futures”, “Level 3. Range of Futures” and “Level 4. True Ambiguity” are reviewed by Klippenberger, together with the application of the Black-Scholes formula to Real Options\(^{35}\) (Klippenberger, 1998:20-22).

In a comprehensive study on a sample of 71 countries, it has been shown that “income inequality increases socio-political instability which in turn decreases investment”, partly “because socio-political instability increases uncertainty, thereby inducing investors to postpone projects, invest abroad (capital flights) or simply consume more”\(^1\) (Alesina, Perotti, 1996:1214). The combination of uncertainty and the level of investment has also been researched and it has been found that “firms reduce resource commitments in the face of growing uncertainty. In turn, reduction in resource commitments would favour non-FDI modes over FDI modes”\(^{13}\) (Erramilli, D’Souza,
Non-FDI modes would include measures such as exporting, contracting and licensing.

The impact of uncertainty on budgetary decisions made in the UK showed that also in the public sector “uncertainty is traceable to the effect of Central Government policies and the general economic conditions”21 (Ibrahim, 2003:Abstract).

The literature presented in Sections 3.1 and in this section has led to the exclusion of Neo-classicist approaches, such as NPV and Real Options in the analysis of capital budgeting decisions in the face of uncertainty because they can “only validly be used in the following idealised world: knowledge exists objectively; the outcomes of the economic system are determined by the operation of objective stochastic processes; and the specifications of these processes do not change unpredictably over time”17 (Gilbert, 1999:143). Instead, the paradigmatic/learning approach to the treatment of uncertainty in analyzing capital investment decisions in the context of uncertainty (as opposed to risk) is adopted in this thesis.

3.1.3. Other Views on Uncertainty

A key thread is that uncertainty can not be quantified using the traditional methods applied to the measurement of risk when contemplating projects – there is a parallel in the construction industry, where this phenomenon has been recognized by Dester and Blockley in their development of the MARIUN system when they discovered that “Extensive research has demonstrated that few failures develop totally ‘out of the blue’ – there are always signs if we know how to look for them.”10 (Dester, Blockley, 2003:83).

Uncertainty is generally referred to in a negative context, constraining capital investment, but indeed it also needs to be pointed out that “profit potential of projects is inversely related to degree of certainty”29 (Johs, et al, 2004:134) – whilst measures of uncertainty should therefore also be viewed in this context, with strategies, particularly in the investment project design phase, being devised to capitalize on such potential.
3.1.4. Relationship between Uncertainty and Capital Investment Decisions

In determining the relationship between uncertainty and capital investment decisions, Gilbert has suggested that “Possible reasons for the changes in (previously) consistent behaviour must be proposed to allow for this hypothesis to be tested (and thus falsified). An adequate econometric analysis would require the building of econometric models of investment expenditure at the macroeconomic level that could then be adjusted to test for the influence of the structural uncertainty and strategic importance concepts. This would also require the definition and construction of time series of proxies for these variables.”17 (Gilbert, 1999:194-195). Indeed, this thesis aims to perform part of the research suggested by Gilbert.

Eugene Fama introduced the EMH (“Efficient Market Hypothesis”)3 (Ball, 1995:6) in 1965. In this context, the EMH implies that as soon as new information is available which increases or decreases the level of “structural uncertainty” associated with a country’s investment climate, markets will react and expected returns will be traded to levels that reflect new level of risk perceived by the market within the changed conditions of “structural uncertainty”.

In a study by Du Plessis and Gilbert, survey data responses and risk premia are identified as two potential proxies for uncertainty. With respect to risk premia, they argue that the premia measure uncertainty “by the size of the difference in expected return for financial instruments with different maturities. Long dated instruments are more exposed to changes in value due to changes in discount rates and thus holders of these instruments would expect a premium to hold them in the face of this risk. For a given inflation rate expectation, the size of the premium is positively related to the expected variability of the interest rate in the economy. The accuracy of this measure thus depends on the nature (and consistency) of the relationship between the interest rate and other sources of uncertainty (e.g. macroeconomic volatility). Moreover, while it is a market determined variable, it assumes that the uncertainty associated with the expectations set reflected in the size of the
premium (i.e. the bond traders) is the same as that of the decision makers at the firm level”\(^{11}\) (Du Plessis, Gilbert, 2005:8).

The arguments of Gilbert, Fama and Du Plessis imply that survey data and market determined variables in general could be examined for factors that may reflect or influence investor sentiment regarding the uncertainty of capital investment decision outcomes.

3.2. **Econometric Models Developed in the South African Context**

3.2.1. **The South African Economy**

In recent times, the South African economy has rallied, with growth accelerating since mid-2003. The success of the economy has been attributed largely to “very conservative fiscal policy” coupled with good monetary policy on the part of the government, which has resulted in unexpectedly high growth and unexpected move to “permanently much lower inflation”\(^{30}\) (Kantor, Marcetti, 2004:2-3). The total South African risk premium, reflected by the “difference in yields on the SA R153 and 10-year US Treasury Bonds”, have also reduced steadily since 1990\(^{32}\) (Kantor, Marchetti, 2005:9,10), reflecting a steady reduction in the risks of investment in South Africa. In addition, the US and emerging market economies have rallied, as have commodity prices, in a low interest rate environment, all of which have had a positive influence on the South African economy.

One explanation for the low interest rates is “that several factors have spurred an excess of global saving over planned investment, such as rising incomes in countries with high savings rates, the desire by aging citizens of many industrialized countries to save for retirement, and apparently diminished investment prospects in many industrialized and developing economies”\(^{18}\) (Greenspan, 2005:19) – the so-called “savings glut”\(^{5}\) (Bernanke, 2005:1).

3.2.2. **Econometric Models**

Explanations for the behavior of the South African economy have been given by a number of economists, who have developed a myriad of econometric models. Some work done by Kantor, Gerson and Marchetti is briefly
reviewed to outline the context within which econometric models have been
developed to explain certain South African economic variables.

Most models considered attempt to explain the JSE and the ZAR/USD rate of
exchange. Less emphasis has been placed on modeling investment, which
also cannot easily be related to work done on the JSE because the JSE is “not
representative”\textsuperscript{31} (Kantor, Marchetti, 2004:6) of the South African economy in
general because of:
- the bias of the JSE towards the resource sector;
- the fact that an important part of companies listed are dependent on
  investments made in other countries;
- the fact that substantial subsidiaries of multinational companies
  operating in South Africa are not listed on the JSE.

Barr and Kantor have shown that “prices and earnings on the JSE are not
cointegrated, which is a consistent with similar results obtained for the New
York Stock Exchange”\textsuperscript{4} (Barr, Kantor, 1999:1). In their study, they went on to
show that when “the influence of world markets and political and exchange
rate risk”\textsuperscript{4} (Barr, Kantor, 1999:1) are added, a cointegrated relationship is
found with the Industrial and Financial Index of the JSE. The ADF
(Augmented Dickey Fuller) and Engle Granger tests were used to test for the
existence of cointegrated relationships, and the Engle Granger procedure was
used to construct error correction models in the formulation of the relationship
between the variables (more discussion on cointegration, ADF and Engle
Granger tests and procedures follows in sections 3.3.2 and 3.3.3).

Kantor and Marcetti hypothesize that what “is good news for the US economy
is good news for the world economy and even better news for emerging
markets and vice versa”, and they also “compared the JSE to the emerging
market index and the S&P500 in US$” where they found that
“outperformance by emerging markets has been highly conspicuous” and the
“JSE has proved itself a well above average emerging market”\textsuperscript{32} (Kantor,
Marcetti, 2005:2). Using an OLS regression model, they concluded that for
“every 1% move in the emerging market index the JSE can be expected to lose or gain about half as much” (Kantor, Marcetti, 2005:4).

Followers of Gerson benefited during the ZAR crash by trusting his econometric model that used PPP between USA and South Africa and the strength of the AUD to predict the equilibrium ZAR/USD value (Gerson, 2004).

3.3. Motivation For and the Application Of the Johansen Procedure

Modeling relationships between time series data of explained variables $y_t$ and explanatory variables $z_t$ can be done using multiple regression (Keller, Warrack, 2003:657). “However, we must be careful to allow for the fact that unobserved, trending factors that affect $y_t$ might also be correlated with the explanatory variables. If we ignore this possibility, we may find a spurious relationship between $y_t$ and one or more explanatory variables” (Wooldridge, 2003:347). “Stochastic trends can lead two time series to appear related when they are not, a problem called spurious regression” (Stock, Watson, 2003:461). In some cases, spurious regression problems can be addressed by adding a time trend to the regression problem. However, time series that have “substantial temporal correlation require special attention in regression analysis” (Wooldridge, 2003:360).

The problems raised call for the development of econometric models that are able to model the dynamic relationships between variables and detect and adapt to changes in underlying relationships between variables. These requirements are very similar to those expected of models describing relationships between physical process variables in the process control and automation industry. A review of this issue specifically is given in an article by David Kendrick (Department of Economics, University of Texas) in the Journal of Economic Dynamics & Control where he reviews progress since a meeting held in 1972 between a group of economists and engineers at Princeton University. “The meeting which was attended by about 40 economists and 20 engineers was to explore the possibility that the application of stochastic control techniques, which
had been developed in engineering, would prove to be useful in economics as well
(Kendrick, 2005:3).

A summary paper on dynamic adaptive modeling and the interaction between economists and engineers is contained in Appendix C – however, more emphasis will be placed in this literature review on work done using conventional econometric modeling techniques.

3.3.1. Serial Correlation and Autoregressive Processes

A time series where $x_t$ depends also on $x_{t-1}$ (the variable for the previous case in time) is known as “an autoregressive process of order one [AR(1)]” (Wooldridge, 2003:363). Given the presence of such serial correlation, “many economic time series are better characterized by the AR(1) model”, and in particular, as “unit root processes”. A popular “test for AR(1) serial correlation is the Durbin-Watson test”. The absence of serial correlation is also a precondition for Engle’s test for “autoregressive conditional heteroskedasticity (ARCH)” (Wooldridge, 2003:372, 374, 397, 416).

3.3.2. Unit Root Tests, Cointegration and the VECM

AR(1) processes that can be rendered weakly dependent I(0) processes by differencing are known as I(1) processes, in which case regression can meaningfully be undertaken on the resultant I(0) process. I(1) processes can be identified using the ADF “augmented Dickey-Fuller test” (Wooldridge, 2003:610) to identify unit roots using the following three equations:

\[
\begin{align*}
\Delta y_t &= a_1 y_{t-1} + \sum_{j=1}^{p} y_j \Delta y_{t-j} + \epsilon \\
\Delta y_t &= a_0 + a_1 y_{t-1} + \sum_{j=1}^{p} y_j \Delta y_{t-j} + \epsilon \\
\Delta y_t &= a_0 + a_1 y_{t-1} + a_2 t + \sum_{j=1}^{p} y_j \Delta y_{t-j} + \epsilon
\end{align*}
\]

“Equation E 1 is the “no constant, no trend” case; Equation E 2 is the “constant, no trend” case; and Equation E 3 is the “constant and trend” case. If the test statistic is less than the corresponding critical value (in absolute
terms), the null hypothesis of a unit root in the original time series is not rejected”\(^\text{14}\) (Ganegodage, Taniguchi, Wang, 2005).

Whilst differencing I(1) processes identified in this manner can be done to construct I(0) processes for regression, differencing reduces the usefulness of a resultant regression model. In some cases however, linear combinations of I(1) processes can yield an I(0) process, in which case the processes are said to be cointegrated, and the “notion of cointegration” makes “regressions involving I(1) variables potentially meaningful”\(^\text{48}\) (Wooldridge, 2003:615).

Stationary and non-stationary variables identified from unit root tests can then be classified as I(0) and I(1) respectively for use in the VECM (Vector Error Correction Model) of a nonstationary vector autoregression process to describe “the vector time series \(Z_t\) with an error correction representation that can be expressed as follows:

\[
DZ_t = \sum_{i=1}^{p-1} G_i DZ_{t-i} + PZ_{t-p} + D_t + m_t + \mu_t + e_t \quad \text{E 4}
\]

where; \(G_i = -I + P_1 + P_2 + \ldots + P_i\); \(i = 1, 2, 3, \ldots, p-1\); and \(P = \alpha\beta'\). \(Z\) is an n by 1 vector of I(1) potentially endogenous variables; and \(DZ\) is the first-difference vector. The first term on the right-hand side, i.e. \(\sum_{i=1}^{p-1} G_i DZ_{t-i}\), is the first-difference VAR term, where \(G\) is the n by n matrix of estimated coefficients; and \(p\) is the order of VAR. This term captures how current changes depend on previous changes in vector \(Z\).

The second term on the right-hand side, i.e. \(PZ_{t-p}\), represents possible cointegration relations between variables in vector \(Z\). The coefficient matrix \(P\) can be decomposed further into the product of two matrices, denoted by \(\alpha\beta'\), where \(\alpha\) and \(\beta\) are k by r matrices of adjustment coefficients; \(\alpha\) is the vector of speed of adjustment parameters that accounts for adjusting the deviation to the long-run equilibrium; and \(\beta\) is the normalized coefficient vector, i.e. the cointegrating vector, which indicates the long-run relationship.
D is an n by 1 vector of I(0) exogenous dummy variables; \( m_t \) stands for I(0) exogenous variables; and \( \mu \) is an n by 1 vector of constant terms. Finally, e is an n by 1 vector of white noise\(^{14}\) (Ganegodage, Taniguchi, Wang, 2005).

3.3.3. Estimating Procedures for the VECM

Two procedures are generally used to test and estimate the VECM, namely the Engle and Granger residual-based approach and the Johansen procedure.

The Engle and Granger procedure has the drawback of relying on the results of the first long-run equation estimation, which if incorrect, impacts negatively on the results of subsequent ECM estimations\(^{14}\) (Ganegodage, Taniguchi, Wang, 2005).

