Price earnings ratios on the Johannesburg Stock Exchange - Are they a guide to value?

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This paper tests whether there is an equilibrium relationship between prices and earnings on the Johannesburg Stock Exchange (JSE). Such a relationship would hold if the JSE Index and index earnings were *cointegrated*. A full explanation of the technique of cointegration is provided. It is shown that prices and earnings on the JSE are not cointegrated, which is aconsistent with similar results obtained for the New York Stock Exchange. The paper then offers a more general explanation of prices on the JSE to include, in addition to earnings, the influence of world markets and political and exchange rate risk, on the value of the JSE as represented by its Industrial and Financial Index. It is found that the variables of these models of the JSE are in fact cointegrated. This means that there have been forces driving long term equilibrium values on the JSE. Movements away from such equilibrium values have represented market beating opportunities. Current prices are thus not the best estimate of future prices, suggesting that the JSE cannot be regarded as an efficient market.

KEY WORDS
Johannesburg Stock Exchange (JSE), P/E Ratios, Market Efficiency, Cointegration, Unit Roots, Error Correcting Mechanism, Bond Market Yield Spreads, Sovereign and Exchange Rate Risks, PPP and Real Exchange Rates, Over or Undervaluation.

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INTRODUCTION - PE RATIOS AND MARKET EFFICIENCY

In financial markets, the search for the holy grail of a reliable market beating model continues unabated. The promise of market beating predictions remains the *raison d' etre* of most professional analysts and portfolio managers. Much attention is given by market commentators to the price to earnings ratios (PE) of listed securities or averages of them as a guide to value calculations. Judgements are often made about the attractions or otherwise of a share or a share market on the basis of current price to historic earnings ratios compared to some benchmark. The benchmark may be the PE of close substitutes or the historic PE of a company or a market.

The ability to take a consistent market beating position presupposes that one has information that the market does not have and that the market will later "discover" this information and price it in a similar fashion. If markets were *efficient,* this endeavour would be pointless as prices would *already* reflect known information. But markets have to be made efficient. The process of capturing and analysing new information and then acting on it, is itself costly and brings its own return. If the market in market research is itself efficient, then presumably market analysts simply capture the value added of their activity as income. Market analysis is thus about establishing the right price now, where the right price is the price that the market will determine when the analysts contribution to knowledge is "properly" incorporated.

If markets are efficient we may assume that security prices are representative of the present value of future earnings (and hence dividend) prospects. The ratio of price to earnings is a measure of the future performance relative to the present. Relatively High PE ratio shares assume good growth prospects and that relatively low current earnings are not representative of much higher earnings expected in the future.. In this paper we look at the relationship between Price and Earnings on the JSE and consider whether it might be expected to be a helpful, market beating, guide over the longer run.

We consider therefore whether there is evidence of a long run equilibrium relationship between prices and earnings on the JSE. Such a relationship would hold if JSE prices and earnings were found to be *cointegrated*. In this paper we provide a full explanation of cointegration and its relevance to this issue. In common with a number of studies of the relationship between prices and earnings or dividends in other stock exchanges we find little evidence for a stable long term relationship between prices and earnings (only) on the JSE.[1]

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[1] A comprehensive survey of such attempts may be found in Chapter 7 of John Y. Campbell, Andrew W. Low and A. Craig MacKinlay (1997). See also Shiller (1981) and Campbell and Shiller (1987, 1988)

We therefore consider whether other variables when combined with earnings influence the relationship in a systematic way. We propose some more general simple models, based upon economic fundamentals, to explain the behaviour of the JSE Financial and Industrial Index. Included in these models are measures of exchange rate and political risk for South Africa as well as the influence of world stock market trends. We test whether price and the arguments of these models form a long term equilibrium relationship.The results of this exercise are consistent with the notion that there are long term economic forces driving value on the JSE and that persistent movements away from equilibrium do represent market beating opportunities.

THE RELATIONSHIP BETWEEN PRICE AND EARNINGS ON THE JSE

In order to abstract from the sharply declining influence of the mining sector on the JSE, this study focuses on the performance of the Financial and Industrial Index after 1980. A cross-sectional plot of the index and indexed earnings is shown below. A plot of the market PE over this period is also given.

