THE PORTFOLIO RISK MANAGEMENT AND DIVERSIFICATION BENEFITS FROM THE SOUTH AFRICAN RAND CURRENCY INDEX (RAIN)

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Abstract

This study attempts to explain the source of risk management and diversification benefits that investors may gain from the South African Rand Currency Index (RAIN) as it relates to an equity portfolio with stock market exposure (locally or international). These diversification benefits may result from the negative correlation between RAIN and the South African All Share Index (ALSI).
To explain and fully exploit the benefits of RAIN, the main variables that represent South Africa's trading partner equity and bond markets movements, were identified. To account for the interaction of RAIN with the ALSI, the latter was firstly decomposed into its economic groups and secondly into its various sub-sectors. Various analyses were carried out to determine which variables describe the relationship between the ALSI and RAIN.
The variables that describe the relationship with a high adjusted R^2, were identified. The findings suggest that when the ALSI is decomposed into its ten economic groups and thirty-seven sub-groups, the quadratic as opposed to linear models using response surface regressions, explained the majority of the variation in RAIN over the entire period. The linear models, however, explained more of the variation in RAIN during the recent 2008/2009 financial crisis.

Key words: RAIN, Unit-Root Tests, Co-Integration, Principal Component Factor Analysis, ALSI, Response Surface Regressions

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1 Introduction

Portfolio managers with large positions in stock or significant exposure to stock markets may identify financial products that can provide risk management benefits to their portfolios during periods of market uncertainty. These benefits, mainly usually diversification benefits where an instrument usually correlates negatively in the long-term with the JSE are sought. A financial product with such qualities was introduced on 8 November 2010 by the Johannesburg Stock Exchange (JSE) is the South African Rand Currency Index (RAIN). The RAIN is calculated as an inverse arithmetic trade-weighted rand currency index relative to South Africa's main trading partners (see Table 1 below). Due to the RAIN's inverse relationship with the trading partners, it may, apart from hedging benefits as a hedgeable instrument, also exhibit diversification benefits in relation to some sub-sectors listed on the JSE.

Table 1. The RAIN is inversely related to the rand value per foreign currency unit

Date	R/€	$/R	CNY/R	£/R	¥/R	RAIN
2006/01/02	R7,5013	R6,3422	R0,7859	R10,9109	R0,0538	10 680,33
2006/02/17	R7,1670	R6,0225	R0,7483	R10,4848	R0,0510	10 182,03
ZAR strengthens against all 5 currencies and the index goes down						
2008/10/22	R14,9784	R11,5650	R1,7046	R18,9508	R0,1193	21 339,82
ZAR weakens against all 5 currencies and the index goes up						

Understanding what affects the underlying RAIN exchange rates, can be used by a trader to accurately hedge. If the trader expects a decrease in the future value of the index, he may decide to, say, short ten index futures today and long the 10 futures of each of the underlying constituents of the RAIN index if it is assumed that he wants to hedge his currency position. Intuitively, the trader therefore expects the rand to strengthen against the trading partner currencies. On closing out date, if the index did in fact decrease as expected, the profit is calculated as [10 x (index price on day 0 – index price on closing out date)]. The profits and losses of the individual contracts (in their respective ratios) should, given the new individual exchange rates on expiry date, equal the profit on the RAIN index, assuming no mispricing of any futures contracts.

Apart from the above where the trader wants to hedge his position, speculative profits can also be realized if a trader sets up an open short RAIN index futures position if a decrease in the index is expected. On closing out date, the trader will then close out the RAIN index future at the new lower spot price. The RAIN selling price minus the closing out price will leave the dealer with a profit due to an expected appreciation of the rand against the currencies of the main trading partners. This will then offset the currency loss where, say, income or funds from the sale of stock is converted from a foreign currency to rand. The number of contracts sold or longed will depend on the monetary value of the funds involved.

Apart from the hedging benefits, RAIN also, due to its negative correlation with the ALSI, may offer diversification benefits. This aspect of RAIN is dealt with in this research.

2 Objectives of the study

The main objectives of this study are to determine which equity markets and bond yield magnitudes are responsible for the negative correlation of RAIN relative to the ALSI around the recent period of market uncertainty. In addition to this, an attempt will also be made to determine the long-term co-integration and causality of RAIN.

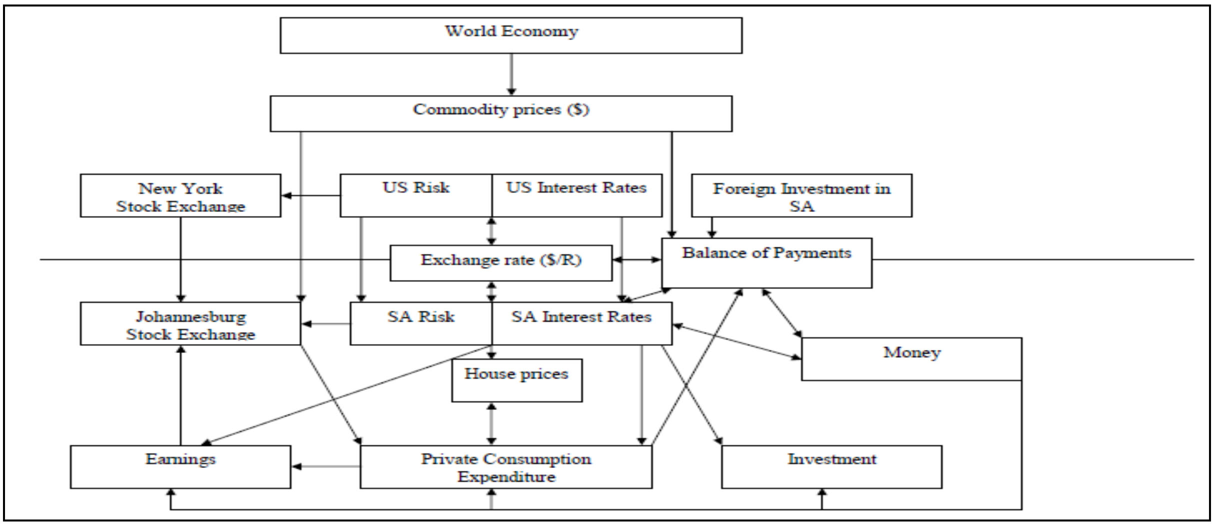
This study may have important benefits for investors, namely:

- Observing the effect of international bond and equity flows on RAIN may provide investors with valuable information on how to formulate a hedging strategy or trading strategy/framework with RAIN. Institutional investors with ALSI and global stock market exposure can hedge rand foreign currency exposure in relation to its main foreign trading partners.
- Investigating and understanding correlations during different economic cycles (especially during a financial crisis) may also contribute to a further understanding of market factors responsible for spurious correlations.

3 The relationship between the ALSI and other Bond and Equity Markets

To account for the interaction of RAIN with the ALSI, the latter is decomposed into the various economic groups and its numerous sub-sectors. This allows the correlation relationship between RAIN and ALSI to be studied over time complemented by the bond and equity flows of South Africa's main trading partners. Barr and Kantor (2002:6) provided one of the earlier econometric models of the South African Economy together with its various feedback loops (see Figure 1). It shows how SA risk and returns are impacted on by US cross border investment flows via the economy and eventually resulting in the ZAR/USD (and other) exchange rate levels. The levels of exchange rates in turn reflect the level of economic activity between SA and its trading partners.

Figure 1. Schematic Representation of the South African Economy with its Feedback Loops



Source: Barr and Kantor (2002:59) Source: JSE (2010b)

When studying the relationship between stock prices/stock indices and exchange rates, two theories may be considered. The first is the "goods market approach" introduced by Dornbusch and Fischer (1980) and the second is the "portfolio balance approach" introduced by Frankel (1993). These two approaches are used when developing models that account for change in macroeconomic variables such as exchange rates. All studies modeling the relationship between stock markets and the exchange rates influencing these stock markets incorporate one of the approaches mentioned above.

As the foreign currencies used in the RAIN cannot be used to explain changes in RAIN itself, other variables have to be used. Although not the only important variable, interest rates were used to explain the bond flows and exchange rates between South Africa and its different trading partners. Moolman (2003) used short term interest rates and yield spreads to predict turning points in the business cycles. Some conclusions that she made when including interest rates were that (1) it helps predict any structural breaks in the economy; (2) interest rate data is more readily available; (3) interest rates provide true change signals and (4) the prediction power of interest rates improves with an increase in the sample period. Moolman and Du Toit (2005) later developed a long-term intrinsic econometric model of the South African economy which accounted for the short-term fluctuations around the intrinsic value. They found that (1) interest rates; (2) the risk premium; (3) exchange rates and (4) foreign stock markets were mostly responsible for these short-term fluctuations around the intrinsic value.

Ocran (2010) studied the relationship between two price indices and the USD/ZAR exchange rate. These two indices included the Standard & Poor 500 Index and the ALSI index.

The construction and pricing of the RAIN is briefly dealt with next. RAIN is calculated as an inverse arithmetic trade-weighted average of South Africa's five trading partners' exchange rates. This inverse quotation of the South African Rand to the RAIN indicates that when the majority of the currencies (included in the RAIN) strengthen, the index declines and vice versa (JSE, 2010b). The formula used to calculate the RAIN at time t is shown below, from the rebalancing date at time T (JSE, 2010b):

$$RAIN_t = \sum_{i=1}^{N} SX_{i,t} \times ContZ_i \times NCont_i \qquad (1)$$

$SX_{i,\,t}$ is the spot exchange rate of currency i at time t. $ContZ_i$ is the number of currency units traded for each futures contract. The more actively traded a currency, the smaller the contract size. This small contract size also serves as a trading incentive in the retail sector. For example, the contract sizes of the EURO, USD and GBP are 1, 000. Whereas for CHY the contract size is 10 000 and for JPY the contract size is 10 000 (JSE, 2010b). The formula used to calculate the number of contracts traded ($NCont_i$) is shown below (JSE (2010b**)**:

$$NCont_i = \frac{(RAIN_T \times W_{i,T})}{SX_{i,T} \times ContZ_i} \qquad (2)$$

$RAIN_T$ is the currency index at rebalancing date, usually at year end. $W_{i,\,t}$ is the weights in the index, calculated based on imports and exports of each trading partner with South Africa. $SX_{i,T}$ is the spot exchange rates of the trading partners of South Africa at rebalancing date (JSE, 2010a; c). On consultation with market participants, it became clear that it was more appropriate to use arithmetic rather than a geometric weighting approach. This weighting approach allows investors using the RAIN as a hedging instrument to enter into static hedge positions in contrast to dynamic hedge positions[2]. Some reasons mentioned by the JSE (2010, a; b) for using RAIN include:

1. It can be used to measure international financial pressure on the South African Rand using RAIN to match a portfolio or basket of foreign currencies.
2. It can be used as a measure of the volatility of the South African Rand versus its prominent international trading partners.

