CHAPTER 6

EMPIRICAL ESTIMATION OF THE SOUTH AFRICAN STOCK MARKET

6.1 INTRODUCTION

In this chapter, a structural model for the South African stock market is developed and estimated based on the theory presented in chapter three. The long run and short-run behaviour or the stock market is modelled separately with the cointegration equation and the error correction model respectively. However, standard cointegration techniques assume that stock market behaviour is symmetric, while theory suggests that there are several potential causes for asymmetry (see chapter three). Therefore, the Enders and Siklos (2001) test for asymmetric cointegration will be used to evaluate the potential asymmetry where appropriate. Three different cases of asymmetry will be evaluated, namely asymmetry conditional on (i) the state of the business cycle, (ii) whether the stock market is over-valued or under-valued and (iii) the direction of the error terms, thus allowing for the possibility that the errors exhibit more "momentum" in one direction than the other[1].

Once cointegration has been established and the cointegration vector estimated, the error correction model (ECM) will be estimated taking into account the asymmetric adjustment if it is found to be significant in the cointegration analysis. Since investors in the stock market is forward-looking, the error-correction model will also be specified in such a way that this is captured.

[1] It is debatable whether the asymmetry exists in the conditional mean or variance of stock prices, and proponents of both can be found in the literature. Studies that analyze asymmetry in the conditional variance of stock prices usually employ GARCH models. However, these studies are typically based on daily or high frequency data (e.g. De Santis 1991, Kitazawa 2000, Masulis and Ng 1995, Koutmos and Booth 1995, Brooks *et al* 1997), in contrast with this study in which quarterly data will be used. In this study, asymmetry in the conditional mean of stock prices will be evaluated, although a test for omitted GARCH non-linearity will be done to show that there are no remaining non-linearity in the conditional variance.

6.2 DATA

The data for the South African gross domestic product (GDP), JSE all-share index (JSE), long-term (R_L) and short-term interest rates (R_S) and the gold price (Gold) were obtained from the South African Reserve Bank (www.reservebank.co.za). Data for the US long-term interest rate (R_L^{US}) and the Standard and Poor 500 Index (SP500) were obtained from the Federal Reserve Bank of St. Louis (www.stlouisfed.org). Quarterly data were used from the third quarter of 1978 to the end of 2000. The construction of the discount rate (Discount), risk premium (Risk) and state of the business cycle indicator (S) is described below.

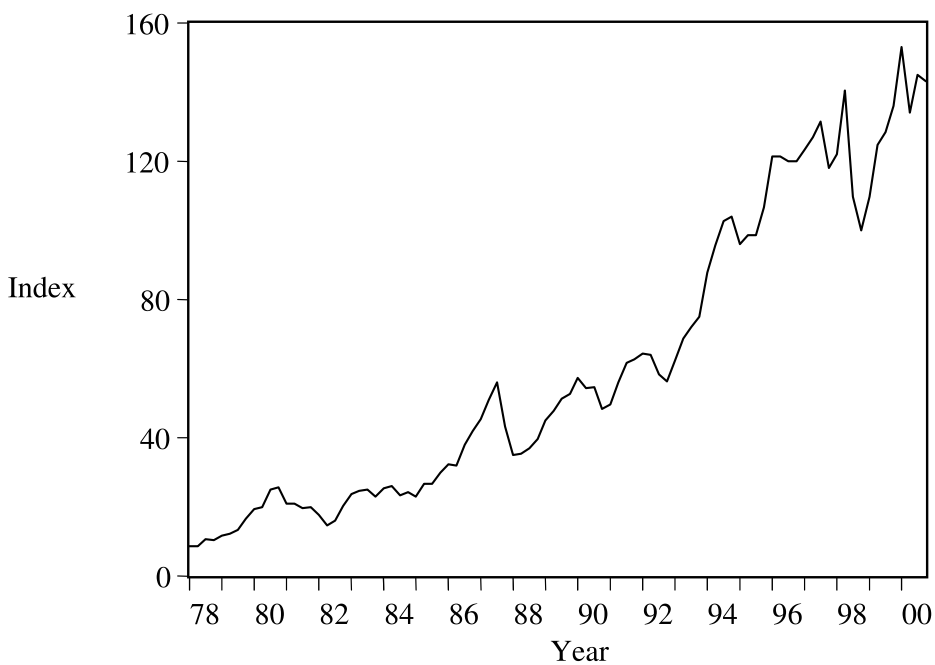
The discount rate comprises the real risk-free long-term interest rate, an inflation premium and a risk premium (see chapter three). The nominal yield on 10-year government bonds captures both the real interest rate and the inflation premium. However, this yield also includes a risk premium that awards investors for taking on the additional risk of investing in South African bonds instead of US government bonds which are considered truly risk-free. Since this yield already includes a premium for the country risk, the additional risk premium included in the discount rate only has to capture the risk of investing in South African stocks rather than bonds, in other words the equity premium. Jagannathan *et al* (2000) showed that the equity premium can be proxied by the sum of the dividend yield and expected dividend growth, less the real bond yield. According to the IMF (2001), the expected dividend growth can by proxied by the growth in potential output. Following Barrel and Davis (2003), the growth in potential output was constructed by using a Hodrick Prescott filter on real economic growth to proxy dividend growth. Hence the discount rate in this study was constructed as the sum of the nominal yield on 10-year government bonds and the equity premium[2].

[2] In many studies the risk premium is assumed to be constant (see e.g. Harasty and Roulet 2000). However, Firer and Bradfield (2002) have shown that South Africa's risk premium has declined over time. Barrel and Davis (2003) have shown that the risk premiums of six developed countries have also been time-varying. It would therefore be inappropriate to follow Harasty and Roulet (2000) in omitting the risk premium based on the assumption that it is constant.

The risk premium (risk) attempts to capture the country risk of investing in South Africa and is therefore constructed as the excess returns on long-term South African government bonds relative to long-term US government bonds.

The state of the business cycle variable was constructed in chapter five with the Markov switching regime model (see section 5.5.4). This variable takes on the value one if the economy is in a recession according to the Markov switching regime model and zero otherwise.

Figure 6.1 The JSE All-share Index



Source: South African Reserve Bank, Quarterly Bulletin, various issues.

Models that contain potentially non-stationary variables can result in a spurious regression, indicating statistically significant relationships where there are none. The statistical significance obtained from standard regression techniques with non-stationary variables is picking up the existence of contemporaneous correlation in the variables due to their trending over time, rather than a meaningful causal relationship between them. It is therefore vital to determine the order of integration of all the variables used in the econometric analysis, since this will determine the correct estimation technique to use.