Figure 1

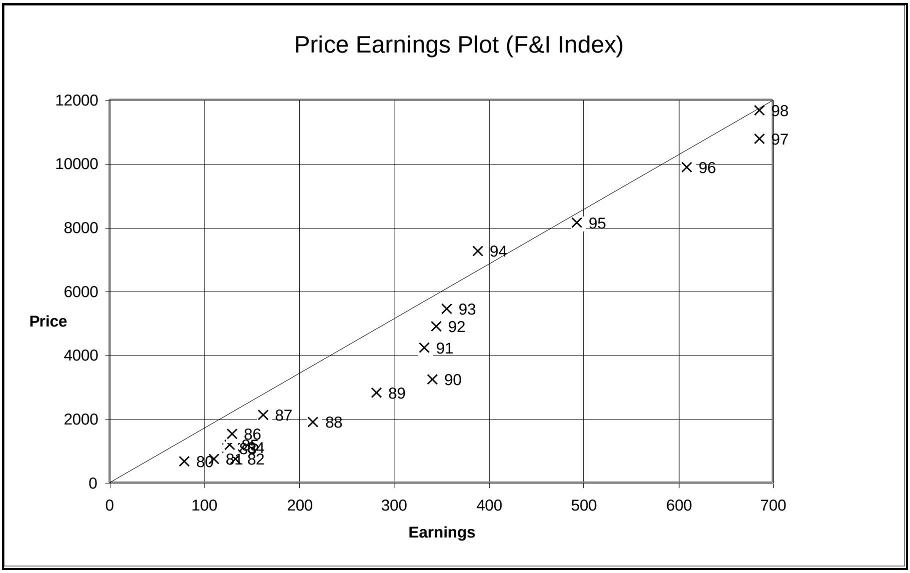
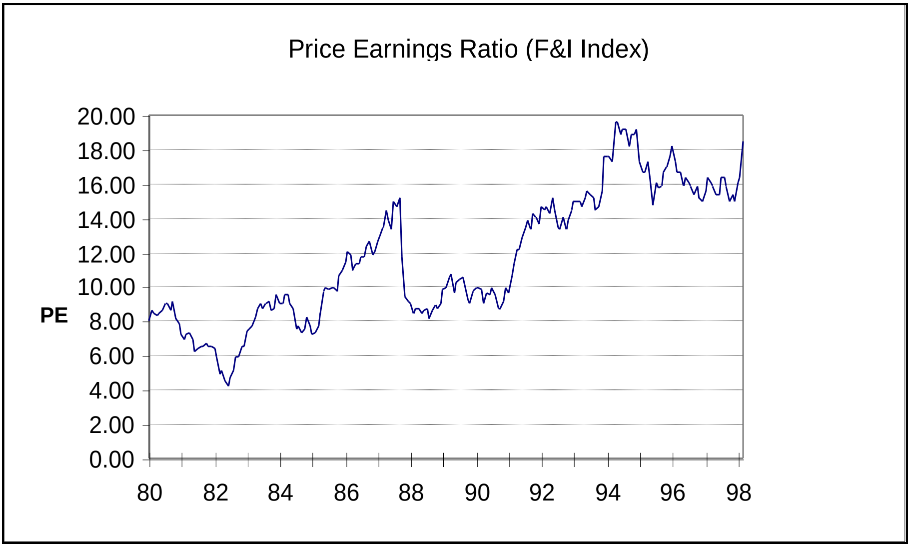


Figure 2



As can be seen, figure 2 indicates a rising trend in the PE. We consider below possible explanations for this behaviour, and show that the relationship is complex and non-linear. The fundamentals of our models of value are most generally captured as a log-log relationship between Price (the value of the Index) and Earnings. The model is then extended to include additional relevant explanatory variables.

THE VALUATION MODEL

The basic theory of value may be reduced to the following general form:

$$PV_t = \sum_{i=t+1}^{\infty} \frac{E(B_i)}{(1+r)^{i-t}} \qquad (1)$$

where PV_t represents the present value benefits expected from an investment project at time t, in this case an investment in a share or basket of shares, E is the expectations operator, B_i represents the realised benefits expected over the future of the project, and r is the opportunity cost of capital or the rate at which the expected benefits will be discounted. This present value is then compared with the cost of making the investment at time t. If the PV_t exceeds the investment cost, then it is worth making.

Any such model clearly presupposes consistency in the calculation of its components. A potential problem is that accountants (or the Stock Exchange) may change the definition of after tax earnings that are reported by listed companies. For example, actual earnings may become less or more smooth depending on the treatment of extraordinary revenue or charges. Investors and their analysts will make their own adjustments to convert reported earnings or dividends to estimate sustainable earnings. Changes in tax rules may also make dividends less or more attractive over time. In addition, the opportunity to buy back shares may replace dividends as a form of shareholder return. Such technical changes may make a significant difference to the relationship between alternative measures of performance and the value of an individual company. When all companies are combined into some market index such differences may well average out. In fact, at the aggregate level a very high correlation between alternative measures of performance for the JSE is observed (see Table 1 below where national income accounting and stock exchange measures of performance are compared). It is thus clear that at an aggregate level performance measures follow each other very closely are are statistically equivalent.

Table 1: Correlations between different corporate performance measures in South Africa. (Annual data 1960- 1996)

Performance Measures	*Correlation*
Gross operating surplus, Net operating surplus**	*99.50 %*
Gross operating surplus, ALSI earning flows*	*97.40 %*
Gross operating surplus, ALSI dividend flows*	*97.61 %*
Net operating surplus, ALSI earning flows*	*97.35 %*
Net operating surplus, ALSI dividend flows*	*98.01 %*
ALSI earning flows, ALSI dividend flows	*99.47 %*

* National Income Statistics- Source South African Reserve Bank

ALLOWING FOR GROWTH AND UNCERTAINTY

If we make the additional assumption that the perpetual stream of earnings (or dividends) is expected to grow at a constant nominal rate *g* and we discount these earnings at the cost of capital *r* we have the well known result:

$$PE = \frac{1}{r-g} \tag{2}$$

Clearly this representation is only a stylisation. An infinite series of Earnings is not discounted by the market nor is the rate at which expected earnings are discounted likely to remain constant. More realistically, some time horizon of earnings is considered and is itself dependent on *r* and *g* , expanding and contracting as the level of uncertainty about the economic and political environment changes. The equation does capture a fundamental tenet, namely that PE is determined primarily by the difference between the cost of capital and growth prospects.