4 Research Methodology

In this research an attempt is made to explain or determine the variables responsible for the negative correlation of the RAIN with the ALSI. In order to achieve this objective, the ALSI has been decomposed into the main economic currency groups and each group further decomposed into the main sub-sectors. This decomposition was used in conjunction with the bond and equity flows of South Africa's main trading partners.

The two primary variables tested in this study is the relationship between the ALSI and RAIN during three time periods shown in Table 2 below.

[2] See Thong (1996) for a detailed examination of dynamic hedging.

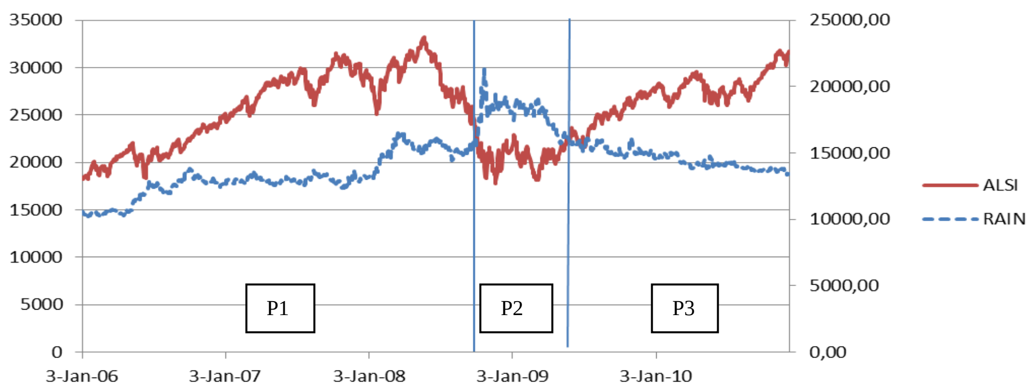
Table 2. Time Periods Chosen in this Study

Date of Time period	Variable Name in each Period
03 January 2006 – 23 October 2008	P1
23 October 2008 - 23 October 2009	P2
23 October 2009 – 17 December 2010	P3

These time periods were selected from the intersection of RAIN with the ALSI as indicated in Figure 2 below. A reason for the stratification of the data into the time periods is to account for shocks in the market and to analyze which sub-sectors of the ALSI strengthen or weaken in relation to the RAIN. Daily ALSI data were obtained from the McGregor BFA (2005) database, while daily RAIN data were obtained from the JSE (2010c).

The first set of variables used in this study was the ALSI decomposed into ten economic groups. The ALSI is also affected by international equity and bond flows. As a result of the RAIN computation, the equity and bond flows of South Africa's five main trading partners were also included in this study, together with the ten economic groups. The second set of variables included was the further decomposition of the ALSI into thirty-four ALSI sub-sectors with three additional sub-sectors. These sub-sectors were also included with the bond and equity flows of South Africa's main trading partners. For data sets P1 and P2, the five main trading partners include: USA, UK, Europe, China and Japan.

Figure 2. Relationship between ALSI and RAIN before, during and after the financial crisis



Source: McGregor (2005); JSE (2010c)

Daily data on the economic groups and sub-sectors comprising of the all share index as well as data on the bond and equity flows were obtained from Inet-bridge. Data were collected for each time period as shown in Table 2. Due to data limitations, J151, J376, J863, J867 and J957 were not included. As a proxy for the bond flows of South Africa's five trading partners, the three month LIBOR rate of each trading partner was used. Some advantages of using these three month yield curves include: (1) These rates are reflective of current economic conditions, in contrast to longer term yields; (2) The cumulative biases of issuers could be removed; (3) These yields are more actively traded than the R153 bond; (4) The bond yields are the most significant variable affecting bond indices. As no three month LIBOR market is created for South Africa and China, the three month JIBAR was used for the former and the short term Chinese interest rate for the latter.

The vast array of variables comprising of international equity and bond flows from South Africa's trading partners which affect the ALSI has resulted in multi-collinearity problems. To overcome these problems and identify significant variables affecting RAIN, principal component factor analyses[3], correlation matrices with significant p-values, cluster analysis (Ward's Method with 1-Pearsons correlation coefficient) and lastly multi-explanatory sub group analyses were used.

In all three sets of variables tested on RAIN, response surface regressions with multi-explanatory forward stepwise characteristics were used to identify the quadratic and interaction amongst variables. This has been compared to the linear regressions with multi-explanatory forward stepwise characteristics and the model with the highest R^2 was chosen.

Once the appropriate model was selected, unit-root tests and co-integration tests were carried out on the All Groups samples from the interaction of firstly, the economic groups and secondly the sub-groups.

[3] Refer to Eichler, Motta and Sachs (2011) for an approach to fit dynamic factor analysis on non-stationary time-series data.

This was done to determine if positive or negative long-term correlation relationships exist. Where long-term relationships exist, both models were fitted on the error terms of the regressions.

5 Research findings

In Figure 2, three periods (P1 to P3) were identified around the sub-prime financial crisis as a lot of market uncertainty existed during this period. From the Figure 2, it is evident that the RAIN predicts the financial crisis with a sharp increase during period two (P2) and the RAIN intersects with the ALSI in 2008. Hereafter, the RAIN intersects the ALSI again in period 3 (P3) and reverts back to its mean value of around 15 000 points thereafter.

Using the approaches mentioned before, the variables were identified for all groups as shown in Table 3 below. The highest eigenvalue was selected from each factor using principal component analysis. By selecting the highest eigenvalue from each factor, the problem of multi-collinearity could be overcome. Due to the interaction amongst the various equity markets, response surface regressions with multi-explanatory forward stepwise characteristics were used to account for interaction of explanatory variables and their quadratics terms. Table 3 below compares the linear and quadratic models. The model with the higher adjusted R^2 was selected. The multi-explanatory forward stepwise characteristics removed the interaction terms which were not significant. This approach was repeated for periods P1 to P3 (see Tables 3 to 7 below).

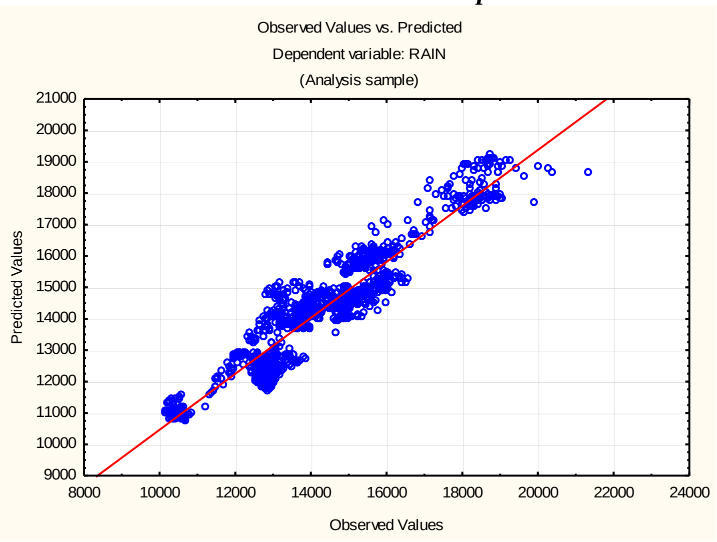
Table 3. Variables Affecting the RAIN and Economic Groups: All Groups

Economic Groups Variable Code: All Groups (Linear)		**Linear Model**		**Economic Groups Variable Code: All Groups (Quadratic)**			**Quadratic Model**	
Variable	**Factor**	**Variable**	**Value**	**Variables**			**Variable**	**Value**
INTERCEPT	0	-	-	INTERCEPT	FTSMC*J530	NK300*LJPY3M		
FTSMC	1	Multiple R^2	0.89134	FTSMC	J530*J500	J520*LJPY3M	Multiple R^2	0.954165
J530 OR DJCBI	2	Adjusted R^2	**0.89081**	FTSMC^2	J530*NK300	-	Adjusted R^2	**0.953604**
J500 OR JIBAR3M	3	SS Model	4.55952	J530	J500*NK300	-	SS Model	4.880898
NK300	4	SS Residual	5558364	J530^2	FTSMC*J520	-	SS Residual	2344633
J520	5	F	1687.083	J500	J500*J520	-	F	1700.081
LJPY3M OR LEUR3M	6	P	0.00	LJPY3M	J530*LJPY3M	-	P	0.00

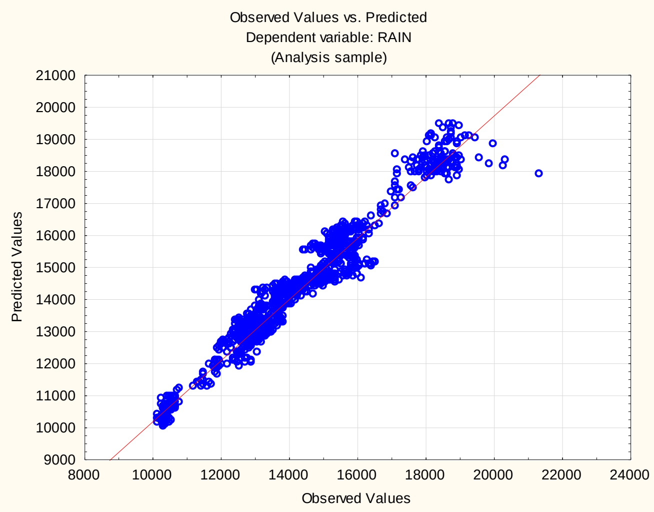
Figure 2 below graphically compares the observed values in relation to the predicted values of both the linear and quadratic models. From the figure it can be seen that the data points were more scattered in the case of the linear model and more clustered around the line in the case of the quadratic model. The quadratic model therefore suggests a better fit with more explanatory power.