The Johansen procedure is generally accepted as being more accurate, and was described by Johansen as follows:

“We consider a nonstationary vector autoregressive process which is integrated of order 1, and generated by i.i.d. Gaussian errors. We then derive the maximum likelihood estimator of the space of cointegration vectors and the likelihood ratio test of the hypothesis that it has a given number of dimensions. Further we test linear hypotheses about the cointegration vectors. The asymptotic distribution of these test statistics are found and the first is described by a natural multivariate version of the usual test for unit root in an autoregressive process, and the other is a \( \chi^2 \) test\(^{25}\) (Johansen, 1988:231).

After using unit root tests to confirm that each series is a I(1) process, Johansen maximum likelihood procedures are used to test for cointegration and to estimate error correction parameters. The technical aspects of the Johansen procedure are described in detail in an annexure to the paper by Ganegodage, Taniguchi, and Wang\(^{14}\) (Ganegodage, Taniguchi, Wang, 2005).

The long-term effects of the variables in question can be represented by the estimated cointegration vector, \( \beta \); however, the impulse response functions have to be relied on to reveal the short-term dynamics. The pair-wise response dynamics between these variables can be plotted with the estimated coefficient
matrices and the error variance-covariance matrix. ... In summary, the estimated cointegration vector will answer the question of the long-term relation, while the plotted impulse response functions will answer the question of the short-term dynamics. Impulse response functions reveal the short-run dynamics. These functions show the responses to Cholesky one standard deviation (SD) innovations to the variables in question.14 (Ganegodage, Taniguchi, Wang, 2005).

Work by Johansen has continued, and includes work on rational expectations27 (Johansen, Swensen, 1999:73), on the development of small sample correction factors for small samples 24 (Johansen, 2002:195), as well as on an extension of the procedure to cater for I(2) processes26 (Johansen, 2005:1).

3.3.4. Applications of the Johansen Procedure

There have been many applications of the Johansen procedure to econometric modeling.

In a study of international gas market integration, the procedure has shown “evidence of cointegration within the European/Japanese and the North American markets, as well as the absence of integration between the two groups of markets. This result converges with the conventional wisdom that gas markets were not integrated across continents, and in particular the divide between the European and the North American natural gas markets during the 1990s”45 (Siliverstovska, et al, 2005:614).

An interesting study linking sentiment to econometric data in the United States showed that “forward rates and expected future rates are cointegrated” 39 (Nourzad, Grennier, 1995:291), which is relevant to this study on factors that may reflect or influence investor sentiment regarding the uncertainty of capital investment decision outcomes.

In a further study applying the Johansen procedure to the Greek economy, it was concluded that “despite the exchange rate regime, a long-run equilibrium relationship exists among output, money, the trade balance and price”41
(Papadopoulos, Papanikos, 2002:114). In further studies on exchange rates, the Johansen technique was used to “estimate cointegration in a monetary exchange rate model modified for real exchange rate fluctuations and applied to seven inflationary OECD countries”³⁹ (Cushman, Lee, Thorgeirsson, 2002:337) and to model the impact of capital controls in Malaysia²⁰ (Ibrabim, 2004:1).

The Johansen procedure has also been applied to dealing with problems related to “seasonal cointegration”³⁶ (Lee, Siklos, 1995:137), ²⁸ (Johansen, Schaumburg, 1999:301).

Highly relevant to this study is a study by Du Plessis and Gilbert, which uses the Johansen procedure in developing a model “to investigate the co-movements of aggregate private investment expenditure in South Africa with a range of potentially explanatory factors”¹¹ (Du Plessis, Gilbert, 2005:1).
4. Problem Relevance, Hypotheses and Details

4.1. Problem Relevance

In his article “An overview of the South African economy”, Stephen Gelb reported that a “lack of (fixed) investor confidence has also been influenced by uncertainty regarding other factors of a longer-run nature. In the National Enterprise Survey of 1 400 firms carried out for the Office of the President in 1999-2000, firms identified a number of individual factors – labour regulations, the tax regime, crime and social policy, uncertainty over economic policy and infrastructure – as investment constraints”¹⁵ (Gelb, 2004:385). In the same article, investment as a percentage of GDP is reported to have declined from a high of about 27% in 1982 to a level of around 15% during the period 1994 through 2003.

At the same time, the “average rate of growth between 1994 and 2003 was in fact 2.77 per cent per annum, but since population growth averaged 2 per cent, the annual per capita increase was barely positive at 0.77 per cent per annum”¹⁵ (Gelb, 2005:367). Although recent projections point to GDP growth increasing from 2.77 to around 6 per cent, South Africa has (not surprisingly) been unable to redress the rising level of unemployment, which has risen steadily from 28.6% to 41.8% between 1994 and 2002² (Altman, 2004:245), although a slight improvement for 2005 was reported the Business Day in July 2005. Also, “with a Gini coefficient ranging between 0.58 to 0.68, South Africa remains one of the world’s most inequitable societies”⁴² (Roberts, 2005:495).

Investment is the engine of growth and employment, so it is therefore of critical importance to attempt to determine, measure and then model the “uncertainty” referred to in Gelb’s article that are acting as “investment constraints”. A model of such constraining uncertainties would be useful in focusing the attention of policymakers on the issues that need to be addressed in order to encourage investment.
4.2. Hypotheses

4.2.1. Hyp1:
Investment can be derived from Survey Data & Hard Data

A time series econometric model can be derived to relate NGDFIA (Gross Fixed Capital Formation – South African Adjusted Rand) as a proxy for Investment, to explanatory variables drawn from a combination of a set of Survey Data and Hard Data relevant to that particular time.

4.2.2. Hyp2:
Forecast Investment can be derived from Survey Data & Hard Data

A time series econometric model can be derived to relate NGDFIA (Gross Fixed Capital Formation – South African Adjusted Rand) figures, advanced in time as a proxy for Forecast Investment, to explanatory variables drawn from a combination of a set of Survey Data and Hard Data relevant to that particular time.

4.3. Definitions, Assumptions and Limitations

4.3.1. Definitions and Assumptions

The following definitions were used:

1. As indicated in Section 3.1.2, the paradigmatic/learning definition of uncertainty will be assumed in this thesis in the analysis of the impact of uncertainty in the context of the capital budgeting decision.

2. “Survey Data” data that may have subjective content, such as the constitution and pricing of a basket of goods for the determination of the rate of inflation and the nature and interpretation of feedback received in constructing consumer or producer indexes;

3. “Hard Data” data that is objective and reasonably easily measures, such as bond yields, sales figures, etc.

The following assumptions were made:

4. The “Hard Data” measure from the national accounts of NGDFIA (Gross Fixed Capital Formation – South African Adjusted Rand) was assumed as a reasonable proxy for Investment at a given time, given
that the measure is the aggregate outcome of capital project investments across the entire economy.

5. The “Hard Data” measure from the national accounts of NGDFIA (Gross Fixed Capital Formation – South African Adjusted Rand), advanced in time, was assumed as a reasonable proxy for Forecast Investment (a perfect estimate of Investment as defined in 4 above, given the benefits of perfect hindsight).

4.3.2. Limitations

The following limitations are acknowledged:

1. The testing of hypotheses 1 and 2 will be limited to the study of capital investment decisions in South Africa over the period 1975 to 2005, as represented by the NGDFIA.

2. Data analyzed was restricted to quarterly data, which limited the number of parameters available for the modeling process.
5. Research Methodology

5.1. Questionnaires Guiding the Research (not for statistical purposes)
In order to guide the research, the questionnaires in Appendix A were used in structured interviews with the following four major financial institutions involved in capital projects in South Africa, i.e.:

- Standard Corporate and Investment Banking  
  (Mr Greg Ansermino, Director)
- Investec Treasury & Specialised Finance  
  (Mr Michael Meeser, Project & Infrastructure Finance)
- Southern African Development Bank  
  (Mr Leon Cornelius, Senior Investment Officer)
- Industrial Development Corporation  
  (Mr. Isaac Leimecke, Senior Project Manager)

A further structured interview was also conducted with Mr Gareth Huckle of the Monitor Group, a consulting firm providing a range of advisory services, including capital project investment appraisal services.

An important factor in conducting the research was the choice of relevant survey data and hard data – a significant part of the questionnaire was dedicated to this factor.

5.2. Data Choice
Using the information deemed relevant from the literature review outlined in section 3, as well as that gathered from the questionnaires indicated in 5.1, relevant data (survey data as well as hard data) was obtained from INET reported for the period 1975 to 2005.

5.3. Data Collection and Conditioning
INET Monthly data was collected where available, as well as quarterly data in the case where monthly data was not available. Monthly data was then converted to
quarterly data in order to create a master database of quarterly data, whilst maintaining a monthly database for further research.

5.4. **Exploratory Factor Analysis**

A factor analysis was run on the master database in order to determine any common factors which appear statistically to explain part of the variation in the quarterly cases of the variables.

Factor loadings were examined for the variable NGDFIA and for variable NGDFIA advanced for 3, 6, .. 21, 24 months respectively.

Where the absolute magnitude of factor loadings for the variable NGDFIA were greater than 0.1, the factors were considered to have significance with respect to **Investment**. Where the absolute magnitude of factor loadings changed for advancing NGDFIA, the factors were considered to be of significance with respect to the **Forecast Investment**.

5.5. **Choice of Data for Model**

In choosing variables for the model, the loading of factors significant to the **Investment**, the dependent variable of the model, were examined more closely.

For the significant factors, variables (representing *survey data* and *hard data*) with high factor loadings were chosen for consideration to represent the respective factors as independent variables in the models. Within this subset of variables, the following variables were excluded:

1. Other national accounting variables arithmetically linked to NGDFIA;
2. Variables for which data was not available for the entire duration of the study (i.e. 1975 to 2005). Variables excluded on this basis are generally more recently introduced variables, and should be considered for future model building.

5.6. **Exploratory Time Trend Analysis**

Variables identified using the process outlined 5.5 were used in the exploratory analysis. Time trends of a selection of the variables were plotted together with
NGDFIA and NGDFIA – ADVANCED 12 MONTHS in an attempt to detect relationships between the variables Investment and Forecast Investment.

5.7. Testing Hypotheses 1 and 2

5.7.1. Exploratory Regression Modeling of Forecast Investment

OLS regressions were then run on all of variables identified using the process outlined 5.5, including a time variable to allow the model to compensate for the time trending problem discussed in section 3.3. The results of the regression were examined for consistency with the observed time trends, and tested for statistic significance by examination of:

- adjusted R2 statistics to test the degree to which movements in the explained variable are explained by the explanatory variables;
- F-statistics and t-statistics to test the significance of the overall model and individual explanatory variables;
- Durbin-Watson statistics to test serial correlation (see section 3.3.1);
- Normality of distribution of raw residuals;
- Scatter plot of predicted vs residual scores, and a
- Listing of outliers.

5.7.2. Rigorous Modeling of Investment and Forecast Investment

Given the problems associated with serial correlation and autoregressive processes described in 3.3.1, the rigorous modeling of Investment and Forecast Investment was performed assuming a nonstationary vector autoregression process, as described in equation E 4. in section 3.3.2.

The following procedure was followed:

1. Different combinations of variables were included in the process and tested for cointegration using the ADF process described in section 3.3.2. Only I(1) processes were considered, as the modeling of I(2) or higher order processes is highly complex;
2. Combinations of cointegrating variables found to be I(1) were included in the process and the Johansen procedure was then used to determine the coefficient matrix $P = \alpha \beta'$, as described in section 3.3.2. The
significance of $\alpha$ (speed of adjustment vector) and $\beta$ (normalized coefficient vector, describing the long-run relationship between the variables) were then tested to determine the significance of the model. Outliers were excluded from the model in order to improve the normality of residuals and the significance of the model. The ECM (error correction model) was then derived and plotted against time to test for mean reversion.

3. The ECM for significant models were then included in the full models including dynamics (as described by equation E 4 in section 3.3.2), and the Johansen procedure was then used to determine the coefficients of matrix $G$ describing the first-difference VAR system (i.e. the dynamics).
6. Results

6.1. Questionnaires Guiding Research (not for statistical purposes)

Responses to questionnaires have been of assistance in the choosing data, reported on in more detail in section 6.3. Whilst all of the respondents used neo-classicist tools identified in the questionnaire (mostly DCF), there was a natural emphasis on debt service coverage ratio analysis, given that most respondents were from the project finance or investment banking sectors.

Apart from neo-classicist techniques, the role of other factors which reflect or influence sentiment regarding the uncertainty of capital investment decision outcomes were seen as significant by the respondents. The inability to procure accurate forecasts and uncertainty were seen to constrain investment. Whilst some indicated that sentiment is often derived through an unconscious process influenced by information on a number of variables, some particular variables were identified as being significant. These included CPI/CPIX, political and commercial risk ratings, World Bank surveys, interest rates, bond yields and yield spreads, unemployment rates, confidence indexes, exchange rates and crime statistics. Where possible, data on these parameters were sought for inclusion in the analysis.

6.2. Dependent Variable

The variable \textit{NGDFIA} is used as a proxy for \textit{Investment} and is plotted in Figure 1 over the period 1975 to 2005 (expressed in South African Rands adjusted for inflation, base year 2000)\textsuperscript{22} (INET, 2005). \textit{NGDFIA – ADVANCED 12 MONTHS} is also plotted as a proxy for \textit{Forecast Investment} (a perfect estimate of investment in one year’s time, given the benefits of perfect hindsight).
Vertical Axis Units: SAAR (South African Adjusted Rands, Base Year 2000)

Figure 1: Investment (Blue Line) and Forecast Investment (Red Dashed Line)

The dip in investment activity in the mid-1980’s is consistent with the views expressed by two respondents, and could be ascribed largely to the political uncertainty and the debt crisis that faced South Africa during that period of time.