THE IMPACT OF INFLATION ON PE RATIOS

As inflation rises, the (nominal) rate of discount *r* would increase and g might be expected to rise by the same amount, so that the difference between them remains, and PE is unaffected.

Other things however do not always remain equal as inflation rises. As inflation increases, so the uncertainty around future inflation may rise. If so, *r* may well then increase (by more than the rate of inflation) to capture this uncertainty (and g may rise by less than the rate of inflation under conditions of higher uncertainty) leading to a decline in PE. It is thus the second moment effects of high (low) inflation rather than the higher (lower) inflation itself which lead to decreasing (increasing) PE.

ALLOWING FOR RISK.

The cost of equity capital, *r*, may be regarded as equal to the long bond yield plus some equity risk premium.

$$r = Bond\, yield + Equity\, Risk\, Premium \qquad (3)$$

The nominal bond yield itself is some combination of a real rate of interest and expected inflation. Bond yields capture both the first and the second moment effects of inflation. Thus, for the most part, bond yields reflect the markets (risk adjusted) expectation of future rates of inflation. If real rates are fairly constant, bond yield changes represent changes in expected inflation. Thus, for example, higher bond yields mean a higher *r* and associated higher *g* with *r* increasing more than *g* to compensate for the higher levels of uncertainty. PE would then fall.

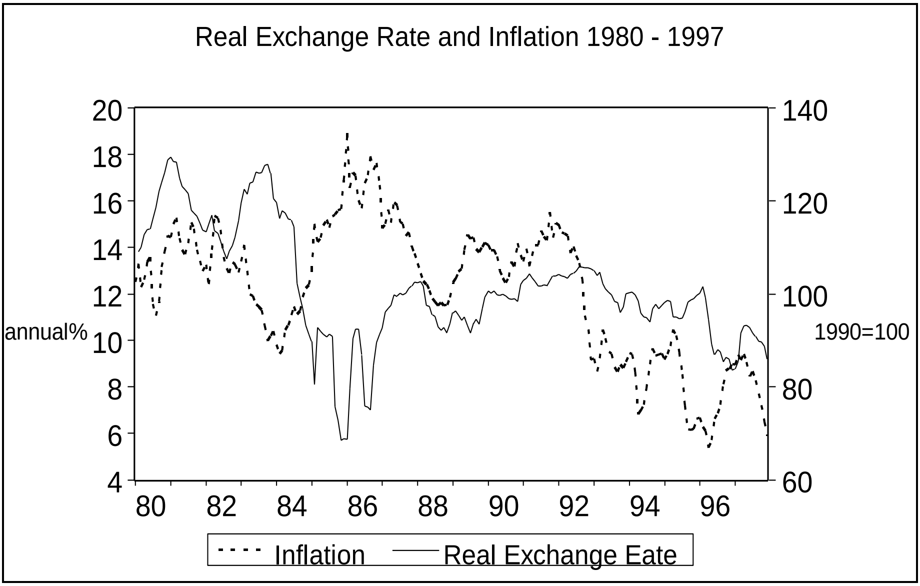
As Figure 1 shows the PE for financial and industrial shares in SA (in line with overseas markets) has drifted up steadily over the last two decades. According to the valuation formula above, this must relate to an increase in *g* or decrease in *r*. However, *r* and *g* would not, in fact, be expected to be independent, even if the degree of uncertainty and the relevant time horizons for investors, remained unchanged. If *g* were to increase across the economy with the advent of improved technology, for example, then the competition for capital would increase and real rates of return to savers would also rise.

The increasing international mobility of capital might mean however that this equilibrating process is long delayed. High saving, low growth countries, can provide the capital for high growth regions of the world without much affecting the average world wide return to capital. If so *g* may well be expected to rise without affecting *r*. If so the PE ratio would rise in response to lower perceptions of country or sovereign risk.

International investors in South Africa would also have to factor in exchange rate and exchange control expectations in the calculation of *r*. If what was lost on the exchange rate swings were immediately regained on the inflation, or growth in earnings roundabout, purchasing power parity exchange rates would be sustained and foreign investors in equities would be insulated from the first order effects of inflation. Of course purchasing power parity (PPP) for the Rand and its foreign exchange value does not always hold. There are times when the exchange rate follows and other times when the exchange rate leads differences in inflation between South Africa and its trading partners.

PPP exchange rates nevertheless may be regarded as a long run equilibrium relationship for SA. As may be seen in Figure 3 the Real Effective exchange rate, (1990 = 100), has deviated temporarily from its PPP values. In 1980 and 1981 the gold price averaged over $600 and the real exchange rate was then more than 20% overvalued. The weaker gold price and the political crisis of the mid eighties soon reversed this. The collapse of the Rand in 1985 caused the currency to be as much as 35% undervalued. But higher inflation brought the currency back into line with its PPP value by 1988. Deviations from PPP values since then have been relatively minor.