Figure 2. Observed versus Predicted RAIN Errors: All Groups (Economic Groups of the JSE)

Linear Model: All Groups



Quadratic Model: All Groups



The variables identified under the quadratic model were substituted into the E-views software program which provided the regression output as shown in Table 4 below.

Firstly, it was tested if the variables identified were co-integrated with RAIN. These residuals were found to fluctuate around the mean of 0 with the residuals or error terms not being rejected, thus co-integrating with RAIN. Secondly, a model was needed that investors could apply to period P1 to P3 when considering the interaction of RAIN with the economic groups or sub-groups of the ALSI. For this model to be identified, the residuals underlying the model must be white noise estimates. When analyzing the error terms, it was found that an AR (1), AR (6) and AR (7) could be fitted to the residuals to provide white noise estimates. This resulted in a R^2 of 0.99 and a Durbin-Watson of 2.05. Thus, serial correlation was not a problem in this model. Other models were also considered and tested on the error terms. The first of these was moving average terms, due to the high AR (n) terms. The second of these was an ARCH/GARCH (1, 1) model. Both were found to be insignificant with the GARCH (1, 1) model providing a negative coefficient which was also a signal of an over fitted model. This illustrated that the fitted AR (1), an AR (6) and AR (7) models on the error terms were the most significant.

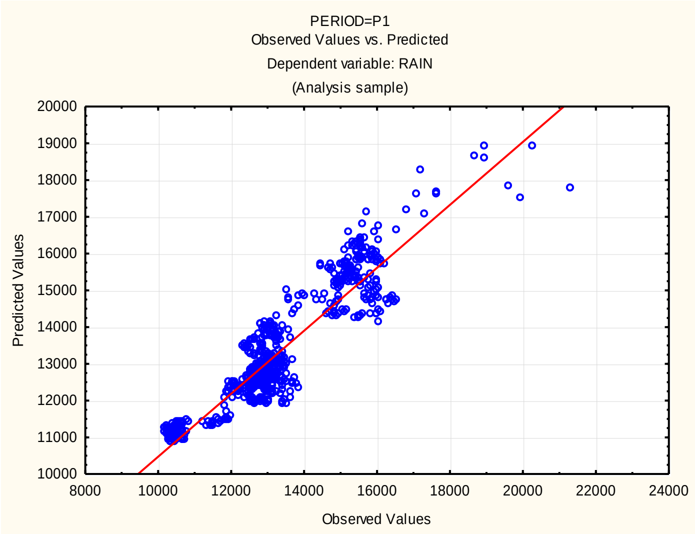
For periods P1 to P3 below, the most significant variables were identified together with the degree of variation explained by the linear versus quadratic models. Lastly, models were also tested for co-integration with RAIN. Co-integrated will allow investors to fit models to the error terms during similar periods for forecasting purposes.

Table 4. Variables Affecting the RAIN and Economic Groups: P1

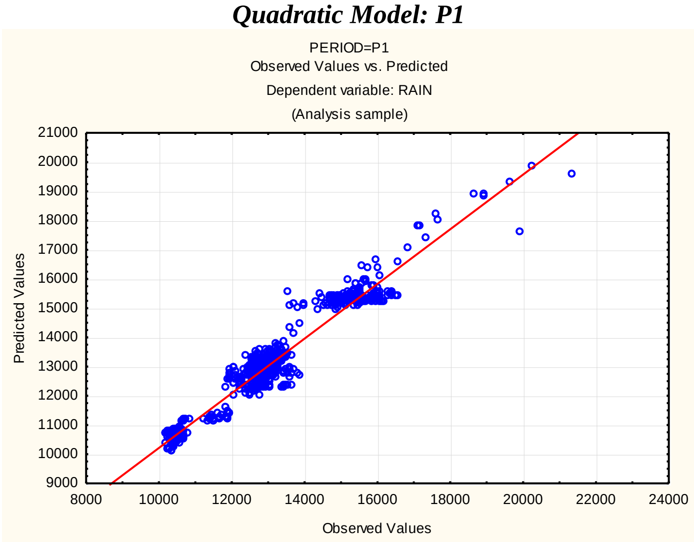
Economic Groups Variable Code: P1 (Linear)		**Linear Model**		**Economic Groups Variable Code: P1 (Quadratic)**		**Quadratic Model**	
Variable	**Factor**	**Variable**	**Value**	**Variables**		**Variable**	**Value**
INTERCEPT	0	-	-	INTERCEPT	J590		-
FCAC40	1	Multiple R^2	0.856	FCAC40	J590^2	Multiple R^2	0.967
JIBAR3M	2	Adjusted R^2	**0.855**	FCAC40^2	FCAC40*JIBAR3M	Adjusted R^2	**0.9357**
VIXI	3	SS Model	1.959	JIBAR3M	FCAC40*VIXI	SS Model	1.794
DJTRPI	4	SS Residual	134497070	JIBAR3M^2	VIXI*DJTRPI	SS Residual	299909
J590	5	F	832.6778	VIXI	VIXI*J590	F	771.015
-	6	P	0.00	VIXI^2	DJTRPI*VIXI	P	0.00

Figure 3. Observed versus Predicted RAIN Errors: P1

Linear Model: P1



Quadratic Model: P1



In period 2, the linear model contains two different variables under factor 5. The reason for this is that the principal component factor analysis provides two variables with high eigenvalues. These two variables are DJUTLI (Dow Jones Utilities Index) and SAPSML (S & P: Small Cap Index). The identification of these two linear variables under factor 5 resulted in the response surface regressions providing different interaction and quadratic terms for P2(1) and P2(2) as shown in Table 5 and 6 below.

Table 5. Variables Affecting the RAIN and Economic Groups: P2 (1)

Economic Groups Variable Code: P2 (Linear)		**Linear Model**		**Economic Groups Variable Code: P2 (Quadratic)**		**Quadratic Model**	
Variable	**Factor**	**Variable**	**Value**	**Variables**		**Variable**	**Value**
INTERCEPT	0	-	-	INTERCEPT	NK300*J500		
FCAC40	1	Multiple R^2	0.9068	LEUR3M	DJUTLI*J500	Multiple R^2	0.916505
LEUR3M	2	Adjusted R^2	**0.9049**	FCAC40*LEUREM	-	Adjusted R^2	**0.914079**
R157	3	SS Model	5128937	FCAC40*R157	-	SS Model	518361937
NK300	4	SS Residual	52692044	LEUR3M*DJUTLI	-	SS Residual	47223842
DJUTLI	5	F	473.0626	NK300*DJUTLI	-	F	377.9121
J500	6	P	0.00	LEUR3M*J500	-	P	0.00

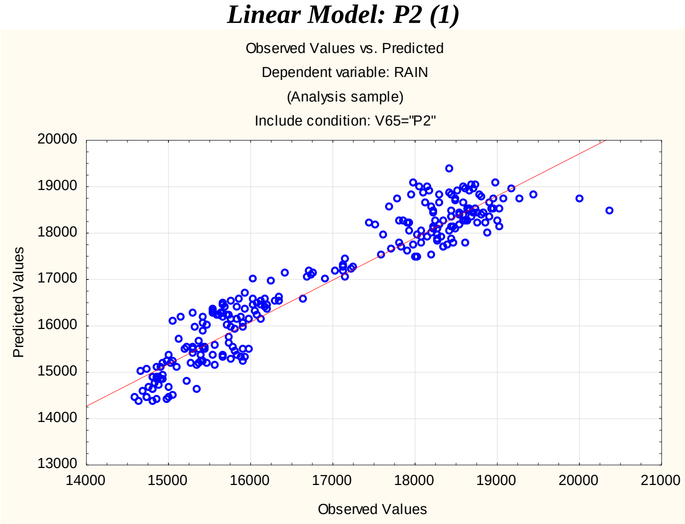
Table 6. Variables Affecting the RAIN and Economic Groups: P2 (2)

Economic Groups Variable Code: P2 (Linear)		**Linear Model**		**Economic Groups Variable Code: P2 (Quadratic)**	**Quadratic Model**	
Variable	**Factor**	**Variable**	**Value**	**Variables**	**Variable**	**Value**
INTERCEPT	0	-	-	INTERCEPT		
FCAC40	1	Multiple R^2	0.912455	LEUR3M	Multiple R^2	0.916894
LEUR3M	2	Adjusted R^2	0.910284	FCAC40*LEUREM	Adjusted R^2	**0.914834**
R157	3	SS Model	86011900	FCAC40*R157	SS Model	518582405
NK300	4	SS Residual	49514378	LEUR3M*J500	SS Residual	47003375
SAPSML	5	F	420.3805	LEUR3M*SAPSML	F	444.9927
J500	6	P	0.00	NK300*SAPSML	P	0.00

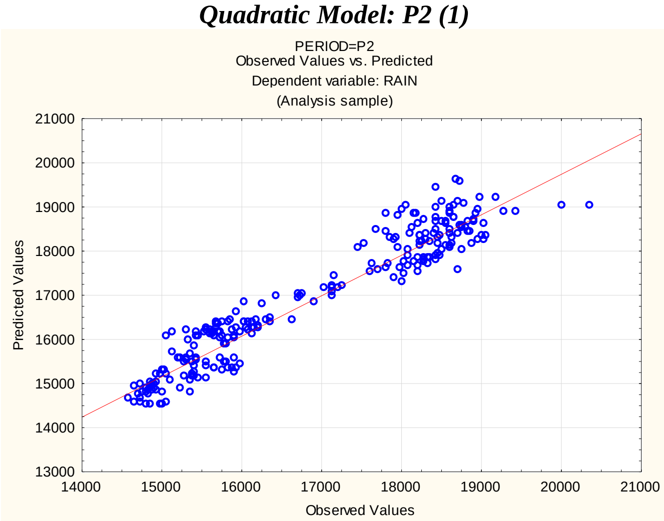
This effect of the different variables identified in explaining RAIN is shown below in figure 4.