Table 6.1 List of Variables

Variable	Explanation
JSE	JSE all-share index
GDP	Gross domestic product
Discount	Constructed discount rate
Gold	Gold price
SP500	Standard and Poor's 500 Index (S&P500)
S	State of the business cycle dummy variable constructed in chapter five
R$	Rand-$US exchange rate
R_S	Short-term interest rate (three-month bankers' acceptance rate)
Risk	Risk premium, defined as difference between long-term interest rates of South Africa and the US (the yields on 10-year government bonds)
Residual	Residual from estimated long-run stock market equation (see table 6.9)

In this study, the augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests were used in conjunction with data plots to establish the order of integration of the variables. The ADF test assumes that the errors are statistically independent and have a constant variance, while the PP test allows the disturbances to be weakly dependent and heterogeneously distributed (Enders 1995:239). The PP test also has greater power to reject the false null hypothesis of a unit root, except when the errors have a moving average (MA) structure, in which case this test tends to reject the null hypothesis whether it is true or false. Since the structure of the error terms is usually unknown, it is preferable to use both tests. Hence both the augmented Dickey Fuller (ADF) and the Phillips-Perron (PP) tests were used in this study to establish the order of integration of the variables.

According to the results in tables 6.2 and 6.3, the stock price index, GDP, the gold price, the Standard Poor 500 index, the short-term interest rate, the Rand-US$ exchange rate and the risk premium is integrated of order one and therefore has to be differenced once before being included in the ECM.

Table 6.2 Augmented Dickey-Fuller and Phillips-Perron Tests for Non-Stationarity, Levels

Series	**Model**	**Lags**	$\tau_\tau, \tau_\mu, \tau$	ϕ_3, ϕ_1	**PP (3 lags)**
Log(JSE)	Trend	1	-4.356***	7.84	-3.88**
	Constant	1	-1.720	2.98	*1.729
	None	1	1.911		2.24
Log(GDP)	Trend	4	-1.26	4.44	-0.48
	Constant	3	-4.31***	6.33	-4.14***
	None	4	2.23		12.13
Log(Gold)	Trend	0	-2.59**	7.81	-3.62**
	Constant	0	-2.60	6.78	-2.56
	None	0	-2.74*		2.47
Log(SP500)	Trend	1	-2.45	2.70	-2.47
	Constant	0	0.52	0.72	0.43
	None	0	5.01		4.64
R_S	Trend	1	-2.82	9.83	-2.26
	Constant	1	-2.92	14.91	-2.39
	None	1	-0.71		-0.61
Log(R$)	Trend	3	-2.76	3.09	-2.32
	Constant	3	-0.35	1.83	0.012
	None	3	1.86		2.87
Risk	Trend	0	-2.087	2.21	-2.20
	Constant	0	-1.35	1.81	-1.34
	None	0	-0.21		-0.19

*/**/*** Significant at a 10%/5%/1% level.

Source: Own calculations

Table 6.3 Augmented Dickey-Fuller and Phillips-Perron Tests for Non-Stationarity, First Differenced

Series	Model	Lags	τ_τ,τ_μ,τ	ϕ_3,ϕ_1	PP (3 lags)
Δlog(JSE)	Trend	0	-7.86***	30.90	-7.81
	Constant	0	-7.81***	61.07	-7.77
	None	0	-7.28***		-7.28
Δlog(GDP)	Trend	2	-6.56***	23.99	-9.72***
	Constant	3	-2.95**	17.38	-8.29***
	None	3	-1.101		-2.61***
Δlog(Gold)	Trend	0	-8.44***	35.6	-8.43***
	Constant	0	-8.30***	68.8	-8.29***
	None	0	-7.69***		-7.73***
Δlog(SP500)	Trend	0	-7.88***	31.25	-7.86***
	Constant	0	-7.93***	62.83	-7.91***
	None	0	-6.45***		-6.55***
ΔR_S	Trend	0	-5.98***	17.89	-5.94***
	Constant	0	-5.96***	35.54	-5.93***
	None	0	-5.99***		-5.97***
Δlog(R$)	Trend	2	-4.12***	19.86	-8.366***
	Constant	2	-4.14***	26.77	-8.39***
	None	2	-3.21***		-7.48***
ΔRisk	Trend	0	-8.46***	35.83	-8.41***
	Constant	0	-8.51***	72.31	-8.46***
	None	0	-8.53***		-8.48***

*/**/*** Significant at a 10%/5%/1% level.

Source: Own calculations

6.3 EFFICIENCY OF THE SOUTH AFRICAN STOCK MARKET

Stock market efficiency has fundamental implications for stock market analysis and trading. If stock markets are not efficient, stock prices are forecastable from past price behavior alone (see section 3.2.1). The Random Walk theory, which assumes that consecutive price changes are independent and identically distributed over time, is central to the testing of the ability of past returns to predict future returns. If prices follow a random walk, it means that yesterday's price change should not be related to the price change of today, or any other day, since it should be independent (Fifield, Lonie and Power 1998). The implication for trading is that future price movements cannot be predicted successfully on the basis of historic price movements and technical analysis will therefore not yield abnormal profits. However, a fundamental analyst capable of making a better than average estimate of the intrinsic value of shares will be able to make above average profits.

Several tests including the runs test, the Durbin-Watson test and the Breusch-Godfrey test have been performed to test whether the South African stock market is weak-form efficient. Although share prices are seldom perfectly independent, stock market investors are mostly concerned with whether the dependence is sufficient to allow the history of the series of price changes to be used to predict the future in such a way that the expected returns would be greater than under a simple buy-and-hold model (Thompson and Ward 1995).

The runs test was performed on the share returns to test the null hypothesis that successive outcomes are independent, in other words that no serial correlation are present and hence that historical price information and trends cannot be used to predict future share prices. The number of runs (k) is distributed asymptotically normally with

m: $$E(k) = \frac{2n_1 n_2}{n_1 + n_2} + 1 \quad (6.1)$$

and

variance: $$\sigma_k^2 = \frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)} \qquad (6.2)$$

where n_1 is the number of positive observations and n_2 the number of negative observations. From the total of 90 share return observations, 61 are positive and the remaining 29 are negative returns. The number of runs (k) was 53. Using the standard normal test statistic of 29.11, the null hypothesis of randomness was rejected, which is evidence against stock market efficiency.

As a second test for efficiency, the level of share prices was modeled with a random walk. According to the results of the Durbin-Watson test for serial correlation, the null hypothesis of no serial correlation was not rejected (the calculated value of the Durbin-Watson test statistic was 2.08). Therefore the residuals of the random walk are not autocorrelated, which is supporting market efficiency since prior observations of share prices do not significantly influence current share prices. Furthermore, an integrated autoregressive moving average (ARIMA) model was also estimated for the share returns to confirm the results of the share price ARIMA model. According to the Akaike and Schwartz-Bayesian model selection criteria, the best ARIMA model had no autoregressive or moving average terms and the order of integration was zero, so that share returns are randomly distributed. According to the results of the Durbin-Watson test for serial correlation (a calculated test statistic of 2.08), the null hypothesis of no serial correlation was not rejected. The Breusch-Godfrey test for no serial correlation were applied to the residuals of this equation and the null hypothesis of no autocorrelation up to order two (LM=3.74) or four (LM=5.27) were not rejected at a five percent level of significance. This also supports weak-form efficiency.