Figure 3

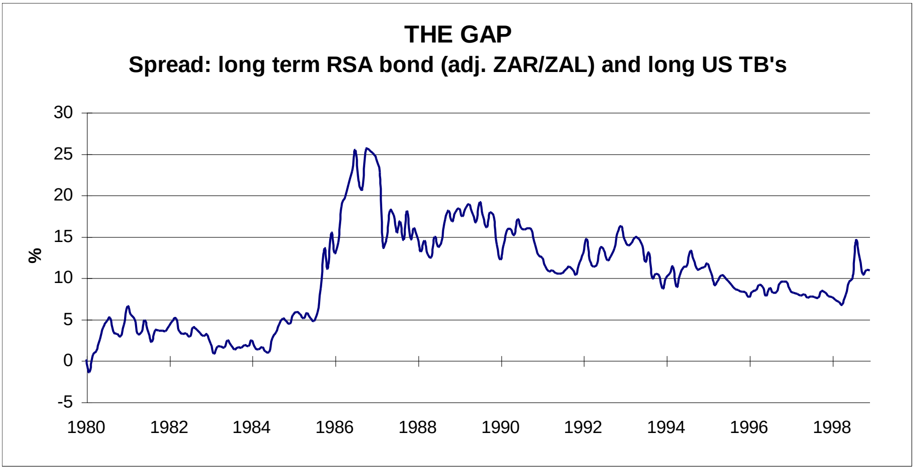


It should be appreciated that weakness in the nominal exchange rate caused by some political shock, as occurred after 1985, will lead rather than follow higher inflation and higher nominal earnings growth. This lag between exchange rate weakness and higher inflation driven earnings growth represents a particular source of inflation related uncertainty for the offshore investor. A weaker exchange rate immediately reduces the value of current earnings expressed in a stronger currency. That nominal earnings growth may catch up in time may not be enough compensation for the immediate decline in the value of current earnings for the off-shore investor. In such cases a decline in share market prices relative to current earnings growth, especially when expressed in the stronger foreign currency, is likely to be observed.

CALCULATING A RISK PREMIUM FOR INVESTING IN SOUTH AFRICA

The difference between the yield on a South African government Rand bond for the off-shore investor (i.e. in US dollar form) and the yield on a US government Treasury Bond of similar maturity may be regarded as the premium for bearing South African currency and other risks. The more negative the sentiment the higher the risk premium required as compensation by investors in Rand Bonds. This yield spread is illustrated in figure 4. In the equations below this yield spread is designated as the GAP.

Figure 4



This risk premium should represent two separate risks borne by the off-shore investor. The first risk is that the currency in which the investment is made may be expected to lose exchange value over time, pure exchange risk. The second risk is that the government of the country will adopt policies that are hostile to investors generally and to offshore investors in particular (sovereign or political risk). Such hostile action may take the form of:

(a) exchange controls that restrict the payment of dividends or capital, or

(b) taxes.

While political risk may be regarded in principle as separate from exchange rate risk, clearly the risks of exchange control, which may be regarded as a political risk but will affect exchange rate expectations, cannot in practice be separated from exchange rate expectations.

In converting Bond yields into their off-shore equivalents the Financial Rand[2] (ZAL) exchange rate is used for those periods where the ZAL was in use. The Commercial Rand (ZAR) exchange rate was used to convert Rand dividend or interest payments into their dollar equivalents. It should also be recalled that dividends and interest were always remitted at the ZAR rate rather than the ZAL exchange rate, which justifies the use of the ZAR rate to convert Rand earnings into their dollar equivalents.

To measure sovereign risk, to the exclusion of exchange rate risks, one could simply compare time equivalent government bonds denominated and traded in the same currency. The absence of a well developed market in foreign currency denominated RSA bonds makes such a calculation impossible for the entire period under review. The recent issues of South African government Yankee, Sumarai and Dmark bonds and the development of a Eurorand bond market provide helpful information about SA sovereign risk over the past two years.

Adapting the PE Model of Value, specifying possible Equilibrium Relationships

Our stylisation (2) above, would tend to imply that the PE ratio was dependent on inflation (and bond yields) but only in so far as second moment (proportional uncertainty) effects are concerned. Improved growth prospects would lead to an increase in the PE only if there were no compensating increase in r , that is, where the risk premium is either reduced or unaffected. Thus it is difficult on *a priori* grounds to regard PEs as having some stable long term equilibrium as the relationship is inflation and risk dependent. The results obtained for the JSE All Share Index and the NYSE bear this out.

We noted also that for the foreign investor in SA, who clearly has a marked influence on the value of the JSE, a critical link is between inflation and the

[2] The Financial Rand (ZAL) was not so much a currency but a ratio of share prices in Johannesburg to prices of the same share traded in New York or London. The difference in the price of, say, De Beers in New York and De Beers in Johannesburg when calculated at the ZAR rate was known as the “financial Rand discount”, measured in Rands per dollar as 100*(ZAL-ZAR)/ZAL. Exchange control on direct purchases or sales between residents and non-residents eliminated the opportunity to arbitrage away these price differences. However interest and dividend payments were made in the more valuable ZAR. In effect exchange control created a largely stagnant pool of South African securities held by non-residents. Non-residents traded these securities between themselves at a discount to market prices which, because the interest and dividends were paid in ZAR, gave the investors higher running returns, and gave rise to arbitrage between the different assets. The discount would rise or fall as market sentiment became more or less negative, and the actual and required running yield would increase or decrease. Thus the ZAL discount may be regarded as a barometer of market sentiment.

exchange rate. Thus a proper specification for any model of the index value of the JSE might include the exchange rate as an argument in the determination of market value. In addition, SA security price trends are linked to perceptions of global prosperity and the global cost of capital. We may capture both these effects by including the value of the NYSE as represented by its composite index, the S&P500, in addition to current earnings levels, as explanatory variables of a model explaining the level of SA equity prices.