6.3. Data Choice, Collection, Conditioning and Factor Analysis

A full list of variables is given in Appendix B (incorporating survey data as well as hard data as defined in points 2 and 3 respectively of section 4.3.1). The variables were chosen, collected and conditioned using the methodologies outlined in sections 5.2 and 5.3. The results generated by the exploratory factor analysis outlined in section 5.4 are also presented in Appendix B. Factor loadings for GDFIA (Investment) and various advancements of GDFIA in time (Forecast Investment) are highlighted in blue, with their maxima highlighted in pink. High factor loadings for other variables are also highlighted, using yellow for variables sourced from survey data and green for those from hard data.
Twenty of the most dominant variables (identified from the exploratory factor analysis shown in Appendix B) were isolated for further factor analysis. These are shown in Table 1. Similar highlighting has been applied to that described for Appendix B. The results in the table imply that there may be four dominant factors linked to GDFIA the proxy for Investment, and the respective advancements in time (forecasts), namely:

- Factor 1: “South African Feel Good Factor” (loading 0.971);
- Factor 2: “World Conditions” (loading -0.276);
- Factor 4: “Capital Inflow” (loading 0.187);
- Factor 5: “South African Reserve Bank Brake” (loading -0.157).

The reasoning behind the factor naming will be outlined in section 6.4. In the context of uncertainty, the loadings of factors 1 and 4 may reflect positively or have a positive influence on investor sentiment regarding (un)certainty of capital investment decision outcomes. The reverse may be said for factors 2 and 5.
## Table 1: Factor Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
<th>Factor 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCAC[CL] - BALANCE ON CURRENT ACCOUNT</td>
<td>-0.24616</td>
<td>0.030212</td>
<td>0.001390</td>
<td>-0.024336</td>
<td>-0.132601</td>
</tr>
<tr>
<td>BCAAX[CL] - BALANCE ON CURRENT ACCOUNT SAAR</td>
<td>-0.30458</td>
<td>0.046337</td>
<td>0.014889</td>
<td>-0.914115</td>
<td>-0.186578</td>
</tr>
<tr>
<td>BTOTE[CL] - TERMS OF TRADE IND EX GOLD S/A</td>
<td>-0.32061</td>
<td>-0.078553</td>
<td>-0.669613</td>
<td>0.092452</td>
<td>-0.449835</td>
</tr>
<tr>
<td>BTOTI[CL] - TERMS OF TRADE IND INC GOLD S/A</td>
<td>-0.20130</td>
<td>0.900560</td>
<td>0.018562</td>
<td>-0.122506</td>
<td>-0.647898</td>
</tr>
<tr>
<td>USINF[CL] - US INFLATION RATE</td>
<td>0.17652</td>
<td>0.747512</td>
<td>-0.379887</td>
<td>-0.027023</td>
<td>-0.336850</td>
</tr>
<tr>
<td>EINF[CL] - INFLATION RATE - SOUTH AFRICA [METRO]</td>
<td>-0.48419</td>
<td>0.601190</td>
<td>0.076699</td>
<td>-0.290777</td>
<td>-0.097296</td>
</tr>
<tr>
<td>PPISA[CL] - PPI - ALL GROUPS - SOUTH AFRICAN [00=100]</td>
<td>0.43518</td>
<td>-0.769830</td>
<td>0.421060</td>
<td>0.062812</td>
<td>0.0090437</td>
</tr>
<tr>
<td>RESTOT[CL] - GOLD AND FOREIGN RESERVES [RM]</td>
<td>0.66873</td>
<td>-0.628802</td>
<td>0.179503</td>
<td>-0.138837</td>
<td>0.113563</td>
</tr>
<tr>
<td>ECI[CL] - COINCIDENT INDICATOR</td>
<td>0.27807</td>
<td>-0.286739</td>
<td>0.839931</td>
<td>0.087712</td>
<td>0.231007</td>
</tr>
<tr>
<td>ELGI[CL] - LAGGING INDICATOR</td>
<td>0.39379</td>
<td>-0.074597</td>
<td>0.335657</td>
<td>0.238303</td>
<td>0.739308</td>
</tr>
<tr>
<td>ELII[CL] - LEADING INDICATOR</td>
<td>0.30124</td>
<td>-0.360781</td>
<td>0.851414</td>
<td>-0.093245</td>
<td>-0.097121</td>
</tr>
<tr>
<td>TOTVEH[CL] - TOTAL CAR AND COMMERCIAL VEHICLE SALES</td>
<td>0.50288</td>
<td>0.552219</td>
<td>0.308864</td>
<td>0.128741</td>
<td>0.265595</td>
</tr>
<tr>
<td>USDZAP[CL] - BASE</td>
<td>0.51520</td>
<td>-0.745768</td>
<td>0.319491</td>
<td>-0.091070</td>
<td>0.120855</td>
</tr>
<tr>
<td>AUDUSD[CL]</td>
<td>-0.04719</td>
<td>0.689432</td>
<td>-0.025238</td>
<td>0.144708</td>
<td>-0.147070</td>
</tr>
<tr>
<td>UST3M[CL]</td>
<td>0.04579</td>
<td>0.916812</td>
<td>0.042831</td>
<td>0.047955</td>
<td>-0.022129</td>
</tr>
<tr>
<td>USG30[CL]</td>
<td>-0.06669</td>
<td>0.937483</td>
<td>0.068523</td>
<td>-0.076521</td>
<td>0.145512</td>
</tr>
<tr>
<td>RBAS[CL] - 90 DAY BANKERS ACCEPTANCE [DISCOUNT] [RBAS]</td>
<td>-0.29214</td>
<td>0.027076</td>
<td>0.454365</td>
<td>0.212263</td>
<td>0.732120</td>
</tr>
<tr>
<td>SAGB10[CL] - SA: GOVT 10 YEAR BOND</td>
<td>-0.54827</td>
<td>-0.084056</td>
<td>0.738106</td>
<td>0.101820</td>
<td>0.218809</td>
</tr>
<tr>
<td>FSP1[CL] - S&amp;P 500</td>
<td>0.44970</td>
<td>-0.733027</td>
<td>0.291706</td>
<td>0.105871</td>
<td>0.141419</td>
</tr>
<tr>
<td>Oil Infl Ad</td>
<td>0.26201</td>
<td>0.890935</td>
<td>-0.335902</td>
<td>-0.067771</td>
<td>0.045666</td>
</tr>
<tr>
<td>NGDFIA[CL] - BASE</td>
<td>0.80613</td>
<td>0.073903</td>
<td>0.061783</td>
<td>0.182765</td>
<td>0.489082</td>
</tr>
<tr>
<td>NGDFIA[CL] - ADVANCED 3 MONTHS</td>
<td>0.86638</td>
<td>0.069890</td>
<td>0.087321</td>
<td>0.187309</td>
<td>0.388003</td>
</tr>
<tr>
<td>NGDFIA[CL] - ADVANCED 6 MONTHS</td>
<td>0.91680</td>
<td>0.051417</td>
<td>0.105256</td>
<td>0.166871</td>
<td>0.276514</td>
</tr>
<tr>
<td>NGDFIA[CL] - ADVANCED 9 MONTHS</td>
<td>0.94975</td>
<td>0.015083</td>
<td>0.106901</td>
<td>0.155805</td>
<td>0.175626</td>
</tr>
<tr>
<td>NGDFIA[CL] - ADVANCED 12 MONTHS</td>
<td>0.96675</td>
<td>-0.032801</td>
<td>0.103101</td>
<td>0.145352</td>
<td>0.067305</td>
</tr>
<tr>
<td>NGDFIA[CL] - ADVANCED 15 MONTHS</td>
<td>0.97083</td>
<td>-0.087649</td>
<td>0.084619</td>
<td>0.123986</td>
<td>-0.008190</td>
</tr>
<tr>
<td>NGDFIA[CL] - ADVANCED 18 MONTHS</td>
<td>0.96073</td>
<td>-0.148316</td>
<td>0.063439</td>
<td>0.098084</td>
<td>-0.074389</td>
</tr>
<tr>
<td>NGDFIA[CL] - ADVANCED 21 MONTHS</td>
<td>0.93787</td>
<td>-0.213358</td>
<td>0.038706</td>
<td>0.077083</td>
<td>-0.121792</td>
</tr>
<tr>
<td>NGDFIA[CL] - ADVANCED 24 MONTHS</td>
<td>0.90160</td>
<td>0.275526</td>
<td>0.056376</td>
<td>0.086286</td>
<td>0.157233</td>
</tr>
<tr>
<td>Expl.Var</td>
<td>10.36103</td>
<td>8.866884</td>
<td>3.963869</td>
<td>2.195913</td>
<td>2.707339</td>
</tr>
<tr>
<td>Prp.Totl</td>
<td>0.35728</td>
<td>0.237824</td>
<td>0.136564</td>
<td>0.075721</td>
<td>0.093357</td>
</tr>
</tbody>
</table>

Table 1: Factor Analysis
6.4. **Exploratory Time Trend Analysis and Factor Naming**

Variables with high factor loadings in Table 1 were examined more closely using time trend plots in order to detect the possibility of relationships between them and the proxy variables for investment.

6.4.1. **Factor 1: “South African Feel Good Factor”**

The impact of factor 1 in Table 1 peaks with a loading of 0.971 for the variable NGDFIA advanced 15 months. This may imply that the factor has significance in forecasting investment. Strongly linked to the factor are the variables RESTOT, TOTVEH, USDZAR and SAGB10.

Figure 2 indeed seems to imply a strong dynamic relationship with investment, where changes in vehicle sales appear to lead NGDFIA. This may mean that increasing vehicle sales reflects positive investor sentiment at a particular time regarding the (un)certainty of investment decisions, thus leading to increased investment at some time in the future (and vice versa). Figure 3 seems to indicate the opposite relationship between 10 year government bond yields and investment. The factor has therefore accordingly been named the “South African Feel Good Factor”.

6.4.2. **Factor 2: “World Conditions”**

The impact of factor 2 swings from slightly positive to a negative loading of -0.276 for the variable NGDFIA advanced 24 months, again possibly implying significance in forecasting investment. Interesting relationships are those of variables BTOTI, USINF, EINF, PPISA, USDZAR, USTB3M, USGB30, FSPI and Oil.

Figure 4 and Figure 5 are difficult to interpret with respect to any underlying relationships that may exist – time trends are evident (especially for FSPI) as are some complicated dynamics between the relative inflation rates and exchange rates. Given the abundance of variables reflecting South Africa’s relationship with the rest of the world, the factor is named “World Conditions”.
6.4.3. Factor 4: “Capital Inflow”

Factor 4 appears to be the most closely related to current investment, with the loading little different for the variable NGDFIA advanced 3 months from the loading for the base variable. This may imply more relevance with respect to \textit{Investment} than with respect to \textit{Forecast Investment}. The negative loading of the factors BCAC and BCAAX may imply that a deficit is good for investment. Intuitively this is plausible, as a current account deficit may reflect investment because by default, capital needs to flow in through the financial account to offset the deficit. There is some evidence of this relationship in Figure 6. The factor has consequently been named “Capital Inflow”.

6.4.4. Factor 5: “South African Reserve Bank Brake”

The impact of factor 5 swings from a strongly positive (0.490) to a negative loading of -0.157 for the variable NGDFIA and NGDFIA advanced 24 months respectively. This may imply significance in forecasting investment. Strong relationships between this factor and BTOTI, ELGI and RBAS are evident.

Figure 7 plots RBAS with the investment proxies, and whilst a relationship is visible, it is difficult to determine the dynamics. Intuitively, it seems that interest rates are increased as investment increases, putting a “brake” on the economy, with investment dropping after sustained raising of interest rates – hence the factor has been named “Reserve Bank Brake”.

An interesting observation is that both BTOTE and BTOTI have negative loadings for Factor 5, but that the sign of the loading for BTOTI is positive for factor 3.
Figure 2: Response in Vehicle Sales to “Feel Good Factor”

Figure 3: Response in 10-Year SA Government Bonds to “Feel Good Factor”
Figure 4: Inflation Exchange Rates Reflecting SA Relative to “World Conditions”

Figure 5: S&P 500 Index Reflecting “World Conditions”
Figure 6: Current Account Deficit reflecting “Capital Inflow”

Figure 7: 90 Day Bankers Acceptance Rate reflecting “Reserve Bank Brake”
6.5. Exploratory OLS Regression Results

Exploratory OLS regressions were performed to explore simple relationships between the 20 variables (from survey data and hard data) in Table 1 and Forecast Investment, using NGDFIA – ADVANCED 12 MONTHS as a proxy for Forecast Investment. A time trend variable was added, as suggested in the literature reviewed in section 3.3 to deal with the time trends observed (especially in Figure 4 and Figure 5).

Results from the exploratory OLS regression including all 20 variables are given in Figure 8. The adjusted $R^2$ is greater than 0.9, the distribution of residuals is relatively normal and the plot of the predicted vs residual scores shows little evidence of heteroscedasticity. The predicted model fits the observed proxy for forecast investment well. However, high $R^2$ values and well fitting models are typical of OLS regression of time series variables, and are quite likely to be a consequence of spurious regression (as suggested in section 3.3). Also, notwithstanding the fact that a time variable was added (variable “Period”), the relatively low Durbin-Watson statistic does imply a serial correlation problem. The model coefficients are also numerous and difficult to understand intuitively (for example, why should high US inflation be bad for South African future investment whilst at the same time high US short term interest rates are good?).

A further OLS regression was performed using hard data variables only, and the results are presented in Figure 9. The Durbin-Watson results are somewhat better, implying reduced serial correlation, and the variables in the final model make more intuitive sense than those seen in the results presented in Figure 8. The positive relationship with TOTVEH and negative relationship with SAGB10 are consistent with the discussion on Factor 1 in section 6.4.1.