The results of the runs and serial correlation tests are inconclusive regarding the efficiency of the JSE and a structural model therefore might outperform trading rules based on technical analysis. Although primary focus of study is on developing and estimating a structural model of the stock market not on developing a trading strategy, the profitability and forecasting ability of the structural model will be compared to other models in chapter seven.

6.4 THE COINTEGRATION EQUATION

According to the expected present value model reviewed in chapter three, stock prices are a function of (a proxy for) dividends and the discount rate. However, it has to be tested empirically whether this model holds for South Africa. If these variables are cointegrated, the cointegration vector will reflect the magnitudes of the impact of each variable on the long-run level of the stock market. In addition to the long-run cointegration equation an error-correction model will be estimated to capture the short-run fluctuations of the stock market. This will evaluate whether and to what extent factors such as exchange rates, interest rates, contagion, foreign stock markets and the gold price influences the stock market in the short-term.

According to the theories reviewed in chapter three, there are several potential asymmetries in these relationships. Theoretically, risk-averse investors might react asymmetrically to good or bad conditions or news, since they will react promptly on receiving bad news or during adverse conditions, while it prevents them from acting quickly when receiving good news or during positive conditions (Chalkley and Lee 1998). There are two potential forces driving this asymmetry. First, since real economic activity is one of the main determinants of dividends an economic upswing (downswing) will cause higher (lower) dividends and can therefore be considered as good (bad) news or conditions. In other words, the speed of adjustment during downswings should be faster than during upswings. This necessitates the use of a variable that reflect the state of the economy. Since the official indicator of the South African business cycle published by the South African Reserve Bank is only available with a considerable lag, the Markov-switching state variable developed in chapter five will be used instead. This variable also has the advantage that it is not biased by the asymmetric recession definition and can therefore indicate the true state of the economy in each period.

Second, if the stock market is undervalued it means that the market prices of shares are below their intrinsic value, so that a profit opportunity created since investors can buy shares at the low current market price and eventually resell it at a higher price once the market has corrected the discrepancy between the market and intrinsic value. In contrast, when the stock market is overvalued market prices of shares are above the intrinsic values. Eventually the market will correct this discrepancy so that share prices fall, in which case investors will loose money. Investors are risk averse which means that when they are not absolutely certain whether the market is under- or over-valued, they would rather choose the least risky option. In other words, they will react quickly when the stock market is overvalued in order to avoid a potential loss, but they will react much slower when the stock market is undervalued. In addition, Siklos (2002) has suggested that the asymmetry might be caused not only by whether the stock market is over- or undervalued, but also by the direction of the error terms so that the momentum depends on whether the errors are increasing or decreasing. Therefore, the possibility of asymmetric cointegration caused by the under- or over-evaluation or by the direction of the error have to be explored.

It has been shown by Pippenger and Goering (1993), Balke and Fomby (1997) and Enders and Granger (1998) that the Johansen and Engle-Granger tests assuming linear adjustment have low power in the presence of asymmetric adjustment. In other words, there is a high probability of not rejecting the null hypothesis of no cointegration when in fact the series are cointegrated. However, this means that the conclusion is reliable if the null hypothesis of no cointegration is rejected and problems only arise when the null hypothesis is not rejected. In order to avoid this problem, the Enders and Siklos (2001) test for threshold cointegration will be employed to evaluate the potential asymmetry introduced by the sign or momentum of the error terms. The asymmetric behavior conditional on the state of the business cycle will be dealt with individually since no test has yet been developed for this case.

6.4.1 Stock Market Asymmetry Conditional on Characteristics of the Error Terms

The test of Enders and Siklos (2001) to determine whether the deviations from the long-run equilibrium are asymmetric in nature is a generalization of the Enders and Granger (1998) threshold autoregressive (TAR) and momentum-TAR (M-TAR) tests for unit roots to a multivariate context. These are, in turn, based on the basic TAR and M-TAR models, which respectively allows the degree of autoregressive decay to depend on state of variable at interest and different degrees of autoregressive decay to depend on whether the series is increasing or decreasing.

In the Enders and Siklos (2001) test, the error term, u_t, is modified to allow for two types of asymmetric error corrections based on the cointegration relationship. First the long-run cointegration equation is estimated in order to calculate the estimated results, which are used to estimate the following equation

$$\Delta\hat{u}_t = I_{t-1}\rho_1\hat{u}_{t-1} + (1 - I_{t-1})\rho_2\hat{u}_{t-1} + \sum_{i=1}^{p}\gamma_i\Delta\hat{u}_{t-i} + \varepsilon_t \qquad (6.3)$$

where I_t is the Heaviside indicator function which takes on one of the following specifications depending on the source of the asymmetry:

(i) $I_{t-1} = 1$ if $\hat{u}_{t-1} \geq \tau$, 0 otherwise (6.4)

(ii) $I_{t-1} = 1$ if $\Delta\hat{u}_{t-1} \geq \tau$, 0 otherwise (6.5)

where τ is the threshold.

In general, the value of τ is unknown and it has to be estimated along with the values of ρ_1 and ρ_2. However, in most economic applications it makes sense to set τ=0 so that the cointegrating vector coincides with the attractor (Enders and Siklos 2001). In such circumstances, adjustment with specification (i) is $\rho_1 u_t$ if the stock market is above the long-run equilibrium and $\rho_2 u_t$ if the stock market is below long-run equilibrium. In other words, the speed of adjustment is different depending on whether the stock market is over- or under-valued.

Specification (ii), the momentum-threshold autoregressive (M-TAR) model, was suggested as an alternative to specification (i) by Enders and Granger (1998) and Caner and Hansen (1998) such that the threshold depends on the previous period's change in the error correction term. The M-TAR model allows for the possibility that the errors (u_t) exhibit more "momentum" in one direction than the other. This type of adjustment is especially relevant in situation where policy makers are attempting to smooth out any large changes in the series. For example, the central bank might take strong measures to counteract shocks to the term structure relationship if these shocks are deemed to indicate increases, but not decreases, in inflationary expectations.

Similarly, with a managed float exchange rate regime, the central bank may want to mitigate large changes in the exchange rate without attempting to influence the long-run level of the rate.