Figure 4. Observed versus Predicted RAIN Errors: P2 (1) and P 2(2)

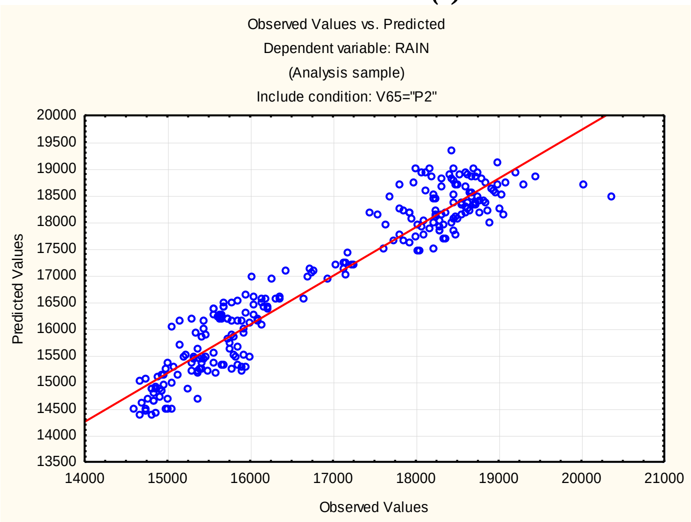
Linear Model: P2 (1)



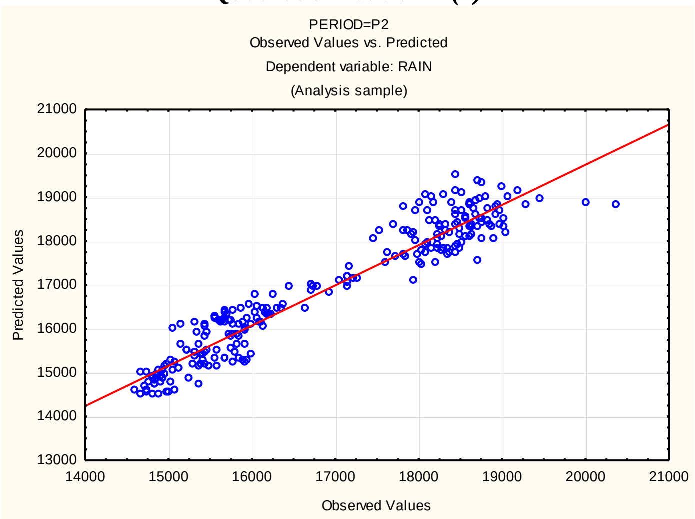
Quadratic Model: P2 (1)



Linear Model: P2 (2)



Quadratic Model: P2 (2)



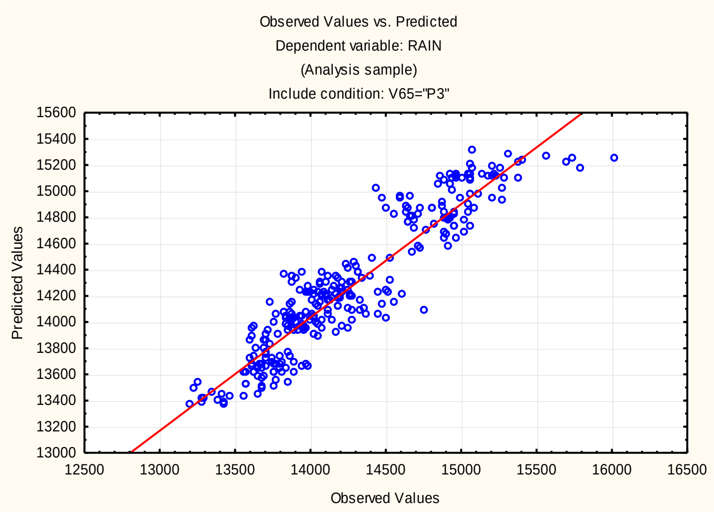
From Table 7 and 8, it can be seen that there is approximately a 1% increase when a quadratic model with interaction terms is used opposed to a linear model. When examining this visually, there is a small improvement in the error terms. There are, however, two periods when the data clusters as shown in Figure 4 above. The variables identified during period P3 are also shown below, with the observed and predicted rain errors.

Table 7. Variables Affecting the RAIN and Economic Groups: P3

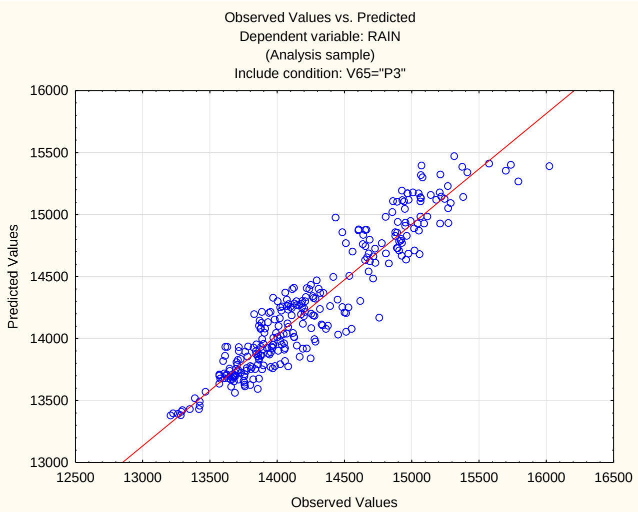
Economic Groups Variable Code: P3 (Linear)		Linear Model:		Economic Groups Variable Code: P3 (Quadratic)	Quadratic Model	
Variable	**Factor**	**Variable**	**Value**	**Variables**	**Variable**	**Value**
INTERCEPT	0	-	-	INTERCEPT	-	-
SAPMID	1	Multiple R^2	0.86034	SAPMID	Multiple R^2	0.893622
CNSHI	2	Adjusted R^2	**0.863675**	DJCBI	Adjusted R^2	**0.891366**
DJCBI	3	SS Model	7856631	J500^2	SS Model	81069135
J500	4	SS Residual	12153402	SAPMID*DJCBI	SS Residual	9650598
DJUTLI	5	F	367.1867	SAPMID*J500	F	396.2201
-	6	P	0.00	CNSHI*DJUTLI	P	0.00

Figure 5. Observed versus Predicted RAIN Errors: P3

Linear Model: P3



Quadratic Model: P3



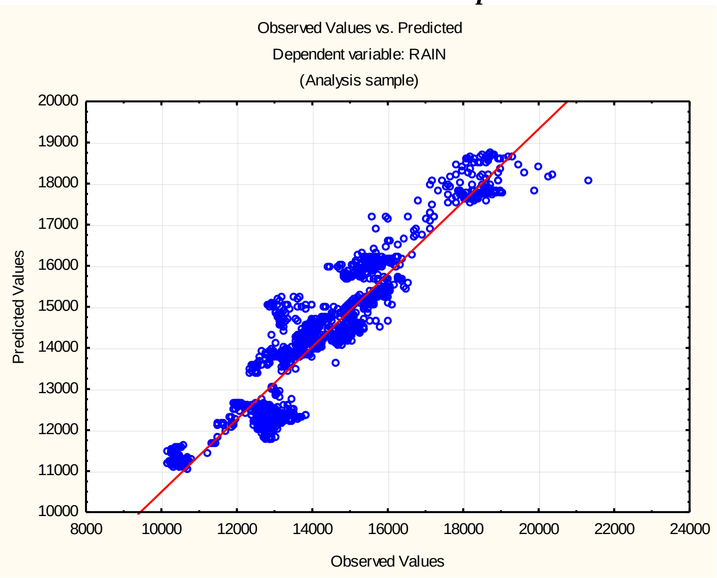
When considering the interaction of RAIN with the ALSI sub-groups over the entire time period, four factors were identified, namely FTSMC (FTSE Small Cap Ex Investment Trusts), J272 (FTSE/JSE:AFR General Industrial Sector), J177 (FTSE/JSE:AFR Mining Sector) and LJPY3M (3 Month Libor Rate: Japan). Using response surface regressions, the interaction amongst these variables were also identified in Table 8 below. This has been provided together with the observed and predicted rain errors for all the groups of RAIN in Figure 6.

Table 8. Variables Affecting the RAIN and Sub-Groups: All Groups

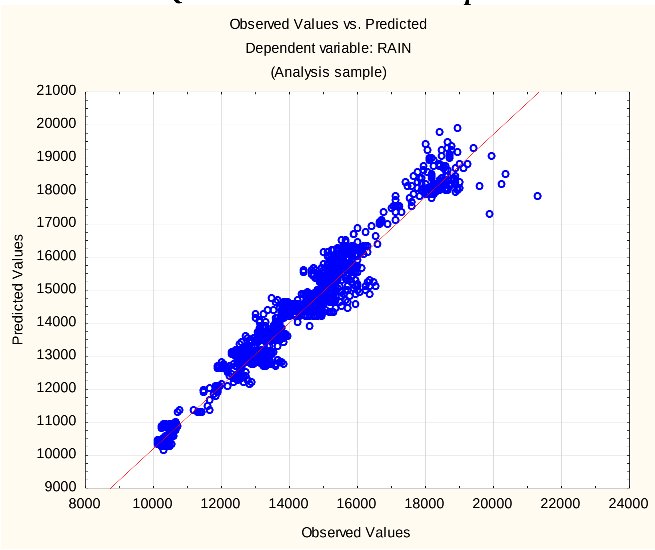
Sub-sectors Variable Code: All Groups (Linear)		**Linear Model:**		**Sub-sectors Variable Code: All Groups (Quadratic)**			**Quadratic Model**	
Variable	**Factor**	**Variable**	**Value**	**Variables**			**Variable**	**Value**
INTERCEPT	0	-	-	INTERCEPT	LJPY3M	J177*LJP Y3M		
FTSMC	1	Multiple R^2	0.882993	FTSMC	LJPY3M^2	-	Multiple R^2	0.951298
J272	2	Adjusted R^2	**0.882614**	FTSMC^2	FTSMC*J272	-	Adjusted R^2	**0.951298**
J177	3	SS Model	4.516826	J272	FTSMC*J177	-	SS Model	4.868844
LJPY3M	4	SS Residual	598534767	J272^2	J272*J177	-	SS Residual	246517210
-	5	F	2331.860	J177	FTSMC*LJPY3M	-	F	1864.145
-	6	P	0.00	J17^2	J272*LJPY3M	-	P	0.00

Figure 6. Observed versus Predicted RAIN Errors: All Sub-sectors (Sub-sectors of the JSE)

Linear Model: All Groups



Quadratic Model: All Groups



A model has been fitted to the RAIN error estimates of the quadratic model as opposed to the linear model as a result of the high R^2. To find a model that fits, the error terms must be white noise estimates. Firstly, AR (n) estimates have been regressed on the residual series created from the co-integrated errors of the explanatory variables identified to explain RAIN. AR (1), AR (3), AR (5), AR (6) and AR (7) terms were found to be significant at a 5 % level of significance, which were then fitted to the error terms. Hereafter, the AR (N) terms identified as significant are applied to the original explanatory variables identified. This resulted in several explanatory variables being excluded as well as AR (5) and AR (7). The end model with the interaction shown below has a Durban Watson statistic of 1.97 and a R^2 of 0.99. This showed that autocorrelation was not a problem.