Whilst the model results in Figure 9 are promising, the results of the more rigorous approach to deal with the problem of serial correlation (as suggested in section 3.3) are reported on in section 6.6.
Durbin-Watson d = 1.289969; Serial Correlation = 0.353587

Figure 8: OLS Regression Results with Survey Data and Hard Data

Student FT127, Final Dissertation, UCT GSB MBA Full Time 2005
Regression Summary for Dependent Variable: NGDFIA[CL] - ADVANCED 12 MONTHS (051126 Statistica Data)

\[ R = 0.94615174 \quad R^2 = 0.89520311 \quad \text{Adjusted } R^2 = 0.88943447 \]
\[ F(6,109) = 155.18 \quad p<0.0000 \]

Std. Error of estimate: 7193.7

Include cases: 1:116

N = 116

<table>
<thead>
<tr>
<th>Beta</th>
<th>Std.Err. of Beta</th>
<th>B</th>
<th>Std.Err. of B</th>
<th>t(109)</th>
<th>p-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>116519.1</td>
<td>5</td>
<td>19627.6</td>
<td>9</td>
<td>5.936</td>
</tr>
<tr>
<td>BCAAX[CL] - BALANCE ON CURRENT ACCOUNT SAAR</td>
<td>0.32574</td>
<td>2</td>
<td>0.03526</td>
<td>0</td>
<td>-0.70</td>
</tr>
<tr>
<td>BTOTE[CL] - TERMS OF TRADE IND EX GOLD S/A</td>
<td>-0.19703</td>
<td>5</td>
<td>0.04567</td>
<td>2</td>
<td>-4.314</td>
</tr>
<tr>
<td>BTOTI[CL] - TERMS OF TRADE IND INC GOLD S/A</td>
<td>0.20417</td>
<td>5</td>
<td>0.03857</td>
<td>5</td>
<td>96.2</td>
</tr>
<tr>
<td>TOTVEH[CL] - TOTAL CAR AND COMMERCIAL VEHICLE SALES</td>
<td>0.32591</td>
<td>6</td>
<td>0.04057</td>
<td>9</td>
<td>8.031</td>
</tr>
<tr>
<td>USDZAR[CL]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAGB10[CL] - SA: GOVT 10 YEAR BOND</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Durbin-Watson d = 1.381096; Serial Correlation = 0.289846

Figure 9: OLS Regression Results with Hard Data Only
6.6. Rigorous Modeling Results

The variables listed in Table 1 were standardized with respect to their means and standard deviations (over the time period under consideration), and the factor analyses and regressions reported on in sections 6.3 and 6.5 were repeated – the results, as expected, were the same.

Using the standardized data, models were constructed using the “feel” for the variables gained from the time series plots and the OLS regression. Processes were constructed by trial-and-error in terms of the choice of variables and in terms of the number of lags to be used in the cointegration testing.

The first cointegrating relationship identified was that between Investment (represented by its proxy NGDFIA) and the variables TOTVEH, SAGB10 and FSPI (found to be a cointegrating I(1) process with $P = 0.005$). A long-term model was constructed using the Johansen procedure, and the results of the modeling process are presented in Figure 10. However, the coefficients of $\alpha$ were found not to be significant (highlighted in yellow).

**I(0) Cointegration Analysis 1977(1) to 2004(2)**

<table>
<thead>
<tr>
<th></th>
<th>VAR(6) in: $\beta$</th>
<th>SE($\beta$)</th>
<th>$\alpha$</th>
<th>SE($\alpha$)</th>
<th>$\chi^2(\alpha=0)$</th>
<th>$P$</th>
<th>Unrestricted Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGDFIA</td>
<td>-1.0000</td>
<td>0.00000</td>
<td>0.16836</td>
<td>0.058760</td>
<td></td>
<td></td>
<td>Constant; D80-4; D85-3</td>
</tr>
<tr>
<td>TOTVEH</td>
<td>0.8562</td>
<td>0.07567</td>
<td>-0.19187</td>
<td>0.187480</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAGB10</td>
<td>-0.5879</td>
<td>0.06805</td>
<td>0.30067</td>
<td>0.108120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FSPI</td>
<td>0.5577</td>
<td>0.06047</td>
<td>-0.12335</td>
<td>0.047415</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 10: Modeling Investment using Vehicle Sales, SAGB10 & S&P500

A similar cointegrating relationship was found between Forecast Investment (represented by a proxy NGDFIA3, i.e. advanced three quarters of one year), and the modeling results are presented in Figure 11. Similar conclusions can be drawn to those discussed earlier for Figure 10.

**I(0) Cointegration Analysis 1976(2) to 2004(2)**

<table>
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<tr>
<th></th>
<th>VAR(3) in: $\beta$</th>
<th>SE($\beta$)</th>
<th>$\alpha$</th>
<th>SE($\alpha$)</th>
<th>$\chi^2(\alpha=0)$</th>
<th>$P$</th>
<th>Unrestricted Variables</th>
</tr>
</thead>
<tbody>
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<td>NGDFIA$^3$</td>
<td>-1.0000</td>
<td>0.00000</td>
<td>0.12681</td>
<td>0.052806</td>
<td>3.5667</td>
<td>0.0589</td>
<td>Constant; D76-3; D77-2; D79-3; D84-2; D85-3; D86-1; D89-2; D99-4; D01-1; D01-3; D02-2; D98-3; D98-4; D02-3</td>
</tr>
<tr>
<td>TOTVEH</td>
<td>0.6639</td>
<td>0.07104</td>
<td>-0.24812</td>
<td>0.142480</td>
<td>2.0549</td>
<td>0.1517</td>
<td></td>
</tr>
<tr>
<td>SAGB10</td>
<td>-0.6584</td>
<td>0.06954</td>
<td>0.22096</td>
<td>0.086399</td>
<td>6.3784</td>
<td>0.0116 *</td>
<td></td>
</tr>
<tr>
<td>FSPI</td>
<td>0.5408</td>
<td>0.07227</td>
<td>-0.05222</td>
<td>0.025448</td>
<td>4.2217</td>
<td>0.0399 *</td>
<td></td>
</tr>
</tbody>
</table>

Figure 11: Modeling Forecast Investment using Vehicle Sales, SAGB10 & S&P500
The models described in Figure 10 and Figure 11 do however make intuitive sense and are consistent with the factor analysis and time trends in that vehicle sales reflect positive sentiment and rising bond rates reflect negative sentiment regarding the (un)certainty of capital investment decision outcomes through Factor 1 (“South African Feel Good Factor” in section 6.4.1). Furthermore, the positive relationship between FSPI and investment is consistent with the findings of Barr and Kantor$^4$ (Barr, Kantor, 1999:1) and those of Kantor and Marchetti$^{32}$ (Kantor, Marcetti, 2005:4) reviewed in section 3.2.2. The variable FSPI could therefore be considered to be a positive influence on investor sentiment through Factor 2 (“World Conditions). A further model was therefore constructed in which the variable SAGB10 was substituted with the variable RBAS, effectively removing one of two variables representing Factor 1 and replacing it with a variable representing Factor 5 (“South African Reserve Bank Brake”), which is thought to influence investor sentiment. The resultant model is highly significant, with a mean reverting ECM (error correcting model), and the results are summarized in Figure 12.

Figure 12 also shows the results of the application of the Johansen procedure to develop a parsimonious dynamic model for the cointegrating I(1) process, in which the ECM (error correcting model) is represented (indicating a speed of adjustment of approximately 5.7% per quarter).

Figure 13 shows results generated from the process of using the same variables to develop a model for \textit{Forecast Investment}, which is as significant as, and is consistent with, the model for \textit{Investment}. 
(10) Cointegration Analysis 1977(1) to 2004(2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>SE(β)</th>
<th>α</th>
<th>SE(α)</th>
<th>χ²(α=0)</th>
<th>P</th>
<th>χ²(α=0)</th>
<th>P</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGDFIA</td>
<td>-1.0000</td>
<td>0.00000</td>
<td>0.13257</td>
<td>0.03667</td>
<td>13.7420</td>
<td>0.0002**</td>
<td>Constant; D78-2</td>
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<td></td>
</tr>
<tr>
<td>TOTVEH</td>
<td>1.1851</td>
<td>0.13655</td>
<td>0.19429</td>
<td>0.09150</td>
<td>4.2628</td>
<td>0.0390*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RBAS</td>
<td>-0.9344</td>
<td>0.14163</td>
<td>0.26418</td>
<td>0.07390</td>
<td>11.0820</td>
<td>0.0009**</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>FSPI</td>
<td>0.5891</td>
<td>0.09157</td>
<td>-0.07897</td>
<td>0.02774</td>
<td>8.9444</td>
<td>0.0028**</td>
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<td></td>
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</table>

Specific Model for DNGDFIA

<table>
<thead>
<tr>
<th>Variable</th>
<th>η</th>
<th>SE(η)</th>
<th>t</th>
<th>P</th>
<th>Test</th>
<th>Value</th>
<th>P</th>
</tr>
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<td>DNGDFIA_3</td>
<td>0.26461</td>
<td>0.08368</td>
<td>3.162</td>
<td>0.0020</td>
<td>Chow(1990:4)</td>
<td>0.3360</td>
<td>0.9999</td>
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<tr>
<td>DNGDFIA_5</td>
<td>0.23131</td>
<td>0.08161</td>
<td>2.834</td>
<td>0.0055</td>
<td>Chow(2001:4)</td>
<td>0.7407</td>
<td>0.6845</td>
</tr>
<tr>
<td>DTOTVEH</td>
<td>0.07336</td>
<td>0.02898</td>
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<td>0.0129</td>
<td>AR 1-4 test</td>
<td>1.3322</td>
<td>0.2632</td>
</tr>
<tr>
<td>DRBAS_4</td>
<td>-0.09444</td>
<td>0.04680</td>
<td>-2.018</td>
<td>0.0461</td>
<td>ARCH 1-4 test</td>
<td>0.8063</td>
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<tr>
<td>ECM</td>
<td>-0.05707</td>
<td>0.01508</td>
<td>-3.785</td>
<td>0.0003</td>
<td>Hetero test</td>
<td>0.6148</td>
<td>0.7977</td>
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Figure 12: Modeling Investment using Vehicle Sales, RBAS & S&P500
I(0) Cointegration Analysis 1976(2) to 2004(2)

<table>
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<tr>
<th>Variable</th>
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<th>SE(( \beta ))</th>
<th>( \alpha )</th>
<th>SE(( \alpha ))</th>
<th>( \chi^2(\alpha=0) )</th>
<th>P</th>
<th>Unrestricted Variables</th>
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<td>NGDFIA3</td>
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<td>0.08459</td>
<td>0.015956</td>
<td>15.3250</td>
<td>0.0001 **</td>
<td>Constant; D76-3; D79-3; D83-1; D84-2; D84-3; D98-2; D98-4; D99-4; D01-1; D01-3; D02-2; D02-3</td>
</tr>
<tr>
<td>TOTVEH</td>
<td>0.9071</td>
<td>0.20316</td>
<td>0.12396</td>
<td>0.046594</td>
<td>4.7387</td>
<td>0.0295 *</td>
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</tr>
<tr>
<td>RBAS</td>
<td>-1.6527</td>
<td>0.19637</td>
<td>0.11020</td>
<td>0.0227084</td>
<td>7.2963</td>
<td>0.0069 **</td>
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</tr>
<tr>
<td>FSPI</td>
<td>0.8233</td>
<td>0.16692</td>
<td>-0.02059</td>
<td>0.0086626</td>
<td>5.4933</td>
<td>0.0191 **</td>
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Specific Model for DNGDFIA3

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<th>t</th>
<th>P</th>
<th>Test</th>
<th>Value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.04356</td>
<td>0.01682</td>
<td>2.589</td>
<td>0.0110</td>
<td>Chow(1990:2)</td>
<td>0.5036</td>
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<tr>
<td>DNGDFIA3</td>
<td>-0.21658</td>
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<td>-2.454</td>
<td>0.0157</td>
<td>Chow(2001:3)</td>
<td>1.2506</td>
<td>0.2650</td>
</tr>
<tr>
<td>DTOTVEH</td>
<td>0.09664</td>
<td>0.02962</td>
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<td>0.0015</td>
<td>normality test</td>
<td>6.8276</td>
<td>0.0329</td>
</tr>
<tr>
<td>DFSPI</td>
<td>0.30875</td>
<td>0.12848</td>
<td>2.403</td>
<td>0.0180</td>
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<td>1.1516</td>
<td>0.3366</td>
</tr>
<tr>
<td>ECM</td>
<td>-0.07633</td>
<td>0.01217</td>
<td>-6.189</td>
<td>0.0000</td>
<td>ARCH 1-4 test</td>
<td>2.1151</td>
<td>0.0845</td>
</tr>
</tbody>
</table>

Figure 13: Modeling Forecast Investment using Vehicle Sales, RBAS & S&P500
Further I(1) cointegration was found between NGDFIA, BTOTE and USINF, and the results of the modeling process are presented in Figure 14. The results are however somewhat counterintuitive in that improving terms of trade are seen to impact negatively on investment and in that increasing inflation in the USA is seen to impact positively on investment.