This specification is consistent with a wide variety of error-correcting models. Given the existence of a single cointegrating vector with stationary residuals $\{u_t\}$ the error-correcting model for any variable y_{it} can be written in the form

$$\Delta y_{it} = \rho_{1,i} I_{t-1} \mu_{t-1} + \rho_{2,i}(1 - I_{t-1})\mu_{t-1} + ... + v_{it} \quad (6.6)$$

where $\rho_{1,i}$ and $\rho_{2,i}$ are the speed of adjustment coefficients of Δy_{it}. In other words, once cointegration has been established and the cointegrating vector has been estimated, the error correction model can be estimated as usual as long as the speed of adjustment is allowed to differ conditional on the indicator variable (I_t).

The procedure for using the Engle and Siklos (2001) test is as follows. Equation 6.3 is estimated and the two t-statistics for the null hypothesis ρ_1=0 and ρ_2=0 along with the F-statistic for the joint hypothesis $\rho_1 = \rho_2 = 0$ (called the ϕ test statistic) are recorded. The smallest of the two t-statistics is called t-Min and the largest t-statistic is called t-Max. The t-Min statistic has been shown to have very low power and therefore only the t-Max and ϕ tests are used. The distribution of t-Max depends on number of variables included in the cointegration equation and the sample size as well as the dynamic structure of the data generating process (similar to Engle-Granger ADF critical values). The t-Max and ϕ tests are used to test the null hypothesis of no cointegration using the critical values given by Enders and Siklos (2001). If the variables are cointegrated, the null hypothesis of symmetric adjustment H_0: $\rho_1=\rho_2$ can be tested.

Similar to the case of the Engle-Granger test for symmetric cointegration, the error terms have to be white noise. Serial correlation is eliminated by the lagged changes in the first difference of the long-run residual (u_t) in equation 6.3. Following the recommendation of Said and Dickey (1984), serial correlation was tested from a maximum of int($T^{1/3}$) = int(4.48) = 4 lags. In both cases only the first lag of the differenced residual were significant. The results of the cointegration test for TAR and M-TAR adjustment are presented in tables 6.4 and 6.5. The cointegration equation underlying the results in tables 6.4 and 6.5 is based on the discounted dividend model, in other words between share prices, GDP and the discount rate. The estimation results of this equation are presented in table 6.9.

Table 6.4 Cointegration Results, Case (I) TAR-Adjustment

Dependent Variable: Δ*Log(Residual)*

Variable	*Coefficient*	*t-statistic*	*Probability*
Residual(-1)*I(-1)	-0.25	-2.29	0.025
Residual(-1)*(1-I(-1))	-0.35	-2.65	0.010
ΔResidual(-1)	-0.25	-2.29	0.025
t-Max	-2.29*	F-test ($\rho_1 = \rho_2$)	0.226
ϕ-statistic	8.31*		

Source: Own calculations

According to the results in table 6.4, the ϕ-statistic of 8.31 is greater than the 10 percent critical value of 5.08, while the t-Max statistic of –2.29 is less than the 10 percent critical value of -1.92, so that the null hypothesis of no cointegration is rejected by both tests at the 10 percent level. According to the results for testing the null hypothesis of symmetric adjustment (F-statistic is 0.226), the null hypothesis is not rejected and therefore the adjustment is symmetric. This means that the adjustment is symmetric regardless whether the stock market is over- or undervalued.

According to the results in table 6.5, the ϕ-statistic of 8.31 is greater than the five percent critical value of 6.01 and the t-Max statistic of –2.885 is less than the 10 percent critical value of –1.92 so that the null hypothesis of no cointegration is rejected at least at the 10 percent level by both tests. According to the results for testing the null hypothesis of symmetric cointegration/adjustment (F-statistic is

0.003), the null hypothesis is not rejected and therefore the adjustment is symmetric. In other words, the adjustment is symmetric regardless of the direction of the stock market.

Table 6.5 Cointegration Results, Case (II) MTAR-Adjustment

Dependent Variable: Δ*Log(Residual)*			
Variable	*Coefficient*	*t-statistic*	*Probability*
Residual(-1)*I(-1)	-0.29	-3.51	0.000
Residual(-1)*(1-I(-1))	-0.30	-2.88	0.005
ΔResidual(-1)	0.32	3.25	0.002
t-Max	-2.88*	F-test ($\rho_1 = \rho_2$)	0.003
ϕ-statistic	8.31*		

Source: Own calculations

6.4.2 Stock Market Asymmetry Conditional on the State of the Business Cycle

It is has been established that no asymmetry of the first two types, i.e. based on the sign or momentum of the error terms, are present in the stock market. However, the possibility of asymmetry conditions on the state of the business cycle remains to be tested. No test equivalent to that of Enders and Siklos (2001) is available for testing asymmetry conditional on the state of the business cycle. However, since the problem with applying the Johansen and Enders and Granger tests for symmetric cointegration in the presence of asymmetric adjustment is low power (Pippenger and Goering (1993), Balke and Fomby (1997) and Enders and Granger (1998)), the problem is a high probability of not rejecting the null hypothesis of no cointegration when in fact the series are cointegrated. However, this means that the conclusion is reliable if the null hypothesis of no cointegration is rejected and problems only arise when the null hypothesis is not rejected. The results of the Johansen cointegration tests are presented in tables 6.7 and 6.8.

The order of the VAR was determined on the basis of the Likelihood and the Akaike and Schwartz-Bayesian criteria (see table 6.6). Tables 6.7 and 6.8 give the results of the trace and eigenvalue tests, which indicate that the equation is cointegrated at a five percent level of significance and that there is only one cointegration vector. The cointegration results are reported in table 6.9.

Table 6.6 Test Statistics and Choice Criteria for Selecting the Order of the VAR Model

Order	Log Likelihood	Akaike	Schwarz Bayesian
4	**229.5090**	193.5090	149.3308
3	223.0076	**196.0076**	**162.8739**
2	175.5390	157.5390	135.4499
1	117.4193	108.4193	97.37490
0	-597.2638	-597.2638	-597.2638

Source: Own calculations

Table 6.7 Trace Test For Cointegration

Cointegration LR Test Based on Trace of the Stochastic Matrix
Order of VAR = 3

Null	*Alternative*	*Statistic*	*95% critical value*	*90% critical value*
r=0	r>=1	39.3256*	31.54	28.78
r<=1	r>=2	14.7101	17.86	15.75
r<=2	r=3	4.79810	8.070	6.500

* Reject null hypothesis on 5% level of significance

Source: Own calculations

Table 6.8 Eigenvalue Test For Cointegration

Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
Order of VAR = 3

Null	*Alternative*	*Statistic*	*95% critical value*	*90% critical value*
r=0	r=1	24.6155*	21.12	19.02
r<=1	r=2	9.91200	14.88	12.98
r<=2	r=3	4.79810	8.070	6.500

* Reject null hypothesis on 5% level of significance
Source: Own calculations

The trace and eigenvalue tests rejected the null hypothesis of no cointegration and confirmed the presence of a single cointegrating vector. The Engle and Granger test statistic of –4.85 is smaller than the relevant critical value, so that the null hypothesis of no cointegration is rejected, which confirms that the variables are cointegrated. This means that there is a cointegrated relationship between these variables and that the long-run relationship can be estimated using cointegration techniques.