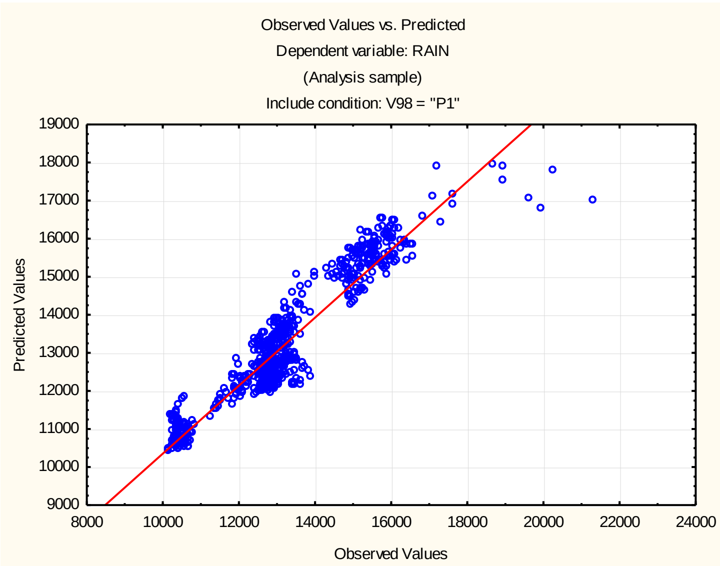
The variables identified during periods P1 to P3 with the interaction of the ALSI sub-sectors and RAIN have been shown in Table 9 to 11. For each of these periods, the observed versus the predicted errors have been shown graphically (Figure 7 to 9) under both the linear and quadratic models.

Table 9. Variables Affecting the RAIN and Sub-Groups: P1

Sub-sectors Variable Code: P1 (Linear)		Linear Model		Sub-sectors Variable Code: P1 (Quadratic)			Quadratic Model	
Variable	**Factor**	**Variable**	**Value**	**Variables**			**Variable**	**Value**
INTERCEPT	0	-	-	INTERCEPT	VIXI	JIBAR3 M*VIXI	-	-
FCAC40	1	Multiple R^2	0.892746	FCAC40	VIXI^2	DJTRPI* VIXI	Multiple R^2	0.952385
JIBAR3M	2	Adjusted R^2	**0.891975**	FCAC40^2	FCAC40*JIBAR3M		Adjusted R^2	**0.951344**
DJTRPI	3	SS Model	1.869347	JIBAR3M	JIBAR3M*DJTRPI		SS Model	1.994229
J457	4	SS Residual	224583299	JIBAR3M^2	FCAC40*J457		SS Residual	9970195 3
VIXI	5	F	1158.649	J457	JIBAR3M*J457		F	914.7537
-	6	P	0.00	J457^2	FCAC40*VIXI		P	0.00

Figure 7. Observed versus Predicted RAIN Errors: P1 of Sub-sectors

Linear Model: P1



Quadratic Model: P1

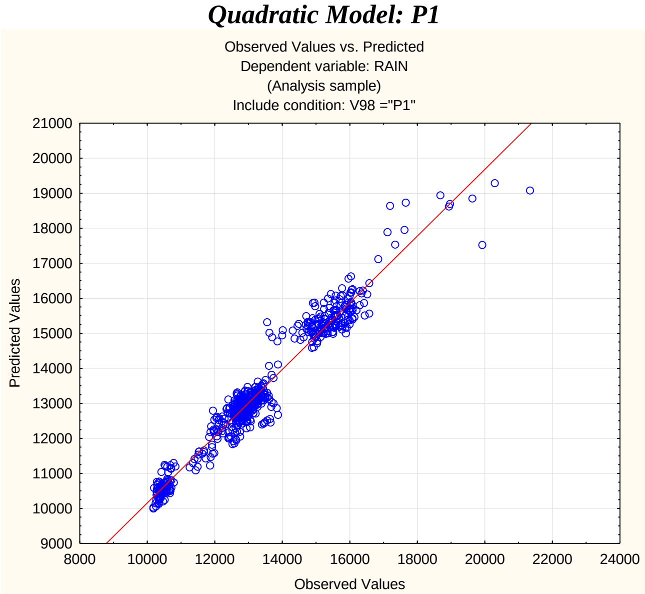
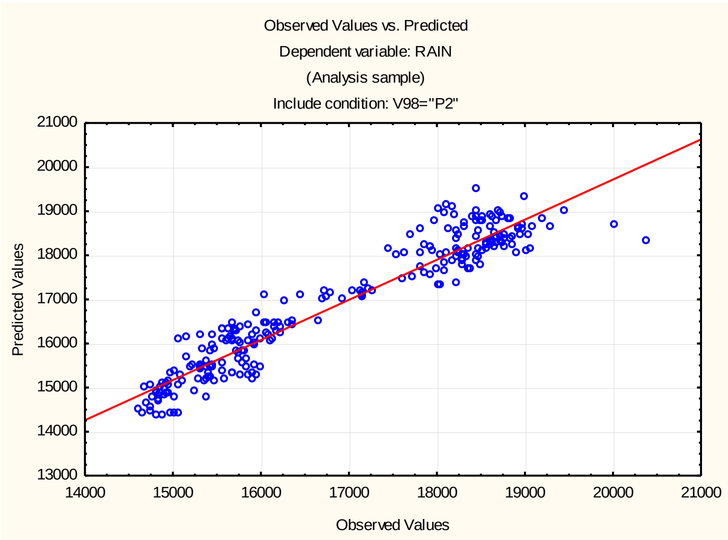


Table 10. Variables Affecting the RAIN and Sub-Groups: P2

Sub-sectors Variable Code: P2 (Linear)		Linear Model:		Sub-sectors Variable Code: P2 (Quadratic)	Quadratic Model	
Variable	**Factor**	**Variable**	**Value**	**Variables**	**Variable**	**Value**
INTERCEPT	0	-	-	INTERCEPT	-	-
FCAC40	1	Multiple R^2	0.910154	LEUR3M	Multiple R^2	0.907330
LEUR3M	2	Adjusted R^2	**0.908306**	FCAC40*R157	Adjusted R^2	**0.905811**
R157	3	SS Model	514770378	LEUR3M*SAPSML	SS Model	513172888
NK300	4	SS Residual	50815402	NK300*SAPSML	SS Residual	52412892
SAPSML	5	F	492.3279	-	F	597.2490
-	6	P	0.00	-	P	0.00

Figure 8. Observed versus Predicted RAIN Errors: P2 of Sub-sectors

Linear Model: P2



Quadratic Model: P2

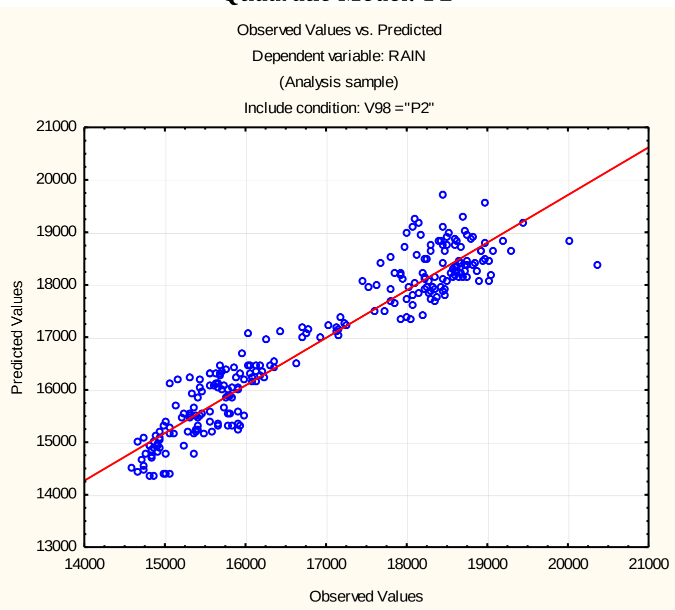
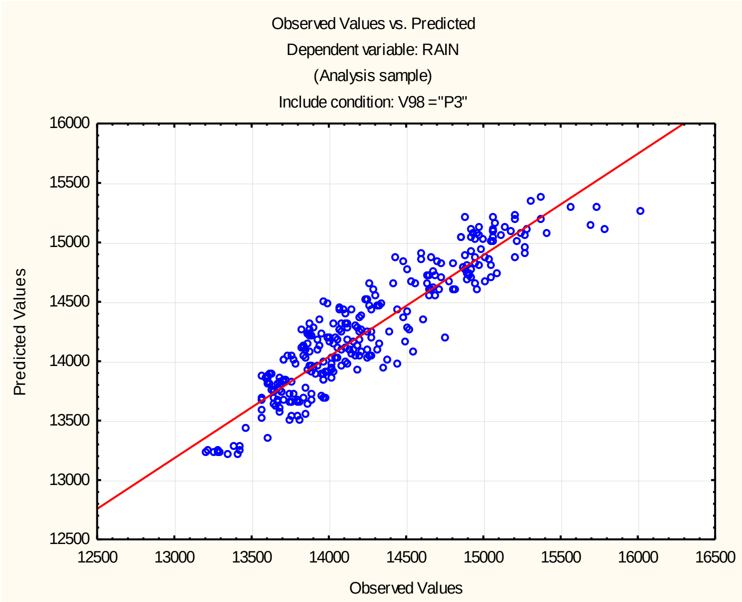