As discussed in section 6.4.2, the relationships between the variables driving Factor 2 (“World Conditions” - BTOTI, USINF, EINF, PPISA, USDZAR, USTB3M, USGB30, FSPI and Oil) are difficult to interpret (as also highlighted in Figure 4 and Figure 5). However, if the USA is used as a proxy for the world, USINF, EINF and USDZAR are the determinants of the “real exchange rate”\(^{44}\) (Black, Hartzenbert, Standish, 2004:281) of South Africa, as described by the equation:

\[
\frac{e_r}{e} = \frac{P_w}{P}
\]

Where

- \(e_r\) = real exchange rate
- \(e\) = nominal exchange rate
- \(P_w\) = world prices
- \(P\) = domestic prices

An increase in the real exchange rate reflects an improvement in competitiveness relative to other countries in the world. A time series of the calculated real exchange rate for South Africa for the period 1975 to 2005 was constructed (USINF is one of the drivers of the real exchange rate, together with the other variables EINF and USDZAR, all of which have high factor loadings relative to Factor 2). Results from the modeling process with USINF replaced by the calculated variable ER (real exchange rate) are given in Figure 15. The results appear to be consistent with conventional thinking that improved terms of trade and competitiveness will have a positive influence on investor sentiment. Whilst the long-range model is significant and the ECM mean reverting, the ECM was removed from the dynamic model during the process of making it parsimonious – this may indicate some inconsistencies with respect the dynamic parsimonious model.
I(0) Cointegration Analysis 1978(1) to 2004(2)

H0: rank < 0: 60.841 P = 0.000 **

VAR(10) in:

<table>
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<tr>
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<th>SE(β)</th>
<th>α</th>
<th>SE(α)</th>
<th>χ²(α=0)</th>
<th>P</th>
<th>Unrestricted Variables</th>
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<tbody>
<tr>
<td>NGDFIA</td>
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<td>0.00000</td>
<td>-0.01386</td>
<td>0.006740</td>
<td>5.0698</td>
<td>0.0243 *</td>
<td></td>
</tr>
<tr>
<td>BTOTE</td>
<td>-4.2078</td>
<td>0.66684</td>
<td>0.07106</td>
<td>0.015794</td>
<td>15.1100</td>
<td>0.0001 **</td>
<td></td>
</tr>
<tr>
<td>USINF</td>
<td>1.3539</td>
<td>0.64928</td>
<td>-0.02623</td>
<td>0.006738</td>
<td>12.8980</td>
<td>0.0003 **</td>
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Specific Model for DNGDFIA

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<tr>
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<th>SE(η)</th>
<th>t</th>
<th>P</th>
<th>Test</th>
<th>Value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNGDFIA_3</td>
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<td>0.07920</td>
<td>4.853</td>
<td>0.0000</td>
<td>Chow(1991:2)</td>
<td>0.8872</td>
<td>0.6644</td>
</tr>
<tr>
<td>DNGDFIA_9</td>
<td>-0.18885</td>
<td>0.08247</td>
<td>-2.290</td>
<td>0.0241</td>
<td>Chow(2001:4)</td>
<td>1.3615</td>
<td>0.2111</td>
</tr>
<tr>
<td>DBTOTE</td>
<td>-0.19040</td>
<td>0.03875</td>
<td>-4.914</td>
<td>0.0000</td>
<td>AR 1-4 test</td>
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<td>0.0239</td>
</tr>
<tr>
<td>DBTOTE_5</td>
<td>-0.17573</td>
<td>0.03731</td>
<td>-4.710</td>
<td>0.0000</td>
<td>ARCH 1-4 test</td>
<td>1.1195</td>
<td>0.3522</td>
</tr>
<tr>
<td>DUSINF_2</td>
<td>0.18754</td>
<td>0.07990</td>
<td>-2.347</td>
<td>0.0209</td>
<td>hetero test</td>
<td>0.4854</td>
<td>0.9183</td>
</tr>
</tbody>
</table>

Figure 14: Modeling Investment using Terms of Trade and US Inflation
### I(0) Cointegration Analysis 1977(1) to 2004(2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>SE(β)</th>
<th>SE(α)</th>
<th>χ2(α=0)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGDFIA</td>
<td>-1.0000</td>
<td>0.00000</td>
<td>0.00902</td>
<td>0.002918</td>
</tr>
<tr>
<td>BTOTE</td>
<td>7.5644</td>
<td>1.32600</td>
<td>-0.02736</td>
<td>0.006068</td>
</tr>
<tr>
<td>ER</td>
<td>4.8286</td>
<td>1.30700</td>
<td>-0.01730</td>
<td>0.005351</td>
</tr>
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</table>

**Unrestricted Variables**
- Constant; D01-4; D78-3; D80-4; D01-3; D99-1

### Specific Model for DNGDFIA

<table>
<thead>
<tr>
<th>Variable</th>
<th>η</th>
<th>SE(η)</th>
<th>I</th>
<th>P</th>
<th>Test</th>
<th>Value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNGDFIA_1</td>
<td>0.23028</td>
<td>0.09043</td>
<td>2.547</td>
<td>0.0125</td>
<td>Chow(1991:2)</td>
<td>0.5545</td>
<td>0.9795</td>
</tr>
<tr>
<td>DNGDFIA_3</td>
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<td>0.08472</td>
<td>3.776</td>
<td>0.0003</td>
<td>Chow(2001:4)</td>
<td>1.0165</td>
<td>0.4364</td>
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<td>DNGDFIA_5</td>
<td>-0.21840</td>
<td>0.08710</td>
<td>-2.507</td>
<td>0.0138</td>
<td>AR 1-4 test</td>
<td>0.2046</td>
<td>0.9353</td>
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<td>DNGDFIA_6</td>
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<td>0.0256</td>
<td>ARCH 1-4 test</td>
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<td>0.8089</td>
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<td>DBTOTE</td>
<td>-0.23376</td>
<td>0.04242</td>
<td>-5.510</td>
<td>0.0000</td>
<td>hetero test</td>
<td>0.9697</td>
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<tr>
<td>Der_8</td>
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<td>0.04957</td>
<td>2.431</td>
<td>0.0169</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Figure 15: Modeling Investment using Terms of Trade and Real Exchange Rates
7. Conclusions

The review of literature and the consideration of questionnaire responses have shown that, apart from factors generated for consideration by neo-classicist investment analysis techniques, there are other factors that may reflect or influence investor sentiment regarding the uncertainty of capital investment decision outcomes. Such factors may be derived from survey data and hard data, or from hard data only.

Factors, reflecting or influencing investor sentiment, have been identified from an analysis of survey data and hard data spanning the period 1975 to 2005. Statistically significant models to explain investment and to forecast investment have been constructed using a selection of explanatory variables underpinning these factors, thus proving Hypotheses 1 and 2 articulated in sections 4.2.1 and 4.2.2 respectively.

The most significant hard data model of Investment finds a long-run equilibrium model with a normalized coefficient cointegrating vector
\[ \beta' = \{-1.00, 1.19, -0.93, 0.59\} \]
for the vector time series
\[ Z_t = \{NGDFIA, TOTVEH, RBAS, FSPI\}, \]
as well as the coefficients
\[ \{0.26, 0.23, 0.07, -0.09, -0.05\} \]
describing the dynamics of the vector time series
\[ DZ_t = \{DNGDFIA_3, DNGDFIA_5, DTOTVEH, DRBAS_4, ECM\}. \]
where NGDFIA is gross fixed capital formation (the proxy for Investment), TOTVEH is total vehicle sales, RBAS is 90 short-term interest rates, FSPI is the S&P500 index, _X represents X lags and D represents the difference vector.

The most significant hard data model of Forecast Investment finds a long-run equilibrium model with a normalized coefficient cointegrating vector
\[ \beta' = \{-1.00, 0.91, -1.65, 0.82\} \]
for the vector time series
\[ Z_t = \{NGDFIA3, TOTVEH, RBAS, FSPI\}, \]
as well as the coefficients
\[ \{0.04, -0.22, 0.10, 0.31, -0.08\} \]
describing the dynamics of the vector time series
\[ DZ_t = \{Constant, DNGDFIA3_1, DTOTVEH, DFSPI, ECM\}. \]
where NGDFIA3 is the proxy for Forecast Investment.
These models make intuitive sense and are consistent with the factor analysis and time trends in that vehicle sales reflect positive sentiment regarding the (un)certainty of capital investment decision outcomes through Factor 1 ("South African Feel Good Factor" in section 6.4.1). Furthermore, the positive relationship between FSPI and investment is consistent with the findings of Barr and Kantor\(^4\) (Barr, Kantor, 1999:1) and those of Kantor and Marchetti\(^{32}\) (Kantor, Marcetti, 2005:4) reviewed in section 3.2.2. The variable FSPI could therefore be considered to be a positive influence on investor sentiment through Factor 2 ("World Conditions"). The variable RBAS represents Factor 5 ("South African Reserve Bank Brake"), and the negative impact that increases in short-term interest rates have on investment are quantified.

A second \textit{survey data} and \textit{hard data} model of \textit{Investment} finds a long-run equilibrium model with a normalized coefficient cointegrating vector 
\[
\beta' = \{ -1.00, 7.56, 4.82 \}
\]
for the vector time series 
\[
Z_t = \{ \text{NGDFIA, BTOTE, ER} \},
\]
with a more complex model of the dynamics.

Where BTOTE is the South African terms of trade and ER is the real exchange rate.

These results also appear to be consistent with conventional thinking that improved terms of trade and competitiveness (which improves with an increasing real exchange rate) will have a positive influence on investor sentiment.

It is hoped that this research will contribute to further research into the formulation of a quantitative "\textit{investment barometer}" for policymakers in South Africa, based on the factors identified, which will contribute to the knowledge base required to promote the climate for investment in, and hence growth of, the South African economy.
References:

12. Energy Information Administration of the US Government (Oil data for correlations and regressions);
22. INET (Monthly and Quarterly Data 1975 to 2005 used for correlations and regressions);
30. Kantor, B.S., Marchetti, C., “All about Goldilocks @ the MPC (and a far too stubborn FRA curve)”, 2004, Investec Securities Limited, pp. 1-17;
32. Kantor, B.S., Marchetti, C., “The JSE is no island”, 2005, Investec Securities Limited, pp. 1-12;
Bibliography

4. Investment Climate Survey data, World Bank, 2005;
8. South African Reserve Bank;
9. South African Revenue Services;
10. Statistics South Africa;
11. World Development Indicators database, World Bank, 2005;
Appendix A. Questionnaires Guiding the Research (not for statistical purposes)
To Whom it May Concern

This survey forms part of the dissertation of Alex de Waal, a full-time MBA student at the Graduate School of Business of the University of Cape Town, and has been authorized by the University. The MBA program is scheduled for completion in December 2005.

The purpose of the survey is to understand the main factors, including, but not limited to, financial analysis such as DCF, Monte Carlo, or Real Options Analysis, which affect investment decisions in South Africa, and then to perform a statistical analysis on data describing these factors in an attempt to develop an "investment climate benchmark" that policymakers and investors can consider in their decision making.

The replies to the survey questionnaires will be collected by the student and stored in the Institute of Business. The analysis will be performed and the results presented at the University in a manner that will ensure confidentiality and prevent traceability with respect to the data collected.

The survey is split into two parts, and will take place to the form of structured interviews with individuals defining investment policy and strategy in general (Questionnaire A) and with those involved with the execution of specific project investments (Questionnaire B). Therefore, A will be completed once only for the company in general, while B will be completed once only for each particular project surveyed.

Your cooperation with the student would be appreciated.

Yours sincerely,

[Signature]

[Name]

[Position]
A.7. What, in your opinion, could be done to reduce the uncertainty described above?

________________________________________________________________________

________________________________________________________________________

A.8. In the period 1975 to 2005, which were, in your opinion, considered to be the
Best Years for Investment Project Approvals:

________________________________________________________________________

Worst Years for Investment Project Approvals:

________________________________________________________________________

A.9. Please rank the relative importance (when assessing the risk and uncertainty associated
with an investment decision) that you feel should be attached to the information generated
by those of the listed surveys which you are familiar. Please also add your opinion
regarding other surveys not listed.

(1 = absolute, 2 = major, 3 = significant, 4 = some, 5 = insignificant)

☐ CPI or Core CPI
☐ BES Financial Services Index
☐ BES Consumer Confidence Index
☐ BES Retail Index
☐ BES Manufacturing Index
☐ BES Construction Index
☐ BES Business Confidence Index
☐ BES Purchasing Managers' Index
☐ BES Building & Construction Index
☐ Retail Price Index
☐ Retail Price Index (core)
☐ Retail Price Index (non-core)
☐ Retail Price Index (consumer)
☐ Retail Price Index (manufacturing)
☐ Retail Price Index (construction)
☐ Retail Price Index (business)
☐ Retail Price Index (construction)
☐ Retail Price Index (business)
☐ Retail Price Index (construction)
☐ Retail Price Index (business)
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☐ Retail Price Index (business)
Questionnaire B - Project Factors

B.1. Economic sector in which project considered:
☐ Mining and Minerals Processing
☐ Manufacturing
☐ Information and Communications Technology
☐ Service
☐ Other (please describe):

B.2. What was the total capital cost of the project?

B.3. The primary source of funding for the project was:
☐ Retained Earnings
☐ Debt
☐ New Share Capital
☐ Venture Capital
☐ Other / Don't Know (please indicate)

B.4. What financial methods were used to value or analyze the project?
☐ Payback period or some simpler and/or more direct method
☐ DCF (Discounted Cash Flow) techniques such as NPV and IRR analysis
☐ Statistical techniques such as Monte Carlo Analysis (using Crystal Ball, etc.)
☐ Real Options Analysis, together with DCF and/or statistical techniques
☐ Other (please describe):

B.5. What method was used to determine WACC (weighted average cost of capital)?
☐ CAPM
☐ Other (please describe):

B.6. What was the WACC determined for the project?

B.7. What was the date of the first major contract payment?

B.8. What was the date of the project completion?

B.9. Please describe the project approval and approval process.

B.10. Please rank the strength of the following factors related to the project:
☐ 1 = very strong
☐ 2 = strong
☐ 3 = average
☐ 4 = weak
☐ 5 = very weak
☐ Management
☐ Resources
☐ Technology
☐ Market
☐ Other Factor 1 (please describe)
☐ Other Factor 2 (please describe)
☐ Other Factor 3 (please describe)

B.11. In your opinion, the project was:
☐ Success
☐ Failure
Please describe why:

B.12. What is the most commonly encountered source of uncertainty that constrained the investment in this project, and what is the root cause of that uncertainty?