We might thus test whether Prices on the JSE are cointegrated with earnings and world markets. A problem with this specification, however, is that it embodies the current rate of exchange in the Rand value given to the S&P 500, rather than expectations of exchange rate movements. We thus also consider a specification which separates the effects of the global confidence effects, as embodied in the S&P500, from the effects of expected movements in the Rand/US dollar exchange rate. This specification therefore includes the value of the S&P 500 expressed in Rands as well as the Gap, the difference in US & SA bond yields (adjusted for the Financial Rand where applicable) which may be regarded largely as a measure of expected exchange rate changes. We test below a range of specifications of such models for cointegration to establish whether there is some long term equilibrium relationship at work in determining the value of the Financial and Industrial Index of the JSE after 1980.

THE ECONOMETRIC PROCEDURES AND THEORY

Testing for the order of integration - Unit roots tests

In order to test for the possibility that variables y_t and x_t (or set of x_t) are cointegrated, it must first be established that y_t and x_t, in our example prices and earnings, have the same order of integration. The most general test for the existence of a unit root is taken to be Augmented Dickey-Fuller (ADF) test. This test can be applied to a time series that reflects an underlying full term AR(p) process and which also includes a constant and a time trend with the following representation:

$$y_t = \beta_0 + \beta_1 t + \sum_{i=1}^{p} \phi_i y_{t-i} + \varepsilon_t \qquad (4)$$

This may be rewritten as:

$$\nabla y_t = \beta_0 + \beta_1 t - \delta_1 y_{t-1} + \sum_{i=2}^{p} \delta_i \nabla y_{t-i+1} + \varepsilon_t \qquad (5)$$

This regression formulation is the basis of the ADF test and tests based on the t-statistic of $\hat{\delta}_1$ are known as the Augmented Dickey-Fuller test statistics. The existence of at least one unit root will be reflected in a value of ρ close to 1 and thus a value of $\hat{\delta}_1$ close to 0. The usual t-statistic is used but under the null hypothesis of H_0: $\delta_1 = 0$, the assumption of normality will not apply. Specially formulated tables of significance points have thus been constructed by MacKinnon (1990) using Monte Carlo techniques according to sample size and the inclusion of a constant and trend term, as well as the number of included lagged difference terms (which should reflect the degree of the underlying AR process)[3]. Such tables of critical values have been generated. In the above formulation, if the t-statistic for $\hat{\delta}_1$ is more negative than the appropriate critical value, then non-stationarity may be rejected and the series may be regarded as ~I(0). One tests successive levels' differences until the null is rejected. The number of differences required thus determines the order of integration. If the variables have the same order of integration then the possibility exists that they are cointegrated.

Cointegration Tests

Engle and Granger (1987) originally provided a number of alternative tests for the existence of a cointegrated relationship between two (or more) variables. These tests considered whether the residuals from the cointegrating regression were ~I(0). The test that has become standard in the econometric literature is the Augmented Dickey-Fuller test for unit roots performed on the cointegrating regression residuals (CRADF), see Muscatelli and Hurn(1992). This test is a standard test of stationarity (unit root test) on the cointegrating regression residuals, except that there is no time trend adjustment and no intercept term. This test is run without an intercept term because the residuals have a zero mean over the sample (with Ordinary Least Squares). If we denote the regression residuals by $\hat{z}_t$ we consider

$$\nabla \hat{z}_t = -\delta_1 \hat{z}_{t-1} + \sum_{i=2}^{p} \delta_i \nabla \hat{z}_{t-i+1} + \varepsilon_t \qquad (6)$$

where p is large enough to ensure that ε_t is white noise. The t-statistic of $\hat{\delta}_1$ is the CRADF statistic. Appropriate critical values have been formulated, as mentioned above, which take account that standard t-table values will result in too often rejecting the null hypothesis that y_t and x_t are not cointegrated (H_0 : z_t~I(1) is the usual case). The test is analogous to the unit root test above and the tables of MacKinnon (1990) apply.

[3] In practice a sequential procedure is generally implemented with the order of the formulation reduced until significant coefficients are obtained.

The test for cointegration between y_t and x_t (or set of x_t , (X_t)) thus comprises two parts:

i) Test each time series for the *same* order of integration. In the case of economic time series, I(1) is the most common representation.

ii) Test the residuals of the cointegrating regression for a *reduction* in the order of integration established in (i) above. In the case of economic time series this will thus usually be a test of whether $z_t \sim I(0)$.

Error Correcting Mechanisms (ECM)

If y_t and x_t (or X_t), are cointegrated, the Granger Representation theorem (see Engle and Granger 1987) states that there is a corresponding error correction representation (amongst others) of the form:

$$\nabla y_t = \alpha_0 + \alpha_1 \hat{z}_{t-1} + \sum_{i=1}^{p} \beta_i \nabla y_{t-i} + \sum_{k=1}^{K} \sum_{j=1}^{q} \gamma_{jk} \nabla X_{k,t-j} + \varepsilon_t \qquad (7)$$

where $\hat{z}_{t-1}$ is the lagged equilibrium error, ε_t is a white noise process and $|\alpha_1| \neq 0$.

This ECM captures the short term interactions between y_t and X_t while maintaining the long term equilibrium relationship. (see Hendry 1996 and Harris 1995)

Testing the model - Applying the Augmented DF tests

As indicated earlier we focus our attention on modelling the Financial and Industrial Index (F&I) of the JSE over the period 1980 to 1997. The relationship between price and earnings for the JSE All Share Index, the Industrial Index and the S&P 500 was also tested using the same procedures outlined above. The results of these tests are given in Appendix 1.