Table 11. Variables Affecting the RAIN and Sub-Groups: P3

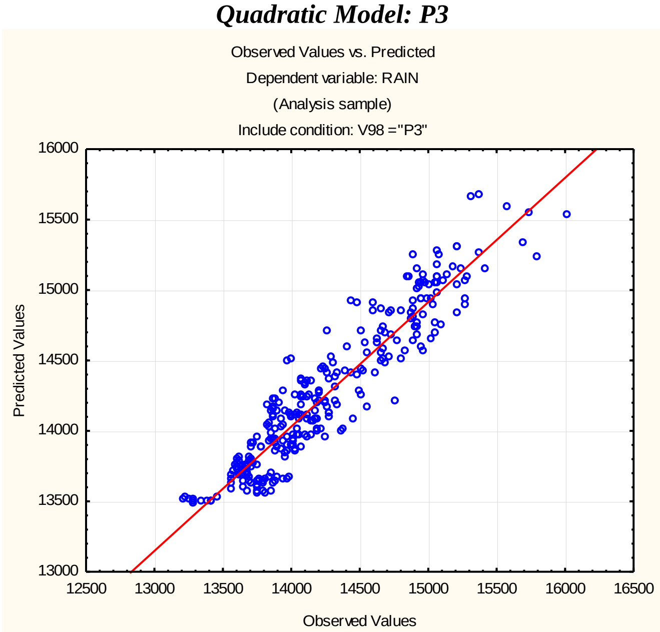
Sub-sectors Variable Code: P3 (Linear)		Linear Model:		Sub-sectors Variable Code: P3 (Quadratic)	Quadratic Model	
Variable	**Factor**	**Variable**	**Value**	**Variables**	**Variable**	**Value**
INTERCEPT	0	-	-	INTERCEPT	-	-
MDAXI	1	Multiple R^2	0.854096	MDAXI	Multiple R^2	0.883003
CNSHI	2	Adjusted R^2	**0.852048**	MDAXI^2	Adjusted R^2	**0.881361**
FJAP	3	SS Model	77483357	CNSHI	SS Model	80105820
J150	4	SS Residual	13236376	CNSHI^2	SS Residual	10613913
-	5	F	417.0846	-	F	537.7413
-	6	P	0.00	-	P	0.00

Figure 9. Observed versus Predicted RAIN Errors: P3 of Sub-sectors

Linear Model: P3



Quadratic Model: P3



6 Summary and conclusions

In this study, the equity and bond market variables of South Africa's main trading partners which could have an effect on the RAIN, were identified. To try and account for South Africa's interaction with these international bond and equity markets, the ALSI was firstly decomposed into its ten economic groups and secondly into its sub-sectors. This decomposition was used to identify the variables which may significantly affect RAIN during the three economic periods (P1 to P3) identified for the sake of this research (see Table 1). An advantage of this approach is that any macroeconomic shocks could be accounted for especially also due to the use of interest rates as one of the independent variables. In each of these periods, both linear and quadratic regression equations were fitted to the data.

As a result of the high adjusted R^2, the quadratic model was chosen (as opposed to the linear model) for the All Groups sample periods. Hereafter, a model was fitted on the error terms from all the groups sample regression equations (All Groups refer to all periods P1 to P3). The eventual model is shown in Appendix 2 and 3 with the explanatory variables shown in Tables 12 and 13 below.

Table 12. Variables Identified for Economic Groups: All Groups

Variables Identified	Coefficient	Standard Errors	T-Statistic	P-Values
FTSMC	4.074443	1.005701	4.051345	0.0001
FTSMC^2	-0.000675	0.000159	-4.246801	0.0000
LJPY3M	-2655.291	783.0269	-3.391060	0.0007
J500*NK300	-4.39E-05	9.07E-06	-4.840687	0.0000
J530*LJPY3M	0.159823	0.035133	4.549124	0.0000
NK300*LJPY3M	1.2333301	0.254029	4.854964	0.0000

Table 13. Variables Identified for Sub-Sector Groups: All Groups

Variables Identified	Coefficient	Standard Errors	T-Statistic	P-Values
FTSMC	4.416587	1.102378	4.006417	0.0001
FTSMC^2	-0.000816	0.000161	-5.054682	0.0000
LJPY3M	-3842.495	1547.382	-2.483223	0.0132
FTSMC*LJPY3M	1.507796	0.512652	2.941170	0.0033

From the tables above, the variables that may explain the effect of SA's main trading partner's equity and bond movement on the JSE, were identified as FTSMC, FTSMC^2, LJPY3M, J500*NK300, J530*LJPY3M. The variables that may explain all groups and sub-sector groups are FTSMC, FTSMC^2, LJPY3M AND FTSMC*LJPY3M. From the tables is it clear that the linear variables provide larger coefficients than the quadratic and interaction variables. For instance, for a one unit increase in FTSMC, RAIN increases by 4.07 units.

For each of the economic periods, the explanatory variables have been identified. In P1, the ALSI was in an upswing phase or bull market with any variations in the ALSI being negatively related to RAIN. Table 14 compares the adjusted R^2 of the linear and quadratic models fitted for each time period and shows that the quadratic models explain more of the variation in RAIN during P1.

Table 14. Comparisons of Adjusted R^2

<table>
<tr><th colspan="5">Adjusted R² of Different Models</th></tr>
<tr><th rowspan="2">Period</th><th colspan="2">Economic Groups</th><th colspan="2">Sub-sectors</th></tr>
<tr><th>Linear</th><th>Quadratic</th><th>Linear</th><th>Quadratic</th></tr>
<tr><td>All Groups</td><td>0.8908</td><td>0.9536</td><td>0.882614</td><td>0.951298</td></tr>
<tr><td>P1</td><td>0.855</td><td>0.9357</td><td>0.89197</td><td>0.951344</td></tr>
<tr><td>P2 (1)</td><td>0.9049</td><td>0.91407</td><td rowspan="2">0.908306</td><td rowspan="2">0.905811</td></tr>
<tr><td>P2 (2)</td><td>0.91028</td><td>0.91483</td></tr>
<tr><td>P3</td><td>0.86367</td><td>0.891366</td><td>0.852048</td><td>0.881361</td></tr>
</table>

P2 on the other hand was characterized by the financial crisis. During this period, there was a negative correlation between RAIN and the ALSI. This may provide hedging benefits to investors that included the tradable RAIN in the portfolios that contained stock market exposure. Another advantage of studying the RAIN in relation to the ALSI is the leading indicator ability of RAIN that may be used to predict periods of extreme market uncertainty. This may be possible due to intersection of RAIN with the ALSI as shown in Figure 1. Table 14 shows that the adjusted R^2 of the linear and quadratic models are similar. A possible reason why they are similar is that the interactions amongst variables in quadratic regression equations break down to such an extent that when economic groups or sub-sectors are used as interaction variables of JSE with RAIN, it does not matter if linear or quadratic models are used. Investors can therefore use linear models to explain and predict variations in RAIN. In period P2, two variables were considered, namely P2(1) and P2(2) in order to reduce selection bias. A possible limitation introduced in this study is selection bias, interpretation of factorials in factor analysis with the highest eigenvalue. The variables selected under P(1) are DJUTLI as factor 5 and the SAPSML in P(2) as factor 5.

In P3, the ALSI is characterized by a bull market with the intersection of the RAIN reverting back to its mean around 15 000 points. P3 is similar to P1, when the ALSI is in a bull market, investors should use quadratic models to study the variation in RAIN.

Variables have been identified using various statistical techniques. Investors can use the analysis in this research as a framework at a time when the ALSI is in a similar business cycle as described above. Other possible uses are the forecasting of variables identified in this research, for time periods similar to the ones described in this research. Investors could also use this research as a framework to study the interaction of variables for numerous financial exchanges.

7 Recommendations for further research

Some recommendations for further research may be considered. These are:

- Forecasting the RAIN for periods P1 to P3 and compare to ex-post data.
- Investigating RAIN's relationship with secondary market indices, derivative market indices and vice versa.
- Including the economic variables from each of the five underlying foreign currencies as explanatory variables of RAIN may further extend the realism of the research.
- Considering the spreads of the short-term interest rates of South Africa's five main trading partners as explanatory variables of RAIN.

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Appendix A

Table A.1 Variable Codes: South Africa's Trading Partners

Code	**South African Equity Market Index (ALSI)**	**Code**	**Decomposed into Sub-sectors**
J203	FTSE/JSE:AFR All Share Index	J055	FTSE/JSE:AFR Oil Producers index
		J135	FTSE/JSE:AFR Chemical
Code	**Headline Index**	J151	FTSE/JSE:AFR Coal
J200	FTSE/JSE:AFR Top 40	J150	FTSE/JSE:AFR Gold Mining
J201	FTSE/JSE:AFR Mid Cap	J153	FTSE/JSE:AFR Platinum
J202	FTSE/JSE:AFR Small Cap	J154	FTSE/JSE:AFR General Mining
J204	FTSE/JSE:AFR Fledging Index	J173	FTSE/JSE:AFR Forestry
		J175	FTSE/JSE:AFR Ind Met
Code	**Economic Groups**	J177	FTSE/JSE:AFR Mining
J258	FTSE/JSE:AFR Resources	J235	FTSE/JSE:AFR Construction
J500	FTSE/JSE:AFR Oil and Gas	J272	FTSE/JSE:AFR General Industrial
J510	FTSE/JSE:AFR Basic Materials	J273	FTSE/JSE:AFR Electricity Sector
J520	FTSE/JSE:AFR Industrials	J275	FTSE/JSE:AFR Industrial Engineering
J530	FTSE/JSE:AFR Construction Goods	J277	FTSE/JSE:AFR Industrial Transport
J540	FTSE/JSE:AFR Health Sector	J279	FTSE/JSE:AFR Support
J550	FTSE/JSE:AFR Construction Services	J335	FTSE/JSE:AFR Auto
J560	FTSE/JSE:AFR Telecommunications	J353	FTSE/JSE:AFR Beverages
J580	FTSE/JSE:AFR Financials	J357	FTSE/JSE:AFR Food Producers
J590	FTSE/JSE:AFR Technological Sector	J372	FTSE/JSE:AFR House
		J376	FTSE/JSE:AFR Personal Goods
		J453	FTSE/JSE:AFR Health
		J457	FTSE/JSE:AFR Pharmaceutical
		J533	FTSE/JSE:AFR Drug Retail
		J537	FTSE/JSE:AFR General Retail
		J555	FTSE/JSE:AFR Media
		J575	FTSE/JSE:AFR Travel
		J653	FTSE/JSE:AFR Fixed Telecom
		J657	FTSE/JSE:AFR Mobile Telecom
		J835	FTSE/JSE:AFR Banks
		J853	FTSE/JSE:AFR Non Life Insurance
		J857	FTSE/JSE:AFR Life Insurance
		J863	FTSE/JSE:AFR Real Estate Development Serv
		J867	FTSE/JSE:AFR Real Estate Investment Trusts
		J877	FTSE/JSE:AFR General Financial
		J898	FTSE/JSE:AFR Equity Investment
		J953	FTSE/JSE:AFR Software
		J957	FTSE/JSE:AFR Technical Hardware & Equipment
Code	**International Equity Flows: Europe**	**Code**	**International Equity Flows: Japan**
FBEL20	Belgium: Brussels 20 Index	FJNK	Nikkei 225 Index
FHEX	Finland: Helsinki Index	NK300	Nikkei 300 Index
FCAC40	Paris: CAC 40 Index	FJAP	Tokyo Stock Exchange Index (TOPIX)
CDAX	Germany : Composite Dax Index		
MDAXI	Germany: Mid-Cap Index	**Code**	**International Equity Flows: USA**
DAXXIN	Germany: Xetra Dax Index	MMIS	AMEX major market Index
FATHEN	Greece: Athens Composite Index	BARCON	Barons Confidence Index
FDUBLIN	Ireland: Dublin Index	VIXI	CBOE Volatility Index
FMIALL	Italy: FTSE Italy Index	DJ65IN	DJ65 Stock Index
FAMEX	Netherlands: Amsterdam Index	DJSX50	Dow Jones Euro Stock 50 Index
IBEX35	Spain: IBEX 35 Index	DJGTI	Dow Jones Global Titans Index
PSI20I	Portugal: Lisbon PSI 20 Index	FDDY	Industrial Dividend Yield Index
		FDEY	Industrial Earnings Yield