Name:
Cause:

B.13. What, in your opinion, could be done to reduce the uncertainty described above?
Appendix B. Variable List and Factor Analysis
<table>
<thead>
<tr>
<th>Variable</th>
<th>Compet 1</th>
<th>World 2</th>
<th>Feel Gd 3</th>
<th>Factor 4</th>
<th>Factor 5</th>
<th>RB Brake 6</th>
<th>K Inflow 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCA[CL] - BALANCE ON CURRENT ACCOUNT</td>
<td>-0.3799</td>
<td>-0.1590</td>
<td>-0.34279</td>
<td>0.10207</td>
<td>-0.04508</td>
<td>-0.036449</td>
<td>-0.43807</td>
</tr>
<tr>
<td>BCAA[CL] - BALANCE ON CURRENT ACCOUNT SAAR</td>
<td>-0.2521</td>
<td>-0.1856</td>
<td>-0.378172</td>
<td>0.10475</td>
<td>-0.066077</td>
<td>-0.031622</td>
<td>-0.45415</td>
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<tr>
<td>BFA[CL] - BALANCE ON FINANCIAL ACCOUNT</td>
<td>0.2864</td>
<td>0.22674</td>
<td>0.114193</td>
<td>0.193489</td>
<td>0.034135</td>
<td>-0.025032</td>
<td>0.045724</td>
</tr>
<tr>
<td>BDA[CL] - DIRECT INVESTMENT - ASSETS</td>
<td>0.05479</td>
<td>-0.13172</td>
<td>-0.037317</td>
<td>0.951342</td>
<td>-0.072752</td>
<td>-0.025734</td>
<td>0.040360</td>
</tr>
<tr>
<td>BDL[CL] - DIRECT INVESTMENT - LIABILITIES</td>
<td>0.2847</td>
<td>0.14197</td>
<td>0.038876</td>
<td>0.027053</td>
<td>0.134618</td>
<td>-0.016680</td>
<td>0.005905</td>
</tr>
<tr>
<td>BDIN[CL] - DIRECT INVESTMENT - NET</td>
<td>0.15909</td>
<td>0.01755</td>
<td>0.004214</td>
<td>0.979520</td>
<td>0.041509</td>
<td>-0.029511</td>
<td>0.022923</td>
</tr>
<tr>
<td>BPI[CL] - PORTFOLIO INVESTMENT - ASSETS</td>
<td>-0.22924</td>
<td>-0.26200</td>
<td>0.011416</td>
<td>-0.740410</td>
<td>-0.095994</td>
<td>-0.037164</td>
<td>-0.039560</td>
</tr>
<tr>
<td>BPI[CL] - PORTFOLIO INVESTMENT - LIABILITIES</td>
<td>-0.01358</td>
<td>0.29397</td>
<td>0.012641</td>
<td>-0.485110</td>
<td>0.442326</td>
<td>0.028623</td>
<td>0.701284</td>
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<tr>
<td>BPN[CL] - PORTFOLIO INVEST - NET</td>
<td>-0.13301</td>
<td>0.11342</td>
<td>0.017307</td>
<td>-0.754956</td>
<td>0.136027</td>
<td>0.003448</td>
<td>0.578927</td>
</tr>
<tr>
<td>BLNN[CL] - UNRECORDED TRANSACTIONS</td>
<td>0.41110</td>
<td>0.06687</td>
<td>0.064857</td>
<td>-0.375391</td>
<td>-0.161470</td>
<td>-0.006191</td>
<td>-0.210679</td>
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<tr>
<td>BTOT[CL] - TERMS OF TRADE IND EX GOLD S/A</td>
<td>-0.19256</td>
<td>-0.20296</td>
<td>0.481170</td>
<td>0.019124</td>
<td>-0.043935</td>
<td>0.400655</td>
<td>0.058444</td>
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<tr>
<td>BTOI[CL] - TERMS OF TRADE IND EX GOLD S/A</td>
<td>-0.30957</td>
<td>-0.43051</td>
<td>0.002972</td>
<td>-0.045094</td>
<td>-0.070008</td>
<td>-0.320244</td>
<td>-0.207202</td>
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<tr>
<td>BRRO[CL] - LIAB REL TO RESERVES CHANGE CURRENT PRICES</td>
<td>-0.05524</td>
<td>0.03129</td>
<td>0.063391</td>
<td>-0.002397</td>
<td>0.124058</td>
<td>-0.037304</td>
<td>0.004286</td>
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<tr>
<td>NGCEAP[CL] - GDE - CONSTANT [SAAR]%</td>
<td>0.07637</td>
<td>0.03617</td>
<td>0.098684</td>
<td>0.042998</td>
<td>-0.089724</td>
<td>0.012966</td>
<td>0.030106</td>
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<tr>
<td>NGDFIP[CL] - GDFI - CONSTANT PRICES [SAAR]CHANGE</td>
<td>0.04759</td>
<td>0.16740</td>
<td>0.357865</td>
<td>-0.015846</td>
<td>-0.067808</td>
<td>-0.360727</td>
<td>-0.074723</td>
</tr>
<tr>
<td>NCAFAP[CL] - GDFI - NON-RESIDENTIAL REAL [SAAR] RM</td>
<td>0.23054</td>
<td>-0.58872</td>
<td>0.201117</td>
<td>0.048086</td>
<td>0.082138</td>
<td>0.326322</td>
<td>-0.17907</td>
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<tr>
<td>NCAFAP[CL] - GDFI - NON-RESIDENTIAL REAL [UNADJ]</td>
<td>-0.23770</td>
<td>-0.57207</td>
<td>0.204506</td>
<td>0.045107</td>
<td>0.084302</td>
<td>0.325065</td>
<td>-0.054107</td>
</tr>
<tr>
<td>NGDFIP[CL] - GDF - GROSS FIXED CAPITAL FORMATION [CONSTANT]</td>
<td>0.83972</td>
<td>-0.02399</td>
<td>0.512017</td>
<td>-0.002995</td>
<td>0.235543</td>
<td>0.156764</td>
<td>0.137057</td>
</tr>
<tr>
<td>NGDFIS[CL] - GDF - GROSS FIXED CAPITAL FORMATION [CURRENT]</td>
<td>0.74961</td>
<td>0.61318</td>
<td>0.107027</td>
<td>0.010689</td>
<td>0.115559</td>
<td>0.106839</td>
<td>0.113425</td>
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<tr>
<td>NGDFIP[CL] - GDF - GROSS FIXED CAPITAL FORMATION [CONSTANT]</td>
<td>0.83126</td>
<td>-0.02395</td>
<td>0.507465</td>
<td>-0.007487</td>
<td>0.253027</td>
<td>0.161765</td>
<td>0.092954</td>
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<tr>
<td>NGDFIP[CL] - GDF - GROSS FIXED CAPITAL FORMATION [CURRENT]</td>
<td>0.74961</td>
<td>0.61318</td>
<td>0.107027</td>
<td>0.010689</td>
<td>0.115559</td>
<td>0.106839</td>
<td>0.113425</td>
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<tr>
<td>NGDE[CL] - GROSS DOMESTIC EXPENDITURE [CONSTANT]</td>
<td>0.85143</td>
<td>0.37890</td>
<td>0.302269</td>
<td>-0.009346</td>
<td>0.072593</td>
<td>0.222659</td>
<td>0.116259</td>
</tr>
<tr>
<td>NGDEA[CL] - GROSS DOMESTIC EXPENDITURE [CURRENT]</td>
<td>0.85143</td>
<td>0.37890</td>
<td>0.302269</td>
<td>-0.009346</td>
<td>0.072593</td>
<td>0.222659</td>
<td>0.116259</td>
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<tr>
<td>NGDE[CL] - GROSS DOMESTIC EXPENDITURE [CURRENT SAAR]</td>
<td>0.74448</td>
<td>0.63211</td>
<td>0.092027</td>
<td>0.014057</td>
<td>0.111514</td>
<td>0.058800</td>
<td>0.109854</td>
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<tr>
<td>NGDEA[CL] - GROSS DOMESTIC EXPENDITURE [CURRENT]</td>
<td>0.74509</td>
<td>0.61318</td>
<td>0.090073</td>
<td>0.013172</td>
<td>0.112628</td>
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</tr>
<tr>
<td>USINFIN[CL] - US INFLATION RATE</td>
<td>-0.23993</td>
<td>0.58713</td>
<td>0.311536</td>
<td>-0.020278</td>
<td>-0.028208</td>
<td>-0.508199</td>
<td>0.038119</td>
</tr>
<tr>
<td>EINF[CL] - INFLATION RATE - SOUTH AFRICA [METRO]</td>
<td>-0.43214</td>
<td>-0.53968</td>
<td>-0.181681</td>
<td>0.011506</td>
<td>-0.284095</td>
<td>0.224161</td>
<td>-0.197003</td>
</tr>
<tr>
<td>ECPF[CL] - CPI - FOOD - METRO [0-100]</td>
<td>0.06534</td>
<td>0.71620</td>
<td>0.065446</td>
<td>0.010752</td>
<td>0.103739</td>
<td>0.072266</td>
<td>0.090371</td>
</tr>
<tr>
<td>Variable</td>
<td>Compet 1</td>
<td>World 2</td>
<td>Fee Gd 3</td>
<td>Factor 4</td>
<td>Factor 5</td>
<td>RB Brake 6</td>
<td>K Inf 7</td>
</tr>
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<tr>
<td>ECPI[CL] - CPI - ALL ITEMS [2000=100] METRO</td>
<td>0.83573</td>
<td>0.74174</td>
<td>0.04320</td>
<td>0.021431</td>
<td>0.129204</td>
<td>0.106534</td>
<td>0.034031</td>
</tr>
<tr>
<td>FRIASA[CL] - PAI - ALL GROUPS - SOUTH AFRICAN [20=100]</td>
<td>0.65693</td>
<td>0.72444</td>
<td>0.053765</td>
<td>0.019068</td>
<td>0.097764</td>
<td>0.116349</td>
<td>0.039313</td>
</tr>
<tr>
<td>RESTOT[CL] - GOLD AND FOREIGN RESERVES [RM]</td>
<td>0.29146</td>
<td>0.36008</td>
<td>0.07298</td>
<td>0.031223</td>
<td>0.197951</td>
<td>0.062328</td>
<td>0.022906</td>
</tr>
<tr>
<td>DEPINC[CL] - DEPOSITS: NON-RESIDENTS</td>
<td>0.78116</td>
<td>0.52517</td>
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<td>0.041430</td>
<td>0.326612</td>
<td>-0.019777</td>
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<td>ECI[CL] - COINCIDENT INDICATOR</td>
<td>0.41175</td>
<td>0.55650</td>
<td>0.387343</td>
<td>0.002034</td>
<td>-0.069770</td>
<td>0.445166</td>
<td>0.089419</td>
</tr>
<tr>
<td>ELG[CL] - LAGGING INDICATOR</td>
<td>0.36653</td>
<td>0.21941</td>
<td>0.466566</td>
<td>-0.013050</td>
<td>0.257998</td>
<td>0.604738</td>
<td>0.102452</td>
</tr>
<tr>
<td>LEL[CL] - LEADING INDICATOR</td>
<td>0.45212</td>
<td>0.58437</td>
<td>0.244808</td>
<td>0.013480</td>
<td>-0.109531</td>
<td>0.195435</td>
<td>0.024750</td>
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<td>BPSM[CL] - SA PURCHASING MANAGERS INDEX [BER]</td>
<td>0.91693</td>
<td>0.19743</td>
<td>0.056199</td>
<td>0.065317</td>
<td>0.076654</td>
<td>-0.054367</td>
<td>0.101018</td>
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<td>BPSMIA[CL] - SA PURCHASING MANAGERS INDEX S/A [BER]</td>
<td>0.91550</td>
<td>0.95471</td>
<td>0.054975</td>
<td>0.069038</td>
<td>0.085096</td>
<td>-0.056877</td>
<td>0.039520</td>
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<td>SCTE[CL] - SA TRADE EXPECTATIONS INDEX [SACOB]</td>
<td>0.92711</td>
<td>0.13735</td>
<td>0.052124</td>
<td>0.099609</td>
<td>-0.110447</td>
<td>-0.057320</td>
<td>-0.077271</td>
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<tr>
<td>CVT[CL] - COMMERCIAL VEHICLES SOLD</td>
<td>0.00329</td>
<td>0.65168</td>
<td>0.872312</td>
<td>0.023961</td>
<td>-0.812894</td>
<td>0.172222</td>
<td>0.037556</td>
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<td>CARTOT[CL] - RETAIL CAR SALES - TOTAL</td>
<td>0.13069</td>
<td>0.17593</td>
<td>0.926820</td>
<td>-0.013360</td>
<td>-0.032451</td>
<td>0.041164</td>
<td>-0.016300</td>
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<tr>
<td>TOTV[CL] - TOTAL CAR AND COMMERCIAL VEHICLE SALES</td>
<td>0.05855</td>
<td>0.10568</td>
<td>0.941257</td>
<td>-0.001538</td>
<td>-0.048599</td>
<td>0.085679</td>
<td>-0.011977</td>
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<td>CARBMW[CL] - RETAIL CAR SALES - BMW</td>
<td>0.46584</td>
<td>0.80712</td>
<td>0.085419</td>
<td>0.021794</td>
<td>0.042414</td>
<td>0.059149</td>
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<td>CARTOY[CL] - RETAIL CAR SALES - TOYOTA</td>
<td>0.14652</td>
<td>0.82367</td>
<td>0.117355</td>
<td>0.001945</td>
<td>0.115049</td>
<td>-0.067131</td>
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<td>ALBBO[CL] - ABI TOTAL RETURN INDEX 1 TO 3 YEARS - BEASSA</td>
<td>0.94296</td>
<td>0.22042</td>
<td>0.039300</td>
<td>0.378533</td>
<td>0.061817</td>
<td>-0.054662</td>
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<td>ALBBO[CL] - ABI TOTAL RETURN INDEX 7 TO 12 YEARS - BEASSA</td>
<td>0.95216</td>
<td>0.20774</td>
<td>0.052670</td>
<td>0.042008</td>
<td>0.015407</td>
<td>-0.054769</td>
<td>0.000375</td>
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<tr>
<td>R157[CL] - RSA 13.5% 15.09.2015</td>
<td>0.17538</td>
<td>0.91990</td>
<td>0.025300</td>
<td>-0.009864</td>
<td>0.159234</td>
<td>-0.036438</td>
<td>0.043065</td>
</tr>
<tr>
<td>R157[CL] - RSA 13.5 15.09.2015</td>
<td>0.17538</td>
<td>0.91990</td>
<td>0.025300</td>
<td>-0.009864</td>
<td>0.159234</td>
<td>-0.036438</td>
<td>0.043065</td>
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<tr>
<td>R157[CP] - RSA 13.5% 15.09.2015</td>
<td>0.17538</td>
<td>0.91990</td>
<td>0.025300</td>
<td>-0.009864</td>
<td>0.159234</td>
<td>-0.036438</td>
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</tr>
<tr>
<td>R157[CP] - RSA 13.5 15.09.2015</td>
<td>0.17538</td>
<td>0.91990</td>
<td>0.025300</td>
<td>-0.009864</td>
<td>0.159234</td>
<td>-0.036438</td>
<td>0.043065</td>
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<tr>
<td>R157[CL] - RSA 13.5% 15.09.2015</td>
<td>0.49795</td>
<td>0.81092</td>
<td>0.045207</td>
<td>0.034065</td>
<td>0.082509</td>
<td>-0.076114</td>
<td>0.075194</td>
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<tr>
<td>R157[CL] - RSA 13.5 15.09.2015</td>
<td>0.91342</td>
<td>0.25876</td>
<td>0.06367</td>
<td>0.088554</td>
<td>0.18492</td>
<td>0.037237</td>
<td>0.098211</td>
</tr>
<tr>
<td>R180[CL] - RSA 6.25% INFL LINKED BOND 31.03.2013</td>