In the presence of non-stationary variables, ordinary least squares (OLS) is super-consistent if the variables are cointegrated. However, in the presence of non-stationary series the OLS coefficients are biased and the t-statistics have a non-standard distribution. Therefore the Fully-Modified OLS (FM-OLS) estimator and t-statistic of Phillips and Hansen (1990), which correct the bias of the OLS estimator and t-statistic, will be used instead. This FM-OLS estimator is super-consistent, asymptotically unbiased and asymptotically normally distributed. The adjusted t-statistic is asymptotically distributed standard normal.

Table 6.9 Cointegration Equation

Dependent Variable: *Log(JSE)*

Method: FM-OLS

Order of VAR: 3

Variable	*Coefficient*
Log(GDP)	0.866
Discount rate	-0.012
Constant	-6.585

Source: Own calculations

The results in table 6.9 confirm that the long-run level of the South African stock market is determined according to the present value model. According to these results, a one percent increase in gross domestic product (GDP) will cause a 0.866 percent increase in the stock market, while a one unit increase in the discount rate will cause a decline of 0.012 percent in the stock market. Since cointegration has been established and the cointegration vector estimated, an ECM can be estimated. In the estimation of the ECM the speed of adjustment will be allowed to differ across business cycle states. Statistically significant differences between the speed of adjustment in the two states would support cyclical asymmetry in stock market adjustment. This will be evaluated in section 6.5.

6.5 THE SHORT-RUN DYNAMICS: AN ERROR CORRECTION MODEL

In addition to the long-run cointegration equation, an error correction mechanism (ECM) can be estimated in order to capture the short-run or dynamic adjustment process to the long-run equilibrium. It incorporates the equilibrium error (residual terms) estimated from the long-run equilibrium relationship. According to theory, stock prices are determined as the sum of all the future income stream discounted at the discount rate, which means that rational stock market investors will be forward-looking. This error correction model has to be consistent with the forward-looking behaviour of stock market investors.

Nickell (1985) derived an ECM from a forward-looking model with quadratic costs of adjustment. He assumes that agents have an infinite horizon and that they minimize the present value of the one period losses given by

$$L_t = \sum_{i=t}^{\infty} \delta^i \left[\frac{1}{2}\left(y_i - y_i^*\right)^2 + \frac{\theta}{2}\Delta y_i^2 \right] \tag{6.7}$$

where δ is the discount factor. This function captures the cost to deviate from some desired level (y*) with the first term $\left(y_i - y_i^*\right)^2$ and the cost of adjustment with the second term Δy_i^2. By letting the desired level (y*) be the predicted level of stock prices, the first term captures the cost of incorrectly predicting the level of stock prices and the cost of making an error is proportional to the size of the error. The appropriate Euler condition for this problem may then be stated as

$$\delta y_{t+1} - (1 + \delta + \theta^{-1}) y_t + y_{t-1} = - y_t^* / \theta . \tag{6.8}$$

Re-arranging equation 6.8 yields the following

$$\Delta y_t = \frac{1}{\delta}\Delta y_{t-1} + \frac{1}{\theta\delta}\left(y_{t-1} - y_{t-1}^*\right). \tag{6.9}$$

Equation 6.9 is in the standard ECM form, with an added lagged first difference of the dependent variable, stock prices. In addition to the terms on the right-hand side of equation 6.9, additional stationary variables influencing the stock market in the short-run will be added when estimating the ECM.

It has been shown in section 6.4.1 that neither the over- or under-valuation or the direction of the stock market are causing asymmetry in stock prices[3]. However, no equivalent test for testing the possibility of different speeds of adjustment based on the state of the business cycle is available. Different speeds of adjustment across business cycle states can be conducted by allowing different coefficients for the error correction term in the ECM. Statistically significant differences between the speeds of adjustment in the two states would support cyclical asymmetry in stock market adjustment.

The state of the business cycle indicator has been developed in chapter five with the Markov-switching regime model. The Markov-switching regime model constructs the probability of being in a particular state, say a recession and when the economy is more likely to be in a recession than an expansion (i.e. the recession probability is greater than 0.5) the state variable takes on the value 1 and 0 otherwise.

In order to test for asymmetry conditional on the state of the business cycle, only the state variable (S) is needed from the Markov-switching regime model. However, an additional output of the Markov model is a probability of being in a particular regime for each period and it can be readily assumed that a higher probability reflect more certainty regarding the predicted state (variable). Therefore, in addition to testing whether the speed of adjustment differs between economic upswings and downswings, the influence of the uncertainty regarding the state of the economy can also be evaluated. For example, it can be tested whether investors react faster (slower) when they are very sure (uncertain) about the state of the economy by adding an interaction term between the error correction term and the Markov state probability variable. This can be combined with the (potential) business cycle asymmetry by

[3] Kia (2003) argues that the magnitude of the error term may also influence the speed of adjustment if speculators ignore small deviations from the equilibrium price while reacting drastically to large deviations. He tested this with various kinds of non-linear specifications in which the squared, cubed and fourth powered equilibrium errors as well as products of the significant errors were added as regressors in the error correction model. He found that some evidence of non-linearity in the Canadian stock market, such that investors don't react to small equilibrium errors (bubbles) but very drastic to big errors (bubbles). These specifications were tested for the South African stock market by including squared, cubed and fourth powered equilibrium errors in the error correction model, but they were all insignificant.

interacting the state variable and the certainty variable with the error correction term. The estimation results of the ECM are reported in table 6.10.

Table 6.10 Error Correction Model

Dependent Variable: Δlog(JSE)

Method: Least Squares

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*p-value*
Residual(-1)	-0.186	0.048	-3.889	0.000
Residual (-1)*S	-0.129	0.095	-1.357	0.179
ΔLog(Gold)	0.177	0.085	2.075	0.042
ΔLog (SP500)	0.869	0.108	8.027	0.000
Risk	-0.044	0.008	-5.681	0.000
Risk(-1)	0.042	0.009	4.889	0.000
ΔLog(R$(-1))	0.350	0.090	3.876	0.000
Constant	0.020	0.016	1.228	0.223
ΔLog(R_S(-1))	-0.025	0.006	-4.119	0.000
S	-0.045	0.015	-3.089	0.003
Dum98	-0.041	0.020	-2.120	0.037
Dum00	-0.146	0.015	-9.725	0.000
Dum94	0.055	0.016	3.419	0.001
ΔLog(JSE(-1))	0.309	0.056	5.473	0.000

R-squared	0.708	F-statistic	13.78
Adjusted R-squared	0.656	Prob(F-statistic)	0.0000
S.E. of regression	0.058		

Source: Own calculations

According to the results of the ECM in table 6.10, the interaction term between the state variable[4] (S) and the error-correction term (Residual) is statistically significant[5].