In the following models we consider the long term equilibrium relationship of the F&I with the earnings of this index, the S&P500 expressed in Rands and the difference between the US and SA bond yields. We thus perform the Augmented Dickie Fuller test for a unit root on the *levels* on the following variables over the period January 1980-December 1997:

Log of the Financial and Industrial Index (F&I) expressed in Rands - LOGFI
Log of the F&I Index expressed in dollars - LOGFI$
Log of the earnings from the F&I Index expressed in Rands - LOGEAFI
Log of the earnings from the F&I Index expressed in dollars - LOGEAFI$
Log of the S&P500 expressed in Rands - LOGSPR

Log of the S&P500 expressed in dollars - LOGSP$
Bond Yields in SA minus Bond yields in US - GAP

Table 2

Variable	DF t-statistics	MacKinnon Critical values for % level of significance		
LOGFI	-3.0400	1%	5%	10%
LOGFI$	-2.7779	-4.0011	-3.4309	-3.1390
LOGEAFI	-2.5587			
LOGEAFI$	-1.6712			
LOGSPR	-1.9434			
LOGSP$	-2.7918			
GAP	-1.4631			

The null-hypothesis of non-stationarity is *accepted* in each case. All variables are thus integrated of order at least one. We thus perform the Augmented Dickey Fuller test for a unit root on the *differences* of the same variables.

Table 3

Variable (differenced)	DF t-statistics	MacKinnon Critical values for % level of significance		
LOGFI	-6.4528	1%	5%	10%
LOGFI$	-6.6742	-4.0011	-3.4309	-3.1390
LOGEAFI	-3.4517			
LOGEAFI$	-6.3798			
LOGSPR	-8.0788			
LOGSP$	-6.3421			
GAP	-7.3280			

The null-hypothesis of non-stationarity is *rejected* in each case. Hence each of the variables considered is seen to be integrated of order 1 and thus we may now test specifications based on these variables for cointegration.

Testing various specifications for cointegration

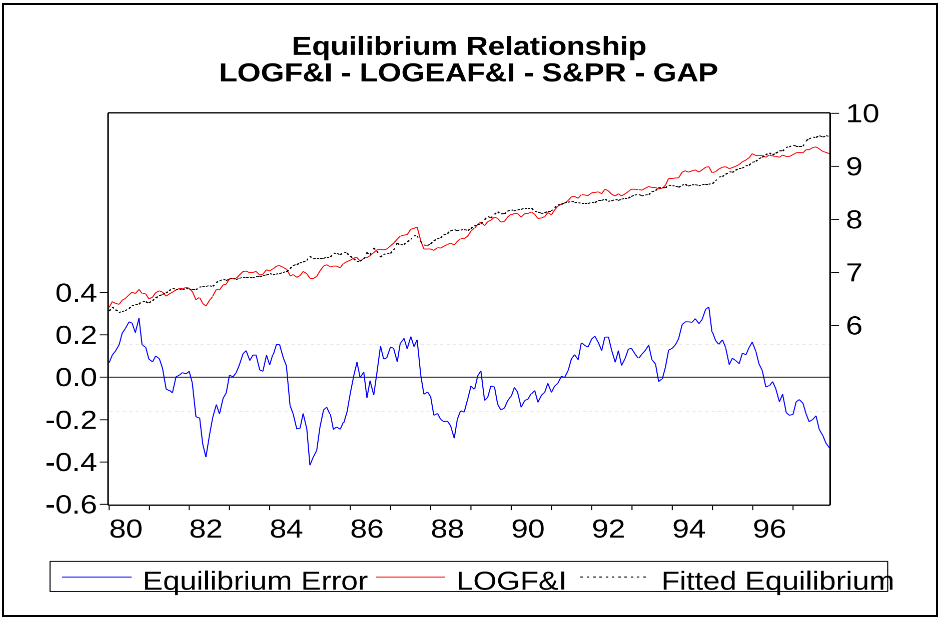
As it has been established that LOGFI (and LOGFI$) as well as LOGEAFI (and LOGEAFI$), LOGSPR (and LOGSPR$) and the GAP have the identical order of integration (~I(1)), one may now proceed to test whether LOGFI (and LOGFI$) are cointegrated with specifications using LOGEAFI (or LOGEAFI$), LOGSPR (or LOGSPR$) and the GAP. As discussed above, this requires that the residuals of the cointegrating regression are tested for stationarity (the absence of unit roots) so that it may be established that the residuals are ~I(0).

Engle-Granger Co-integration Test			**MacKinnon critical values (for % level of significance and # of X_t's)**		
Model Specification	DF t-statistics	Independent variables	1%	5%	10%
LOGFI LOGEAFI LOGSP$	-3.3925	2	-4.7529	-4.1757	-3.8777
LOGFI LOGEAFI LOGSPR	-4.5616	3	-5.0738	-4.4972	-4.1998
LOGFI LOGEAFI LOGSPR GAP	-4.3169				
LOGFI$ LOGEAFI$ LOGSP$	-3.0021				
LOGFI$ LOGEAFI$ LOGSP$ GAP	-2.8225				

Cointegrated specifications

The specifications of the model:
LOGFI LOGEAFI LOGSPR
LOGFI LOGEAFI LOGSPR GAP
are cointegrated at the 5% and 10% level respectively. None of the other specifications are cointegrated at the 10% level. For the establishment of a long run equilibrium relationship for the value of the JSE it thus appears critical to separate the S&P500 into a global risk component (expressed in Rand terms) and a currency expectation component (GAP).
The residuals from the second cointegrating regression
LOGFI LOGEAFI LOGSPR GAP (or $LOGFI = \alpha + \beta_1 LOGEAFI + \beta_2 LOGSPR + \beta_3 GAP$) are shown below in Figure 5.