<td>0.88800</td>
<td>0.17627</td>
<td>0.060357</td>
<td>0.121993</td>
<td>0.086001</td>
<td>-0.105583</td>
<td>-0.155118</td>
</tr>
<tr>
<td>R180[CL] - RSA 6.25% INFL LINKED BOND 31.03.2013</td>
<td>0.88800</td>
<td>0.17627</td>
<td>0.060357</td>
<td>0.121993</td>
<td>0.086001</td>
<td>-0.105583</td>
<td>-0.155118</td>
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<tr>
<td>R180[CP] - RSA 6.25% INFL LINKED BOND 31.03.2013</td>
<td>0.88800</td>
<td>0.17627</td>
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<td>0.121993</td>
<td>0.086001</td>
<td>-0.105583</td>
<td>-0.155118</td>
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<tr>
<td>R180[CL] - RSA 6.25% INFL LINKED BOND 31.03.2013</td>
<td>0.88800</td>
<td>0.17627</td>
<td>0.060357</td>
<td>0.121993</td>
<td>0.086001</td>
<td>-0.105583</td>
<td>-0.155118</td>
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<tr>
<td>Variable</td>
<td>Compet 1</td>
<td>World 2</td>
<td>Fee Gd 3</td>
<td>Factor 4</td>
<td>Factor 5</td>
<td>Factor 6</td>
<td>RB Brake 7</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
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<tr>
<td>R153[TP] - RSA 13% 31.06.2009</td>
<td>0.43009</td>
<td>0.83869</td>
<td>-0.02144</td>
<td>0.03865</td>
<td>0.011955</td>
<td>0.087019</td>
<td>0.057240</td>
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<tr>
<td>R153[VL] - RSA 13% 31.06.2009</td>
<td>0.63300</td>
<td>0.35360</td>
<td>0.067675</td>
<td>0.002159</td>
<td>0.262385</td>
<td>0.015737</td>
<td>0.090933</td>
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<tr>
<td>R184[CL] - RSA 12.50% 21.12.2006</td>
<td>0.51547</td>
<td>0.49782</td>
<td>0.110469</td>
<td>0.014760</td>
<td>0.599945</td>
<td>0.096493</td>
<td>0.070992</td>
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<tr>
<td>R184[TP] - RSA 12.50% 21.12.2006</td>
<td>0.78243</td>
<td>0.43573</td>
<td>0.125032</td>
<td>0.045560</td>
<td>0.343650</td>
<td>0.036146</td>
<td>0.096866</td>
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<tr>
<td>R184[VL] - RSA 12.50% 21.12.2006</td>
<td>0.23150</td>
<td>0.37411</td>
<td>0.051159</td>
<td>0.209155</td>
<td>0.738279</td>
<td>0.065568</td>
<td>-0.097878</td>
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<tr>
<td>R186[CL] - RSA 10.50% 21.12.2025</td>
<td>0.69251</td>
<td>0.32023</td>
<td>-0.045702</td>
<td>0.007927</td>
<td>0.497127</td>
<td>0.045145</td>
<td>0.075980</td>
</tr>
<tr>
<td>R186[TP] - RSA 10.50% 21.12.2025</td>
<td>0.90120</td>
<td>0.26667</td>
<td>0.023837</td>
<td>0.040630</td>
<td>0.213196</td>
<td>-0.007049</td>
<td>0.091800</td>
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<tr>
<td>R186[VL] - RSA 10.50% 21.12.2025</td>
<td>0.91422</td>
<td>0.13940</td>
<td>0.062559</td>
<td>0.203722</td>
<td>-0.033001</td>
<td>-0.042210</td>
<td>-0.074735</td>
</tr>
<tr>
<td>ZARAUD[CL]</td>
<td>0.88671</td>
<td>0.10825</td>
<td>0.101194</td>
<td>0.150611</td>
<td>-0.153294</td>
<td>-0.034346</td>
<td>0.019074</td>
</tr>
<tr>
<td>USD2[CL]</td>
<td>0.94485</td>
<td>0.41503</td>
<td>0.077477</td>
<td>0.051652</td>
<td>-0.090547</td>
<td>-0.054661</td>
<td>-0.038791</td>
</tr>
<tr>
<td>USD2AR[CL]</td>
<td>0.78025</td>
<td>0.56668</td>
<td>0.012140</td>
<td>0.037816</td>
<td>0.205337</td>
<td>0.126362</td>
<td>-0.024847</td>
</tr>
<tr>
<td>AUDUSD[CL]</td>
<td>-0.42473</td>
<td>-0.00603</td>
<td>0.277689</td>
<td>-0.045206</td>
<td>-0.102011</td>
<td>-0.413556</td>
<td>0.058123</td>
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<tr>
<td>ZRUD1[CL] - COMMERCIAL RAND FORWARD x YEAR [CALC]</td>
<td>0.58326</td>
<td>0.49679</td>
<td>0.107341</td>
<td>-0.018342</td>
<td>0.194139</td>
<td>0.084644</td>
<td>0.002034</td>
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<tr>
<td>USD3[CL]</td>
<td>-0.03840</td>
<td>0.74177</td>
<td>-0.010484</td>
<td>0.030487</td>
<td>0.146310</td>
<td>0.255787</td>
<td>-0.010391</td>
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<tr>
<td>UST3[CL]</td>
<td>-0.03423</td>
<td>-0.58214</td>
<td>0.444068</td>
<td>0.013905</td>
<td>0.107479</td>
<td>-0.021911</td>
<td>-0.077386</td>
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<tr>
<td>USI108[CL] - 3.625% TIPS 15.01.2008</td>
<td>0.73846</td>
<td>0.68003</td>
<td>0.032806</td>
<td>0.234625</td>
<td>0.052106</td>
<td>-0.013937</td>
<td>0.035806</td>
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<tr>
<td>USI20[CL] - 3.025% TIPS 15.01.2020</td>
<td>0.67790</td>
<td>0.10400</td>
<td>0.076054</td>
<td>0.150964</td>
<td>-0.089354</td>
<td>-0.022727</td>
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<tr>
<td>USG10[CL]</td>
<td>0.0233</td>
<td>0.72696</td>
<td>-0.058259</td>
<td>0.333731</td>
<td>-0.076390</td>
<td>0.168913</td>
<td>0.018942</td>
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<tr>
<td>USG30[CL]</td>
<td>-0.45551</td>
<td>-0.63410</td>
<td>0.444197</td>
<td>0.001682</td>
<td>-0.133217</td>
<td>0.126352</td>
<td>-0.044848</td>
</tr>
<tr>
<td>RBAS[CL] - 90 DAY BANKERS ACCEPTANCE [DISCOUNT] [RBAS]</td>
<td>-0.24348</td>
<td>0.55947</td>
<td>0.132883</td>
<td>-0.022840</td>
<td>-0.005946</td>
<td>0.058546</td>
<td>-0.012704</td>
</tr>
<tr>
<td>JBMT[CL] - JIBAR 3 MONTH DISCOUNT</td>
<td>0.21430</td>
<td>0.58347</td>
<td>0.132883</td>
<td>0.022840</td>
<td>0.005946</td>
<td>0.058546</td>
<td>0.012704</td>
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<tr>
<td>SAGO10[CL] - 5A: GOVT 10 YEAR BOND</td>
<td>-0.49361</td>
<td>0.30017</td>
<td>0.125006</td>
<td>0.047457</td>
<td>0.000597</td>
<td>0.665436</td>
<td>-0.059180</td>
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<tr>
<td>SAGO30[CL]</td>
<td>0.05576</td>
<td>0.67310</td>
<td>0.037503</td>
<td>0.004551</td>
<td>0.024209</td>
<td>0.217431</td>
<td>0.013177</td>
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<tr>
<td>J263[CL] - FTSE/JSE - ALL SHARE [ALSH]</td>
<td>0.75516</td>
<td>0.47812</td>
<td>0.165509</td>
<td>0.047703</td>
<td>0.315629</td>
<td>0.004661</td>
<td>0.123294</td>
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<tr>
<td>J260[CL] - FTSE/JSE - FINANCIALS</td>
<td>0.81532</td>
<td>0.52389</td>
<td>0.152409</td>
<td>0.060440</td>
<td>0.495247</td>
<td>0.036515</td>
<td>0.146073</td>
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<tr>
<td>J264[CL] - FTSE/JSE - FLEETING (FLD)</td>
<td>0.77798</td>
<td>0.10797</td>
<td>0.120409</td>
<td>0.108983</td>
<td>-0.036783</td>
<td>-0.027370</td>
<td>0.252961</td>
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<tr>
<td>J202[CL] - FTSE/JSE - GENERAL INDUSTRIALS</td>
<td>0.71688</td>
<td>0.40912</td>
<td>0.167220</td>
<td>0.063453</td>
<td>0.293658</td>
<td>0.003264</td>
<td>0.132233</td>
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<tr>
<td>J211[CL] - FTSE/JSE - INDUSTRIAL 25 [INDI]</td>
<td>0.57052</td>
<td>0.55313</td>
<td>0.165536</td>
<td>0.051474</td>
<td>0.455649</td>
<td>0.015612</td>
<td>0.121935</td>
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<tr>
<td>Variable</td>
<td>Compet 1</td>
<td>World 2</td>
<td>Feel Gd 3</td>
<td>Factor 4</td>
<td>Factor 5</td>
<td>RB Brake 6</td>
<td>K Inflow 7</td>
</tr>
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<tr>
<td>JSE0[CL] - FTSE/JSE: RESOURCES</td>
<td>0.87546</td>
<td>0.35909</td>
<td>0.144311</td>
<td>0.033586</td>
<td>0.111355</td>
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<tr>
<td>JSE1[CL] - FTSE/JSE: VENTURE CAPITAL</td>
<td>0.79254</td>
<td>0.10208</td>
<td>0.065797</td>
<td>-0.096825</td>
<td>-0.332125</td>
<td>0.026539</td>
<td>0.171932</td>
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<tr>
<td>EFFE[CL] - JSE FOREIGN TRANSACTIONS EQUITIES - NET (R'000)</td>
<td>0.19452</td>
<td>0.33053</td>
<td>0.037335</td>
<td>0.047730</td>
<td>0.734734</td>
<td>0.030876</td>
<td>0.372991</td>
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<tr>
<td>EFPEP[CL] - JSE FOREIGN TRANSACTIONS EQUITIES - PURCHASES (F)</td>
<td>0.84230</td>
<td>0.39203</td>
<td>0.072535</td>
<td>0.087253</td>
<td>0.298076</td>
<td>-0.008865</td>
<td>0.120998</td>
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<td>EFPEPES[CL] - JSE FOREIGN TRANSACTIONS EQUITIES - SALES (R'000)</td>
<td>-0.89625</td>
<td>-0.53663</td>
<td>-0.074851</td>
<td>-0.065917</td>
<td>-0.012652</td>
<td>0.010467</td>
<td>-0.049492</td>
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<tr>
<td>JSEM[CL] - JSE MARKET CAP - OVERALL</td>
<td>0.78536</td>
<td>0.39380</td>
<td>0.104510</td>
<td>0.040056</td>
<td>0.392611</td>
<td>0.012039</td>
<td>0.118226</td>
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<tr>
<td>JSEVAL[CL] - JSE TOTAL VALUE TRADED (R'M)</td>
<td>0.90234</td>
<td>0.33486</td>
<td>0.073000</td>
<td>0.022713</td>
<td>0.148723</td>
<td>-0.026067</td>
<td>0.124532</td>
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<tr>
<td>MORGAN[CL] - MORGAN STANLEY WORLD INDEX (US$)</td>
<td>0.46790</td>
<td>0.76250</td>
<td>-0.056604</td>
<td>0.37004</td>
<td>0.320160</td>
<td>0.066343</td>
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<tr>
<td>FSP[CL] - S&amp;P 500</td>
<td>0.59774</td>
<td>0.63504</td>
<td>0.012268</td>
<td>0.049526</td>
<td>0.423337</td>
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<td>0.099350</td>
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<tr>
<td>FT100[CL]</td>
<td>0.45736</td>
<td>0.29937</td>
<td>0.004126</td>
<td>0.049471</td>
<td>0.402066</td>
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<td>0.069711</td>
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<tr>
<td>Oil Inf Ad</td>
<td>-0.14866</td>
<td>-0.74198</td>
<td>0.474456</td>
<td>0.004329</td>
<td>-0.043300</td>
<td>-0.221465</td>
<td>-0.033765</td>
</tr>
<tr>
<td>NGDF1A[CL] - ADVANCED 3 MONTHS</td>
<td>0.64759</td>
<td>0.01735</td>
<td>0.855856</td>
<td>-0.000768</td>
<td>0.211087</td>
<td>0.075624</td>
<td>0.135351</td>
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<tr>
<td>NGDF1A[CL] - ADVANCED 6 MONTHS</td>
<td>0.65714</td>
<td>0.66385</td>
<td>0.844899</td>
<td>-0.007238</td>
<td>0.186714</td>
<td>-0.016380</td>
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<tr>
<td>NGDF1A[CL] - ADVANCED 12 MONTHS</td>
<td>0.90619</td>
<td>0.36338</td>
<td>0.001104</td>
<td>-0.014095</td>
<td>0.137794</td>
<td>-0.172543</td>
<td>0.161740</td>
</tr>
<tr>
<td>log (NGDF1A[CL]) - ADVANCED 12 MONTHS</td>
<td>0.53475</td>
<td>0.13458</td>
<td>0.633210</td>
<td>-0.005237</td>
<td>0.184837</td>
<td>-0.182461</td>
<td>0.147863</td>
</tr>
<tr>
<td>In (NGDF1A[CL]) - ADVANCED 12 MONTHS</td>
<td>0.83475</td>
<td>0.13458</td>
<td>0.633210</td>
<td>-0.005237</td>
<td>0.184837</td>
<td>-0.182461</td>
<td>0.147863</td>
</tr>
<tr>
<td>Period</td>
<td>0.55105</td>
<td>0.76747</td>
<td>0.045226</td>
<td>0.022029</td>
<td>0.097909</td>
<td>0.214827</td>
<td>0.064567</td>
</tr>
<tr>
<td>Reverse</td>
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<td>0.03360</td>
<td>0.068731</td>
<td>-0.081694</td>
<td>0.055185</td>
<td>-0.033804</td>
<td>-0.112184</td>
</tr>
<tr>
<td>Expl/Var</td>
<td>0.25753</td>
<td>2.15299</td>
<td>0.081563</td>
<td>4.190624</td>
<td>5.289455</td>
<td>4.638880</td>
<td>2.005598</td>
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<tr>
<td>Prp. Tuti</td>
<td>0.35773</td>
<td>0.22102</td>
<td>0.077633</td>
<td>0.044114</td>
<td>0.051657</td>
<td>0.045799</td>
<td>0.023490</td>
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</table>
Appendix C. Paper on Dynamic Adaptive Modeling
Market Beating Opportunities from Dynamic Adaptive Modeling