[4] S takes on the value one (zero) when the economy is more likely to be in a recession (expansion) than not.

Since the coefficient of the error-correction term measures the speed of adjustment to equilibrium, this means that the speed of adjustment is significantly different in expansions than recessions. Specifically, since the estimated coefficient of the interaction term between the state variable and error-correction term is negative, the speed of adjustment is significantly slower in expansions than recessions[6]. This is consistent with the theory of Chalkley and Lee (1998) that investors react slower on good news than on bad news[7].

However, the variable (S) reflecting the state of the business cycle was *generated* by the Markov switching regime model in chapter five and the consequences introduced by using generated regressors have been established in the seminal work by Pagan (1984). According to Pagan (1984), the estimator of the generated regressor's coefficient is perfectly efficient as long as the null hypothesis being tested is that this coefficient equals zero. For any other hypothesis, it is necessary to use an instrumental variable or 2-stage least squares (2SLS) program to obtain a consistent estimate of the variance of this coefficient. Therefore, the ECM is also estimated using instrumental variables. The generated state of the business cycle indicator, S, was instrumented with a dummy variable reflecting the actual periods of negative real economic growth. The results are presented in table 6.11.

The results in table 6.11 confirm the different speeds of adjustment between recessions and expansions. Specifically, the speed of adjustment coefficient for expansions is –0.147 and (-0.147-0.243=) –0.39 for recessions. Interactive terms

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[5] The associated p-value of 0.17 is calculated for the two-sided null hypothesis that the coefficient is equal to zero (i.e. insignificant) against the alternative hypothesis that the coefficent is not equal to zero (i.e. significant). However, since it is *a priori* known that the coefficient should be negative, the one-sided hypothesis that the coefficient is smaller than zero should be tested against the alternative that the coefficient is not smaller than zero. The p-value for testing a one-sided hypothesis is half the value of a two-sided hypothesis, and therefore the relevant p-value that should be used for this particular coefficient is actually 0.085, which is smaller than 0.1 and hence this coefficient is significant on a 10 percent level of significance.

[6] The speed of adjustment coefficient for expansions is –0.186 and (-0.186-0.129=) –0.315 for recessions. The speed of adjustment coefficient always has to be negative since that ensures that the adjustment is in the opposite direction than the error and hence *towards* equilibrium. The speed of adjustment is indicated by the *magnitude* of the error correction coefficient – the bigger the coefficient the faster the speed of adjustment.

[7] Marshall and Walker (2002) also found stock market asymmetry with respect to good and bad news. They argue that, since investors are overconfident they will under react to any new information, but that their reluctance to realize losses implies more under reaction (and hence more persistence) in the case of bad news than good news. Their results of their study of the Chilean stock market supported this hypothesis.

between the state variable and each of the explanatory variables have also been tested to detect any additional asymmetries, but all these interaction terms were insignificant. It is also interesting to note that an interaction term between the variable measuring uncertainty and the error correction term was insignificant (regardless of whether the state variable was added), which means that the degree of uncertainty does not influence the speed of adjustment of the stock market[8].

Table 6.11 Error Correction Model with Instrumental Variables

Dependent Variable: Δlog(JSE)

Method: Instrumental variables

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*p-value*
Residual(-1)	-0.147	0.061	-2.420	0.018
Residual (-1)*S	-0.243	0.121	-2.005	0.049
ΔLog(Gold)	0.154	0.079	1.958	0.054
ΔLog (SP500)	0.906	0.133	6.815	0.000
Risk	-0.042	0.007	-5.845	0.000
Risk(-1)	0.040	0.008	5.062	0.000
ΔLog(R$(-1))	0.387	0.099	3.896	0.000
Constant	0.020	0.019	1.027	0.308
ΔLog(R_S(-1))	-0.024	0.006	-4.070	0.000
S	-0.064	0.022	-2.952	0.004
Dum98	-0.047	0.022	-2.157	0.034
Dum00	-0.155	0.016	-9.520	0.000
Dum94	0.054	0.013	4.073	0.000
ΔLog(JSE(-1))	0.285	0.066	4.315	0.000

R-squared	0.666	F-statistic	11.687
Adjusted R-squared	0.609	Prob(F-statistic)	0.0000
S.E. of regression	0.062		

Source: Own calculations

[8] As discussed earlier (see footnote three) the speed of adjustment was also allowed to be non-linear with respect to the magnitude of the error terms, but this was found to be insignificant.

The short-run dynamics of the stock market can be explained by the short term interest rate, the Rand-US$ exchange rate, the Standard and Poor 500-index, the gold price, forward-looking expectations of investors and a risk premium. In many the cases the estimated coefficients of the ECM are not interpreted (see e.g. Du Toit (1999), Koekemoer (1999) and Du Toit and Moolman (2003)) since many of the variables enter the model in differenced form, which makes it difficult to sensibly interpret the relationships. In some sense theory is differenced away – very little is known about the relationship between the growth rates of any variables. However, in this study, the dependent variable of the ECM, the change in the log of the JSE, is equivalent to stock market returns. Following Kia (2003), it is therefore possible to interpret the estimated coefficients in the ECM. Kia (2003) interprets all the coefficients in the ECM. However, the coefficient of, for example, Δlog(R$) should be interpreted as follows: a one unit increase in the growth of the exchange rate causes a 0.387 units increase in stock market returns (the percentage change in the JSE). Even though we expect that a depreciation in the exchange rate will improve stock prices and returns[9], it is difficult to reason about the exact relationship between the growth rate of the exchange rate and stock market returns. Therefore, unlike Kia (2003), only some of the coefficients in the ECM will be interpreted[10].

The stock market of a small, open and financially integrated economy is expected to follow stock markets in the rest of the world (Kia 2003). Lower returns on world stock markets are therefore expected to have a negative influence on returns on the South African stock market. The positive coefficient of foreign stock prices (measured by the Standard and Poor 500-index) is consistent with this *a priori* expectation. This result is also consistent with the results of Kia (2003), Ammer and Mei (1996), Koutmos and Booth (1995), Kearney (1998), Francis and Leachman (1998) and Ramchand and Susmel (1998).