Figure 5



Error Correction Models

We tested the error correction specification in equation (7) using the cointegration specifications above. Two lagged first differences for each variable were used in each specification (see Engle and Yoo 1987). The ECM regressions are listed in Appendix B. Each specification gave a significant α_1 and an insignificant Q-statistic. This confirms that despite short term disequilibrium there is a long term, statistically significant process, to restore equilibrium (see also Harris 1995, 24-25).

CONCLUSION: THE IMPLICATIONS OF THE ECONOMETRIC RESULTS

We have established that versions of the fundamental value model of the JSE are cointegrated. This fundamental value model predicted by a model of value that includes as its arguments the current level of JSE earnings, the current level of world markets and a variable that represents exchange rate expectations and may therefore be regarded as representing long run equilibrium values for the JSE. It follows that, then observed temporary deviations from equilibrium values established by this model may indicate market beating opportunities.

The actual and fitted values of the cointegrating equation (LOGFI LOGEAFI LOGSPR GAP, see also Appendix B Table 3) for the period 1980 -1997 using month end values are shown in figure 5. The residual of this equation indicates the percentage difference between the fitted and actual values. A positive residual represents a selling opportunity and a negative residual provides a buy signal. The identification of a statistically significant error correction process for the time series of residuals (Appendix B Table 7) has important implications. It suggests that the greater the movement away from equilibrium, the more likely the move back to it. The movement thus has a measure of predictability. If so, the JSE could not be regarded as an efficient market that captures all relevant market related information.

It may be seen that the JSE according to the model was overvalued in 1994 and 1995. The subsequent correction through the course of 1996 and 1997 made the JSE appear significantly undervalued and a favourable buying opportunity at the end of 1997. The sharp upward movement in the JSE in the first months of 1998 did bring the market closer to its equilibrium value as the model predicted at the end of 1997.

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APPENDIX A

The Augmented Dickey Fuller (DF) test for a unit root on the *levels* of the following variables over different periods:

January 1960 - December 1997:
Log of the All Share Index expressed in Rands - LOGALSH
Log of the earnings from the All Share Index expressed in Rands - LOGEALSH
Log of the S&P500 Index expressed in dollars - LOGSP$
Log of the earnings from the S&P500 expressed in dollars - LOGEASP$

January 1970 - December 1997:
Log of the Industrial Index expressed in Rands - LOGIND
Log of the earnings from the Industrial Index expressed in Rands - LOGEAIND

Table 1

Variable	DF t-statistics	Unit Root	percentage	MacKinnon Critical values
1960 - 1997				
LOGALSH	-2.5017	accept	1%	-3.9878
LOGEALSH	-1.5533	accept	5%	-3.4236
LOGSP$	-0.8925	accept	10%	-3.1341
LOGEASP$	-2.0134	accept		
1970-1997				
LOGIND	-3.5993	reject at 5%		
LOGEAIND	-1.5267	accept		

The null-hypothesis of non-stationarity is *accepted* in all cases with the exception of the Industrial Index which is significant at the 5% and 10% level, the non stationary hypothesis is rejected and we can conclude that the index is I(0). All the other variables are thus integrated of order at least one. We have performed the Augmented Dickey Fuller test for a unit root on the *differences* of the same variables (results not shown) and they were seen to be integrated of order 1. We than tested the price earnings specifications based on these variables for cointegration.

Table 2

Engle-Granger Co-integration Test		MacKinnon critical values	
Model Specification	DF t-statistics	sig. %	1 independents
LOGALSH LOGEALSH	-2.5084	1%	-4.3648
LOGSP$ LOGEASP$	-0.7906	5%	-4.8034
LOGIND LOGEAIND	-3.1631	10%	-3.5123

None of the price and earnings specifications are cointegrated at the 10% level.

APPENDIX B

Equilibrium Regressions Results:

Table 1

```
LS // Dependent Variable is LOGFI
SMPL range: 1980.01 - 1997.12
Number of observations: 216
========================================================================
      VARIABLE      COEFFICIENT   STD. ERROR      T-STAT.   2-TAIL SIG.
========================================================================
         C         -2.7495655     0.2354290    -11.678961    0.0000
      LOGEAFI       0.4521581     0.0511480     8.8401883    0.0000
       LOGSP$       1.0681668     0.0549399     19.442460    0.0000
========================================================================
R-squared                 0.977079    Mean of dependent var    7.838486
Adjusted R-squared        0.976863    S.D. of dependent var    0.917574
S.E. of regression        0.139570    Sum of squared resid     4.149181
Log likelihood            120.3650    F-statistic              4539.806
Durbin-Watson stat        0.137555    Prob(F-statistic)        0.000000
========================================================================
```

Table 2

LS // Dependent Variable is LOGFI
SMPL range: 1980.01 - 1997.12
Number of observations: 216