Table A.1 Variable Codes: South Africa's Trading Partners (continuation)

Code	**International Equity Flows: China**	DJINDI	Dow Jones Industrial Index
FCHINA	Shanghai A Share Index	DJIFUT	Dow Jones Industrial Index – Near Futures
FSHAI	Shanghai B Share Index	DJTRPI	Dow Jones Transportation Index
CNSHI	Shanghai Composite Index	DJUTLI NASFUT	Dow Jones Utilities Index NASDAQ 100 Index – Near Futures
		NASDAQ	NASDAQ Market Index
Code	**International Equity Flows: UK**	NYECOM	NYSE Composite Index
FT100	FTSE 100 Index	RUSS2	RUSSELS 2000 Stock Price Index
FT250X	FTSE 250 Ex IT Index	RUSSM	RUSSELS Mid Cap Index
FT250	FTSE 250 Index	PSPI SAPIND	S & P: Composite Index S & P: Industrial Composite Index
FT350X	FTSE Ex IT Index	SAPMID	S & P: Mid Cap Index
FT350H	FTSE Higher Yield	SAPSML	S & P: Small Cap Index
FT350	FTSE 350 Index		
FT350L	FTSE 350 Lower Index	**Code**	**International Bond Flows: USA**
FTALL	FTSE All Share Index	DJCBI	DJ Corporate Bond Index
FTALLX	FTSE All Share Index Ex IT	LBNDGL	Lehman Bond Composite Index
GBFTOT	FTSE Euro Top 100 Index	LUSD3M	US Dollar LIBOR 3 Month Rate
FTFLX	FTSE Fledging EX IT Index		
FTSMCX	FTSE Small Cap Index		
FTSMC	FTSE Small Cap Ex IT		
Code	**Bond Flows: SA**		
R153	Short term SA Bond		
R157	Medium Term SA Bond		
R207	Long Term SA Bond		
JIBAR3M	3 Month: Johannesburg Interbank Agreed Rate		
Code	**International Bond Flows: UK**		
LGBP3M	3 Month LIBOR Rate: UK		
Code	**International Bond Flows: Europe**		
LEUR3M	3 Month LIBOR Rate: Europe		
Code	**International Bond Flows: Japan**		
LJPY3M	3 Month Libor Rate: Japan		
Code	**International Bond Flows: China**		
CHINT	China Short Term Interest Rate		

Appendix B

Table B.1. Fitting a Quadratic Model to the Economic Groups

Dependent Variable: RAIN
Method: Least Squares
Sample: 1/03/2006 - 12/17/2010
Included observations: 1241

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	14543.07	845.4841	17.20088	0.0000
FTSMC	-6.290504	0.275537	-22.83000	0.0000
FTSMC^2	0.001016	5.26E-05	19.32728	0.0000
J530	1.522235	0.060172	25.29798	0.0000
J530^2	-5.88E-05	2.11E-06	-27.90559	0.0000
J500	-0.524073	0.050289	-10.42125	0.0000
LJPY3M	15734.91	613.2665	25.65755	0.0000
FTSMC*LJPY3M	-0.838208	0.134781	-6.219013	0.0000
J530*J500	4.09E-05	2.80E-06	14.60237	0.0000
J530*NK300	0.000174	7.61E-05	2.293443	0.0220
J500*NK300	-0.000214	6.17E-05	-3.469945	0.0005
FTSMC*J520	-4.15E-05	4.50E-06	-9.238860	0.0000
J530*LJPY3M	-0.778010	0.036378	-21.38669	0.0000
NK300*LJPY3M	2.697098	0.673417	4.005091	0.0001

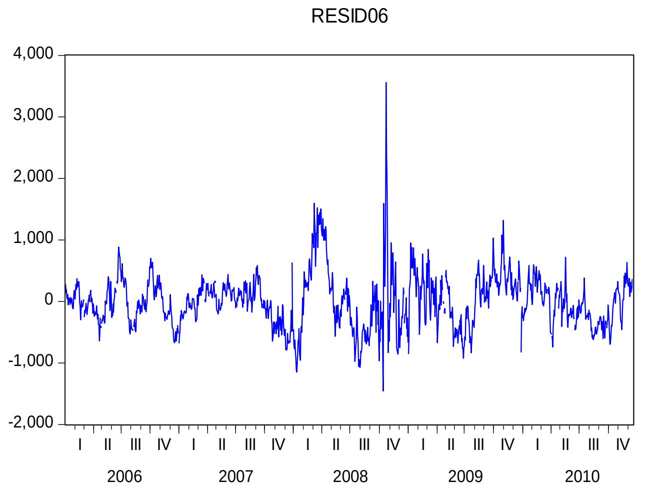
R-squared	0.952314	Mean dependent var	14246.97
Adjusted R-squared	0.951809	S.D. dependent var	2031.081
S.E. of regression	445.8732	Akaike info criterion	15.04916
Sum squared resid	2.44E+08	Schwarz criterion	15.10696
Log likelihood	-9324.006	Hannan-Quinn criter.	15.07090
F-statistic	1884.909	Durbin-Watson stat	0.284443
Prob(F-statistic)	0.000000		

Dependent Variable: RAIN
Method: Least Squares
Sample (adjusted): 1/12/2006 - 12/17/2010
Included observations: 1234 after adjustments
Convergence achieved after 31 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8983.883	1988.291	4.518394	0.0000
FTSMC	4.074443	1.005701	4.051345	0.0001
FTSMC^2	-0.000675	0.000159	-4.246801	0.0000
LJPY3M	-2655.291	783.0269	-3.391060	0.0007
J500*NK300	-4.39E-05	9.07E-06	-4.840687	0.0000
J530*LJPY3M	0.159823	0.035133	4.549124	0.0000
NK300*LJPY3M	1.233301	0.254029	4.854964	0.0000
AR(1)	0.988249	0.015012	65.82882	0.0000
AR(6)	-0.064270	0.031414	-2.045870	0.0410
AR(7)	0.071256	0.028723	2.480752	0.0132

R-squared	0.991176	Mean dependent var	14268.54
Adjusted R-squared	0.991111	S.D. dependent var	2016.465
S.E. of regression	190.1111	Akaike info criterion	13.34117
Sum squared resid	44238094	Schwarz criterion	13.38264
Log likelihood	-8221.499	Hannan-Quinn criter.	13.35677
F-statistic	15276.99	Durbin-Watson stat	2.057730
Prob(F-statistic)	0.000000		

Inverted AR Roots	1.00	.56+.34i	.56-.34i	-.01-.64i
	-.01+.64i	-.56+.32i	-.56-.32i	



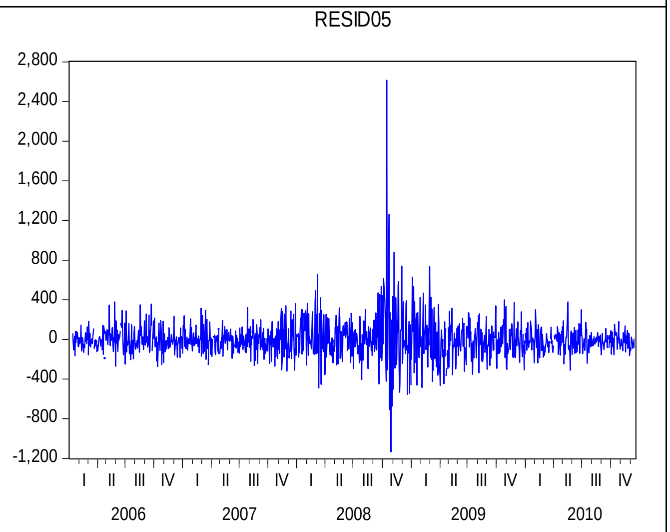


Table B.1. Fitting a Quadratic Model to the Economic Groups (continuation)

Null Hypothesis: RESID06 has a unit root
Exogenous: None
Lag Length: 2 (Automatic - based on SIC, maxlag=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.598290	0.0000
Test critical values:	1% level	-2.566831	
	5% level	-1.941079	
	10% level	-1.616527	

*MacKinnon (1996) one-sided p-values.
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID06)
Method: Least Squares
Date: 06/08/11 Time: 12:05
Sample (adjusted): 1/06/2006 - 12/17/2010
Included observations: 1238 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID06(-1)	-0.117885	0.015515	-7.598290	0.0000
D(RESID06(-1))	-0.090537	0.028789	-3.144860	0.0017
D(RESID06(-2))	-0.109631	0.028293	-3.874825	0.0001

R-squared	0.086495	Mean dependent var	0.090861
Adjusted R-squared	0.085016	S.D. dependent var	236.7986
S.E. of regression	226.5093	Akaike info criterion	13.68587
Sum squared resid	63363495	Schwarz criterion	13.69828
Log likelihood	-8468.553	Hannan-Quinn criter.	13.69054
Durbin-Watson stat	1.997300		