[9] As discussed in chapter two, most of the biggest firms listed on the JSE are mining-related companies who export a substantial part of their production. A depreciation of the rand lowers the relative price of South African exports and hence causes an increase in the demand for exports. This in turn improves the profits and share prices of these companies. For example, the earnings of Anglo American, the biggest company listed on the JSE, falls by US$124 million if the rand appreciates 10 percent against the US dollar (McKay 2003). The income of Impala Platinum, the thirteenth largest share on the JSE, falls by R300 million for every 40 cents improvement in the rand against the US dollar (McKay 2003).
[10] Specifically, all the coefficients except those of the growth in the gold price, the growth in the short-term interest rate and the growth in the exchange rate are interpreted.

According to the results, the risk premium has a negative impact on returns. Risk averse investors require a higher discount rate for higher risk premiums. The discount rate is inversely related to share prices (see chapter three), and therefore the risk premium is expected to have a negative influence on stock market returns (Kia 2003)[11].

The dummy variable Dum98, which takes on the value one during the year 1998 and zero otherwise, is reflecting the lower returns on emerging stock markets following the Asian crisis. Dum00, the dummy variable that takes on the value one in the last quarter of 1999 and zero otherwise, is capturing the lower returns at the end of the previous millennium when investors were selling their shares in anticipation of the so-called Y2K-problems. The third dummy variable, Dum94, takes on the value one during the year 1994 and zero otherwise, which captures the euphoria of South Africa's first democratic election during which the country experienced a significant increase in capital inflows[12] and the volume and value of shares traded[13] on the JSE[14].

6.5.1 Evaluation and Diagnostic Testing of the ECM

The estimated model was subjected to rigorous diagnostic testing. Since all the variables in the ECM are stationary, the assumptions of classical regression analysis

[11] The risk premium was constructed as the interest rate differential between South African and US long-term government bonds. An alternative explanation for the negative relationship between the risk premium and stock market returns can therefore be based on the relationship between the interest rate differential and stock market returns. A lower domestic interest rate relative to the foreign interest rate should have a negative impact on investors' subjective discount rate and a lower interest rate is also associated with higher expectations of corporate profits (Kia 2003). Higher expected corporate profits as well as a lower subjective discount rate will result in a rise of share prices. The relationship between the interest rate differential (used as a proxy for the risk premium) and stock market returns should therefore be negative.

[12] South Africa had net capital inflow in 1994 of R4 359 million compared with a net capital outflow of R5 669 in 1993 (www.reservebank.co.za).

[13] The volume of shares traded on the JSE increased from 303.8 million in 1993 to 444.25 million in 1994 (www.reservebank.co.za). The value of shares traded on the JSE almost doubled from R2843.92 million in 1993 to R5204.33 million in 1994 (www.reservebank.co.za).

[14] The Japan Securities Dealers Association gave the JSE "designation status" in December 1994, which means that the JSE was then considered an "appropriate" market for Japanese investors (Brooks *et al* 1997). The JSE was included in the Morgan Stanley Index from March 1995, while it was included in the IFC Emerging Markets Global and Investable Indices from March 1995 (Brooks *et al* 1997).

are fulfilled. The R^2 value of 66.6 indicates that 66.6 percent of the variation in the dependent variable is explained by the variation in the dependent variables, which is evidence of a very good fit. The F-statistic of 11.687 indicates that the explanatory variables are jointly significant in explaining the stock market index. The t-statistics testing the significance of the individual coefficients indicate that all the coefficients are significantly different from zero and should therefore be included in the model.

Standard diagnostic tests can therefore be used to determine which variables should be included in the final specification of the ECM (Harris 1995: 24). The diagnostic test results reported in table 6.12 indicate that the function passes all the relevant diagnostic tests. The errors are normally distributed, homoscedastic, not serially correlated and the model is not misspecified.

Table 6.12 Diagnostic Tests

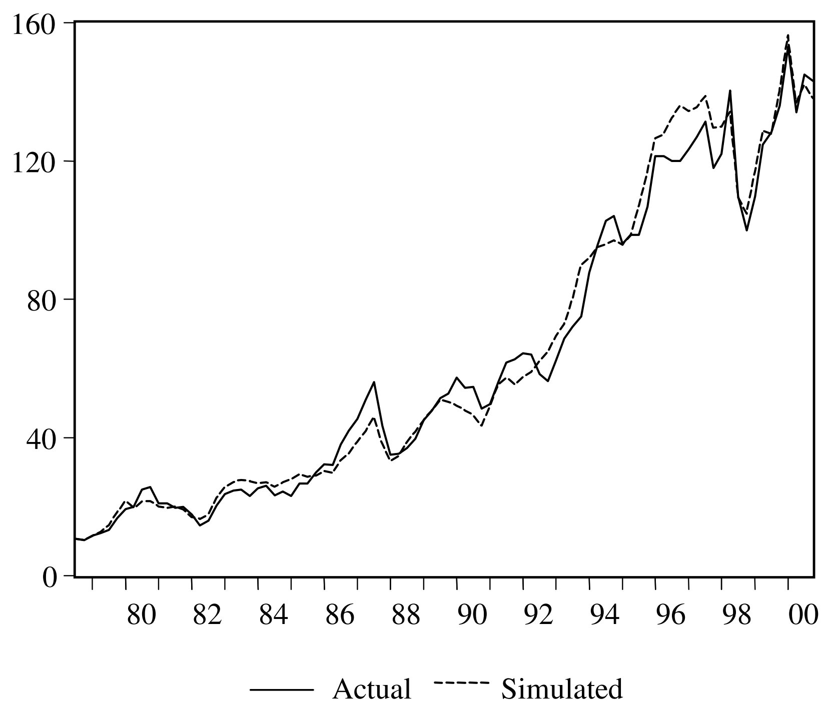
Null hypothesis	Test	Test statistic	Probability
Normality	Jarque-Bera	0.12	0.94
Homoscedasticity	ARCH LM (1)	0.05	0.83
	ARCH LM (2)	0.83	0.66
	ARCH LM (3)	0.96	0.81
Homoscedasticity	White	19.5	0.62
No serial correlation	Breusch-Godfrey (1)	4.30	0.16
	Breusch-Godfrey (2)	4.65	0.20
	Breusch-Godfrey (3)	5.51	0.24
No serial correlation	Durbin-Watson	2.07	
No misspecification	Ramsey Reset	3.84	0.15

Source: Own calculations

6.5.2 Dynamic Simulation

To obtain an indication of the goodness of fit of the model, an initial dynamic simulation was performed (see figure 6.2). From figure 6.2 it is clear that the model is a good representation of the true data generating process. It picks up all the turning points in the stock market and closely tracks the level of the stock market as well.

Figure 6.2 Actual and Fitted Values of the Stock Market



6.6 POLICY IMPLICATIONS

In analyzing the impact of different variables on the stock market, the variables can be classified according to two criteria. First, from a policy perspective, the distinction between variables that policy-makers can influence and those variables that are completely beyond their control is crucial. Second, it is important to distinguish between variables that influence the stock market in the long run and those that only have an influence on the short-term fluctuations of the stock market.