A market moving idea would only be useful to those in the market that move first on better information obtained from the idea. Furthermore, as Eugene Fama pointed out in 1965 with his EMH (Efficient Market Hypothesis), if one did find such an idea, others would soon imitate it and the benefit of using it would be traded away³ (Ball, 1995:6). As a result, economists have expended enormous energy, in building better models that are difficult to imitate and would provide marginally better information, in search of market beating opportunities.

Good regression models hold over long periods of time and those who trusted them have been able to take a position contrary to the market in times when behavioral influences have led markets astray. A good model, when back-tested with the same data over different periods, should yield similar valuation gaps with modeled data ending at times when the valuation gap was shown up over a longer time period. A case in point would be those that benefited during the ZAR crash by trusting the model that uses PPP between USA and South Africa and the strength of the AUD¹⁶ (Gerson, 2004). The problem with such good and relatively simple models is, however, that with time more players in the market start to use the same model, trading away the benefits of using the model.

Linear regression models are generally static and can not easily be used to model the dynamics of response to changes in input variables. Such dynamic effects are seen when nominal exchange rate shocks initially pull the real exchange rate in the same direction, with a time-lagged turn-around in the real exchange rate as inflationary effects set in.

Less good linear regression models generally fail the back-test, and this is often due to changes in the underlying relationships between the variables due to, say, a structural shift in the economy under analysis. An example of this would be the different responses one sees to changes in the oil price – the obvious consequence of higher oil prices is expected inflation, which should result in bond yields rising, whilst the less obvious one is the expected impact on growth, which generally pushes bond yields in the opposite direction. A set of correlations were performed on monthly changes in data between 1974 and 2005 – these are given in Appendix A. Such correlations are the basic building blocks for linear regression, and the appendix shows considerable changes in the correlations for different time periods and under different economic conditions. Whilst the correlation between the oil price and 30 year US government bonds is weak (possibly due to lag effects not being considered) the correlation has moved from positive to negative since 2004, illustrating the changing effects of oil prices outlined earlier.

The problems raised call for the development of models that are able to:
1. Model the dynamic relationships between variables;
2. Detect and adapt to changes in underlying relationships between variables.
The requirements outlined above are very similar to those expected of models describing relationships between physical process variables in the process control and automation industry. A review of this issue specifically is given in an article by David Kendrick (Department of Economics, University of Texas) in the Journal of Economic Dynamics & Control where he reviews progress since a meeting held in 1972 between a group of economists and engineers at Princeton University. “The meeting which was attended by about 40 economists and 20 engineers was to explore the possibility that the application of stochastic control techniques, which had been developed in engineering, would prove to be useful in economics as well” (Kendrick, 2005:3). This paper examines some of the similarities and opportunities for meaningful development, which could motivate interaction between the economics and engineers in South Africa.

1. Modeling Dynamic Relationships

In the simplest of forms, the responses of first-order models of processes output variables (normally analyzed using Laplace Transforms) to unitary step inputs (or shocks as economists like to put it) are shown in Figure 16.

These could typically be the response in the price of tradeable goods \( P_t \) (settling at price at after time \( T_t \)) and non-tradeable goods \( P_n \) (settling at price an after time \( T_n \)) to a shock in the nominal exchange rate \( e_n \). Now, using process control modeling techniques, a model describing the dynamics of the overall price response \( P \) to changes in \( e_n \), as well as the response of the real exchange rate \( e_r \) can be developed as described in Figure 17.

A simulation of this model was run using the following assumptions:
- \( at = 1, T_t = 2 \), meaning that any change in nominal exchange rate would be reflected fully in the price of tradeables in the country, with a first-order lag of 2 months (i.e. 63.21% of final value attained after 2 months);
- \( an = 0.75, T_n = 8 \) for non-tradeables;
- \( bt = 0.7, bn = 0.3 \), meaning that 70% of the domestic consumption basket consists of tradeables;
- $er = en (Pw/P)$, the relationship between the real exchange rate, $er$ and its drivers, the nominal exchange rate $en$ and the inflation differential ($Pw/P$);

The responses of variables ($Pt$, $Pn$, $P$, $P/Pw$, $er$) within the modeled process to a shock in the nominal exchange rate ($en$) are given in Figure 18 to Figure 20. The dynamic plot of the response of real exchange rates shows an initial move with the nominal, followed by a reversion as inflation dynamics are incorporated. Responses are faster and fully reverting for tradeables ($ert$ in Figure 18), but slower and non-reverting for non-tradeables ($ern$ in Figure 19), thus impacting on the overall dynamics ($er$ in Figure 20). The impact of trade barriers, current/capital account changes and intervention (e.g. Chinese purchase of USD denominated securities to keep their currency weak) on the variables have not been considered, but can be incorporated in the model relatively easily.

![Figure 18](image1.png)

**Figure 18: Fast and Reverting Response of Real Exchange Rate for Tradeables**

![Figure 19](image2.png)

**Figure 19: Slower and Non-Reverting Response of Real Exchange Rate for Non-Tradeables**

![Figure 20](image3.png)

**Figure 20: Combined Response of Real Exchange Rate for Overall Economy**
2. Detecting and Adapting to Changes in Relationships

Engineers are often accused of being too inflexible and deterministic, and consequently, models developed by engineers are perceived to be impractical when used to model an economy where relationships (such as that between oil and bond yields) change depending on the overall state of the economy and are highly interactive.

However, such situations are commonly encountered in chemical and metallurgical processes, where very different responses to an input variable can be expected depending upon the state of the reaction. Also, in aeronautics, dynamics at low speed are vastly different to those at high speed. One input variable can also interact with any number of other variables.

To deal with these issues, control engineers have developed "multiple-input multiple-output (MIMO)" (Mendonca, et al, 2004:199) process models, often described by arrays of Laplace Transforms arranged in matrices. MIMO control matrices can then be designed that include feed-forward (off-diagonal elements in the matrices) that reduce interaction to allow a measure of independent control of individual variables.

Whilst a MIMO model can be used to explain interaction between variables, a model is only as good as the parameters that determine it – the model forecasts will become inaccurate as the underlying relationships between variables change. In order to deal with this, control engineers have designed Adaptive MIMO Control techniques that use process estimators to constantly monitor process inputs and outputs to update parameters in the matrix that describes the process – see Figure 21 (Guo, et al, 2001:6784).

![Figure 21: Adaptive MIMO Control System](Guo, et al, 2001:6784)

Examples of such estimators would include the Kalman Filter (Kendrick, 2005:15). The Kalman approach is passive, whilst another approach, the Dual Control (Kendrick, 2005:7) approach, is active in that it relies on purposeful disturbances to a process in order to update parameters (not really accessible to economists, unless they are maverick policymakers). "Model predictive control (MPC) has become the leading form of advanced multivariable control in the chemical process industry" (Dougherty, Cooper, 2003:649). Other techniques include statistical process control and neural network techniques, where a set of parameters for a given process state are memorized for re-application when the process once again enters that state. The estimator looks at changes in relationships which might be “indicating a change in operating regime and a potential change in character due to process nonlinearity” (Megan, Cooper, 1995:172).
3. Conclusions
In summary, a dynamic MIMO model of the economy can be created using the
techniques developed by process control engineers, and such models can be made
flexible to adapt to changes in relationships between the underlying variables. A
MIMO model of an economy would be useful because the ability to forecast changes
in economic variables with a better accuracy than the market in general would provide
the forecaster with market-beating opportunities.

In the words of Jos Gerson:
- Any area that is not properly understood or researched creates opportunities
  for those who know more. Superior knowledge is like gold but average
  knowledge is worthless.
- Such areas may involve short- or long-term issues; and could be of a micro or
  macro nature. (Because 95%+ of analysts and fund managers have a micro
  training - to pick stock - macro is often badly misunderstood - even by
  economists). Yet, 'they' say that only 20% of returns come from stock picking
  and 80% from asset allocation.16 (Gerson, 2004)

Since average knowledge is worthless, regression models that are easily run would
already have been imitated and the market would already have moved. The challenge
therefore for forward-looking investment houses in South Africa is to combine their
economics expertise with that of engineers to create superior adaptive dynamic
models that are difficult to imitate and which can forecast certain key economic
variables used in making asset allocation decisions.

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9. Energy Information Administration of the US Government (Oil data for Appendix
   A).
Appendix A: Correlations at Various Times and under Different Conditions

| GBPUSD(CLP) | JPYUSD(C) | Oil Infl Ad | USCP(C) | USINF(C) | USDEFC | CLSGB30(C) | CLSSTB3M | CLSCOINC | CLSUSD(C) | CLSSHOUS(C) | CLSTB3M(C) | CLSUSD(C) | CLSCOINC | CLSSHOUS(C) | CLSTB3M(C) |
|-------------|-----------|-------------|---------|----------|--------|------------|----------|----------|-----------|------------|------------|------------|----------|------------|------------|----------|
| 0.44029     | 0.45771   | 1           | Correlation Between Monthly Changes in Variables | 0.130815 | 0.105515 | 0.262775  | 1        | 0.119997 | 0.117986  | 0.114701  | 0.169485   | 0.138562   | 0.019492  |           |            | 1         |
| -0.12849    | -0.04124  | 1           | Period 2004 to 2005 Inclusive | 0.133264 | 0.143811 | 0.141821  | 0.199742 | 0.226314 | 0.039316  | 0.039316  | 0.039316   | 0.039316   | 0.039316  |           |            | 1         |
| 0.44447     | 0.45391   | 1           | Correlation Between Monthly Changes in Variables | 0.103133 | 0.032172 | 0.396964  | 0.382079 | 0.36374  | 0.393136  | 0.103133 | 0.103133  | 0.103133   | 0.103133  | 0.103133  |           |            | 1         |
| 0.41261     | 0.42216   | 1           | Correlation Between Monthly Changes in Variables | 0.093745 | 0.182892 | 0.304465  | 0.49415  | 0.071009 | 0.085025  | 0.022293  | 0.04415  | 0.04415    | 0.04415    | 0.04415   |           |            | 1         |
| 0.50236     | 0.50216   | 1           | Correlation Between Monthly Changes in Variables | 0.091997 | 0.191525 | 0.554074  | 0.11753   | 0.149333 | 0.027813  | 0.00114  | 0.00114    | 0.00114    | 0.00114   |           |            | 1         |