Dependent Variable: RAIN
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 06/08/11 Time: 12:07
Sample (adjusted): 1/12/2006 12/17/2010
Included observations: 1234 after adjustments
Convergence achieved after 99 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(11) + C(12)*RESID(-1)^2 + C(13)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	25251.48	3353857.	0.007529	0.9940
FTSMC	4.733019	1.275876	3.709624	0.0002
FTSMC^2	-0.000760	0.000186	-4.075419	0.0000
LJPY3M	-1175.081	942.0860	-1.247318	0.2123
J500*NK300	-4.36E-05	1.20E-05	-3.629657	0.0003
J530*LJPY3M	0.105228	0.040451	2.601374	0.0093
NK300*LJPY3M	1.257744	0.315205	3.990246	0.0001
AR(1)	0.984627	0.016834	58.48938	0.0000
AR(6)	-0.021401	0.040781	-0.524779	0.5997
AR(7)	0.036792	0.039394	0.933944	0.3503
Variance Equation				
C	297766.4	16579.29	17.96014	0.0000
RESID(-1)^2	0.005087	0.001297	3.923148	0.0001
GARCH(-1)	-0.999668	4.71E-05	-21224.24	0.0000

R-squared	0.991092	Mean dependent var	14268.54
Adjusted R-squared	0.991026	S.D. dependent var	2016.465
S.E. of regression	191.0196	Akaike info criterion	13.79646
Sum squared resid	44661912	Schwarz criterion	13.85037
Log likelihood	-8499.414	Hannan-Quinn criter.	13.81674
Durbin-Watson stat	2.036258		

Appendix C

Table C.1. Fitting a Quadratic Model to the Sub-Sectors

Dependent Variable: RAIN
Method: Least Squares
Sample: 1/03/2006 - 12/17/2010
Included observations: 1241

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8912.620	1202.568	7.411326	0.0000
FTSMC	-2.112440	0.383004	-5.515449	0.0000
FTSMC^2	0.000369	5.84E-05	6.310133	0.0000
J272	0.447976	0.036406	12.30506	0.0000
J272^2	-3.42E-06	3.61E-07	-9.464114	0.0000
J177	-0.384840	0.046628	-8.253405	0.0000
J177^2	6.02E-06	6.32E-07	9.516235	0.0000
LJPY3M	18777.85	847.2169	22.16416	0.0000
LJPY3M^2	-3962.296	310.8053	-12.74848	0.0000
FTSMC*J272	-3.60E-05	9.89E-06	-3.639849	0.0003
J272*J177	2.63E-06	1.07E-06	2.459859	0.0140
FTSMC*LJPY3M	-0.783681	0.169569	-4.621604	0.0000
LJPY3M*J272	-0.096831	0.020034	-4.833271	0.0000
LJPY3M*J177	-0.167319	0.022415	-7.464620	0.0000

R-squared	**0.951808**	Mean dependent variable	14246.97
Adjusted R-squared	0.951298	S.D. dependent variable	2031.081
S.E. of regression	448.2304	Akaike info criterion	15.05971
Sum squared resid	2.47E+08	Schwarz criterion	15.11751
Log likelihood	-9330.549	Hannan-Quinn criter.	15.08145
F-statistic	1864.145	Durbin-Watson stat	**0.277164**
Prob (F-statistic)	0.000000		

Dependent Variable: RAIN
Method: Least Squares
Sample (adjusted): 1/11/2006 - 12/17/2010
Included observations: 1235 after adjustments
Convergence achieved after 13 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FTSMC	4.416587	1.102378	4.006417	0.0001
FTSMC^2	-0.000816	0.000161	-5.054682	0.0000
LJPY3M	-3842.495	1547.382	-2.483223	0.0132
FTSMC*LJPY3M	1.507796	0.512652	2.941170	0.0033
AR(1)	0.965932	0.022705	42.54241	0.0000
AR(3)	0.070617	0.027407	2.576614	0.0101
AR(6)	-0.036650	0.017254	-2.124136	0.0339

R-squared	**0.990939**	Mean dependent var	14265.31
Adjusted R-squared	0.990895	S.D. dependent var	2018.843
S.E. of regression	192.6421	Akaike info criterion	13.36520
Sum squared resid	45572271	Schwarz criterion	13.39421
Log likelihood	-8246.009	Hannan-Quinn criter.	13.37611
Durbin-Watson stat	**1.973086**		

Inverted AR Roots	1.00	.57	.09+.52i	.09-.52i
	-.39-.28i	-.39+.28i		

Dependent Variable: RESID01
Method: Least Squares
Sample (adjusted): 1/12/2006 - 12/17/2010
Included observations: 1234 after adjustments
Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.789266	0.021996	35.88198	0.0000
AR(3)	0.076784	0.026212	2.929367	0.0035
AR(5)	0.066646	0.031269	2.131401	0.0333
AR(6)	-0.147598	0.036304	-4.065604	0.0001
AR(7)	0.111521	0.028202	3.954300	0.0001

R-squared	0.750081	Mean dependent var	-1.105007
Adjusted R-squared	0.749267	S.D. dependent var	446.8225
S.E. of regression	223.7384	Akaike info criterion	13.66288
Sum squared resid	61522352	Schwarz criterion	13.68361
Log likelihood	-8424.994	Hannan-Quinn criter.	13.67068
Durbin-Watson stat	1.941120		

Inverted AR Roots	.93	.54+.37i	.54-.37i	.01+.72i
	.01-.72i	-.62-.39i	-.62+.39i	

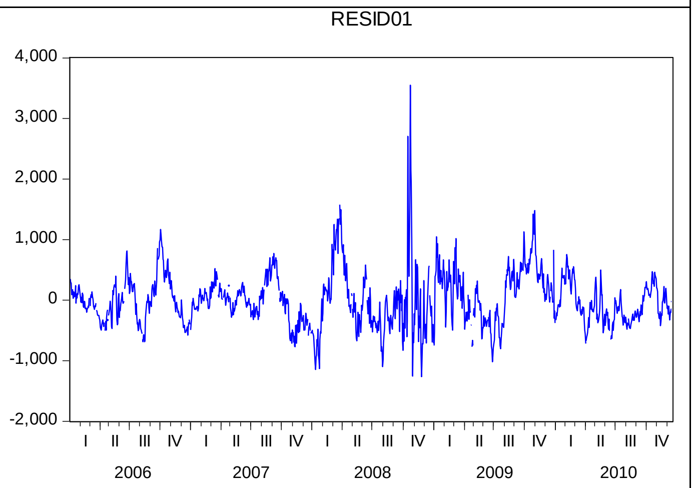
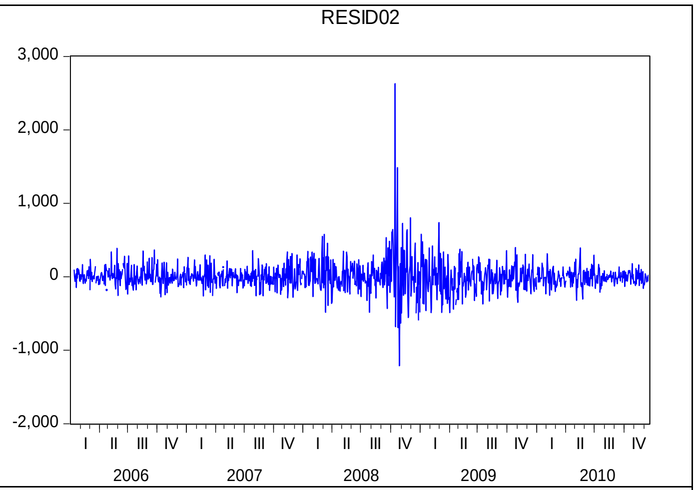


Table C.1. Fitting a Quadratic Model to the Sub-Sectors (continuation)



Null Hypothesis: RESID01 has a unit root
Exogenous: None
Lag Length: 2 (Automatic - based on SIC, maxlag=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.596280	0.0000
Test critical values:	1% level	-2.566831	
	5% level	-1.941079	
	10% level	-1.616527	

*MacKinnon (1996) one-sided p-values.
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID01)
Method: Least Squares
Sample (adjusted): 1/06/2006 - 12/17/2010
Included observations: 1238 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID01(-1)	-0.116358	0.015318	-7.596280	0.0000
D(RESID01(-1))	-0.073713	0.028697	-2.568651	0.0103
D(RESID01(-2))	-0.116163	0.028261	-4.110400	0.0000

R-squared	0.084581	Mean dependent var	-0.257378
Adjusted R-squared	0.083099	S.D. dependent var	235.0144
S.E. of regression	225.0380	Akaike info criterion	13.67284
Sum squared resid	62542998	Schwarz criterion	13.68525
Log likelihood	-8460.485	Hannan-Quinn criter.	13.67750
Durbin-Watson stat	2.001506		

Dependent Variable: RAIN
Method: ML - ARCH (Marquardt) - Normal distribution
Sample (adjusted): 1/11/2006 - 12/17/2010
Included observations: 1235 after adjustments
Convergence achieved after 90 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(8) + C(9)*RESID(-1)^2 + C(10)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
FTSMC	4.138976	1.008316	4.104841	0.0000
FTSMC^2	-0.000757	0.000150	-5.046307	0.0000
LJPY3M	-3114.118	1388.008	-2.243587	0.0249
FTSMC*LJPY3M	1.298258	0.477801	2.717152	0.0066
AR(1)	0.982755	0.014737	66.68591	0.0000
AR(3)	0.046612	0.018668	2.496833	0.0125
AR(6)	-0.029388	0.009429	-3.116631	0.0018
	Variance Equation			
C	60880.04	1924.390	31.63601	0.0000
RESID(-1)^2	0.008498	0.001358	6.258303	0.0000
GARCH(-1)	-0.703598	0.044417	-15.84091	0.0000

R-squared	0.990926	Mean dependent var	14265.31
Adjusted R-squared	0.990881	S.D. dependent var	2018.843
S.E. of regression	192.7845	Akaike info criterion	13.34196
Sum squared resid	45639680	Schwarz criterion	13.38341
Log likelihood	-8228.661	Hannan-Quinn criter.	13.35755
Durbin-Watson stat	2.019321		

Inverted AR Roots	1.00	.55	.09-.49i	.09+.49i
	-.37+.27i	-.37-.27i		