The only variables that have an influence on the long run equilibrium level of the stock market are expected dividends (which can be proxied with economic activity) and the variables that influence the discount rate (i.e. the domestic long term interest rate, the growth rate of dividends and the equity premium). Variables that influence the short term fluctuations of the stock market includes the gold price, foreign stock markets, the exchange rate, the short-term interest rate and the state of the business cycle.

The variables that are truly exogenous to the stock market from a policy-maker's perspective are the gold price and foreign stock prices. The gold price is determined on international markets by the global demand for and supply of gold. As explained in chapter two, South Africa, one of the world's largest gold producers, was traditionally heavily influenced by the gold mining industry. Gold exports used to be one of the major earners of foreign currency for South Africa and the mining sector is traditionally one of the biggest employers, an important source of tax revenue and an important stimulant of industries that provide products or services to the mines. Since the gold mining industry played such an important role in the economy, the gold price, which has an important influence on the profits of mining-related companies and hence their share prices, also has an important influence on the general stock market. This situation may change gradually as the role of the primary sector in the economy diminishes[15]. However, from the estimated model in this chapter the gold price seems to have only an influence on the short-term fluctuations of the stock market and not its long-run level.

Exchange controls on South African residents to invest abroad imply at least mild segmentation of the South African financial markets from the international financial markets (Brooks, Davidson and Faff 1997). However, the significant influence of the Standard & Poor 500 index confirms that even though there might be some degree of market segmentation, the South African financial markets do not operate in isolation and are influenced by the international financial markets. This is expected in the case of a small, open economy such as South Africa. However, although international financial markets influence the domestic stock market, domestic factors play bigger role in determining the stock market[16]. This means that the JSE is vulnerable to

[15] In 1960, the primary sector produced 23 percent of South Africa's total GDP. By 1970 this proportion has declined to 18.7 percent and by 1980 the proportion was only 13.5 percent. This declined even further to 12.2 percent in 1990 and 10 percent in 2000 (www.reservebank.co.za).
[16] This is consistent with the results of Harvey (1995a,b), who found that domestic information variables accounts for more than half of the predictable variance in the returns of emerging markets.

changes in the rest of the world, but that these markets are not the sole factor driving the South African stock market. This also implies that the JSE will be susceptible to contagion from the rest of the world, but that should only have a short-term impact and it should not change the long run equilibrium level of the stock market.

The stock price determinants other than the gold price and foreign stock prices can be influenced either directly or indirectly by policy-makers. These variables are not necessarily controlled by policy authorities, but they can to varying extents be influenced by policy-makers. The short-term interest rate, which is controlled by the South African Reserve Bank, influences the stock market through two channels that both impacts only on the short-run behavior of the stock market. First, it directly influences the returns on the stock market in the short-run. Second, it indirectly influences the speed of adjustment by influencing the state of the business cycle. An increase in the short-term interest rate increases the probability of a recession, which in turn increases the stock market's speed of adjustment towards equilibrium while lowering stock market returns.

Changes in the long term interest rate channels through to the stock market via three mechanisms. First, it influences the stock market indirectly through its influence on the state of business cycle. An increase in the long-term interest rate lowers the likelihood of a recession, which in turn lowers the stock market's speed of adjustment towards equilibrium. Second, an increase in the long-term interest rate increases the discount rate, which lowers the level of the JSE in the long-run. Finally, increases in the long-term interest rate causes increases in the excess returns of South Africa relative to the US, in other words it increases the risk premium, and this lowers returns. While the short-term interest rate can be influenced directly by monetary policy authorities, the long-term interest rate can be influenced indirectly through the expectations of inflation and future short-term interest rates (see Pretorius 2000). Pretorius and Du Toit (2001) showed that in South Africa the influence of inflation expectations on the long-term interest rate is greater than that of the short-term interest rate. This means that the recently introduced inflation-targeting[17] framework

[17] In 2000 the Reserve Bank adopted an inflation-targeting regime, with a target range for average CPIX inflation, in other words headline consumer inflation excluding mortgage cost. The initial target

can have a significant impact on the long-term interest rate through its influence on inflation expectations.

The exchange rate only influences the stock market in the short-run. This means that any once off change in any direction (i.e. depreciations as well as appreciations) only influence the stock market in the subsequent period. However, every change in the exchange rate will be reflected by the stock market and hence a volatile exchange rate will cause a volatile stock market. The exchange rate is determined not only by economic fundamentals, but also by market sentiment towards South Africa (BEPA 2002). Policy authorities can therefore influence the exchange rate by maintaining sound economic fundamentals and economic policies. However, it is equally important that they manage market psychology, which includes generally responsible politics and good public governance, perceptions of political and other types of risk and the total cost of doing business in South Africa.

Economic activity, measured by gross domestic product (GDP), has a positive influence on the long-run level of share prices. Since GDP influences the long-run level of the stock market, an increase in domestic activity leads to a permanent increase in the JSE, in contrast with variables such as the exchange rate that only has a temporary impact on the stock market. GDP also influences the short-run behavior of the stock market since the state of the business cycle determines the speed of adjustment towards equilibrium.

6.7 CONCLUSION

In this chapter, a structural model for the South African stock market was developed and estimated based on the theory presented in chapter three. Theoretically, several reasons exist that may cause asymmetric stock market behaviour. Three different cases of asymmetry has been evaluated, namely asymmetry conditional on (i) whether the stock market is over-valued or under-valued, (ii) the momentum of the stock market (thus allowing for the possibility that the errors exhibit more “momentum” in

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was between three and six per cent for 2002 and 2003 and between three and five per cent for 2004 and 2005. The target for 2004 was subsequently amended to between three and six percent.

one direction than the other) and (iii) the state of the business cycle. The results have shown that neither the over- or under-valuation nor the direction of the error terms cause stock market asymmetry. However, it has been shown that the speed of adjustment differs based on the state of the business cycle. Investors are loss-averse, in other words more sensitive to declines in their well being (losses) than increases (profits), and hence they react faster on bad news (recessions) than good news (expansions).

The results confirmed that the long-run level of the South African stock market is determined according to the present value model. Therefore, the long-run level of share prices are determined by discounted future dividends. In addition, the short-run fluctuations are caused by the short term interest rate, the rand-$US exchange rate, the S&P500 index, the gold price, forward-looking expectations of investors and a risk premium.

In the next chapter this model will be used for forecasting the stock market. The model's in-sample and forecasting accuracy as well as its profitability will be compared with that of other models, such as the ones used by technical analysts. This should give an indication of the model's usefulness for forecasting purposes.