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-1.8569437	0.3607487	-5.1474711	0.0000
LOGEAFI	0.6837855	0.0540615	12.648286	0.0000
LOGSPR	0.4387902	0.0311131	14.103049	0.0000

R-squared	0.967111	Mean of dependent var	7.838486
Adjusted R-squared	0.966802	S.D. of dependent var	0.917574
S.E. of regression	0.167184	Sum of squared resid	5.953456
Log likelihood	81.37039	F-statistic	3131.681
Durbin-Watson stat	0.111358	Prob(F-statistic)	0.000000

Table 3

LS // Dependent Variable is LOGFI
SMPL range: 1980.01 - 1997.12
Number of observations: 216

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-0.9375236	0.3822091	-2.4529077	0.0150
LOGEAFI	0.5090195	0.0608052	8.3713170	0.0000
LOGSPR	0.5930643	0.0414456	14.309460	0.0000
GAP	-0.0204064	0.0038739	-5.2677092	0.0000

R-squared	0.970918	Mean of dependent var	7.838486
Adjusted R-squared	0.970506	S.D. of dependent var	0.917574
S.E. of regression	0.157582	Sum of squared resid	5.264397
Log likelihood	94.65496	F-statistic	2359.223
Durbin-Watson stat	0.122878	Prob(F-statistic)	0.000000

Table 4

LS // Dependent Variable is LOGFI$
Date: 4-27-1998 / Time: 19:01
SMPL range: 1980.01 - 1997.12
Number of observations: 216

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-2.7638325	0.3594025	-7.6900761	0.0000
LOGEAFI$	0.7197111	0.0418063	17.215393	0.0000
LOGSP$	0.5570703	0.0197511	28.204470	0.0000

R-squared	0.890288	Mean of dependent var	7.059675
Adjusted R-squared	0.889258	S.D. of dependent var	0.472739
S.E. of regression	0.157318	Sum of squared resid	5.271507
Log likelihood	94.50919	F-statistic	864.2267
Durbin-Watson stat	0.116296	Prob(F-statistic)	0.000000

Table 5

LS // Dependent Variable is LOGFI$
SMPL range: 1980.01 - 1997.12
Number of observations: 216

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-1.8370498	0.3989673	-4.6045127	0.0000
LOGEAFI$	0.5647694	0.0523994	10.778159	0.0000
LOGSP$	0.6704275	0.0311594	21.516071	0.0000
GAP	-0.0172166	0.0037639	-4.5741008	0.0000

R-squared	0.900143	Mean of dependent var	7.059675
Adjusted R-squared	0.898730	S.D. of dependent var	0.472739
S.E. of regression	0.150439	Sum of squared resid	4.797990
Log likelihood	104.6741	F-statistic	637.0141
Durbin-Watson stat	0.123673	Prob(F-statistic)	0.000000

Error Correcting Mechanism Regressions

Table 6

LS // Dependent Variable is DFI
SMPL range: 1980.04 - 1997.12
Number of observations: 213

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	0.0095578	0.0047908	1.9950391	0.0474
RES2(-1)	-0.0577382	0.0229919	-2.5112458	0.0128
DFI(-1)	0.1849344	0.0705274	2.6221638	0.0094
DFI(-2)	0.0039824	0.0711489	0.0559727	0.9554
DEAFI(-1)	0.1699089	0.1646019	1.0322410	0.3032
DEAFI(-2)	-0.0925495	0.1664409	-0.5560505	0.5788
DSPR(-1)	0.0060303	0.0798484	0.0755222	0.9399
DSPR(-2)	0.0131109	0.0803581	0.1631556	0.8706

R-squared	0.063005	Mean of dependent var	0.013228
Adjusted R-squared	0.031010	S.D. of dependent var	0.053144
S.E. of regression	0.052314	Sum of squared resid	0.561029
Log likelihood	330.2988	F-statistic	1.969202
Durbin-Watson stat	2.005102	Prob(F-statistic)	0.060782
Ljung-Box Q-Stat (12 Lags)	3.98	Prob 0.9839	

Table 7

LS // Dependent Variable is DFI
SMPL range: 1980.04 - 1997.12
Number of observations: 213

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	0.0096218	0.0048698	1.9758028	0.0495
RES1(-1)	-0.0550742	0.0254659	-2.1626678	0.0317
DFI(-1)	0.1888869	0.0738189	2.5587892	0.0112
DFI(-2)	0.0227584	0.0742313	0.3065869	0.7595
DEAFI(-1)	0.1564904	0.1698583	0.9212995	0.3580
DEAFI(-2)	-0.0563070	0.1705849	-0.3300819	0.7417
DSPR(-1)	-0.0186577	0.0849727	-0.2195727	0.8264
DSPR(-2)	-0.0027336	0.0824205	-0.0331662	0.9736
DGAP(-1)	-8.820E-05	0.0039267	-0.0224618	0.9821
DGAP(-2)	0.0046844	0.0040372	1.1603090	0.2473

R-squared	0.061680	Mean of dependent var	0.013228
Adjusted R-squared	0.020080	S.D. of dependent var	0.053144
S.E. of regression	0.052608	Sum of squared resid	0.561822
Log likelihood	330.1484	F-statistic	1.482683
Durbin-Watson stat	2.012550	Prob(F-statistic)	0.156174
Ljung-Box Q-Stat (12 Lags)	4.18	Prob 0.9800	