Global commodities and African stocks: insights for hedging and diversification strategies

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Abstract

Owing to frequent fluctuations in global markets, diversifying across emerging markets is increasingly becoming a necessity. Despite this, a cloud of uncertainty surrounds the relative capacities of emerging markets to provide the required shields for international investors, especially during extreme market conditions. In this paper, we explore the relative potentials of African equities to provide opportunities for hedging and diversification for global commodity investors by using data of daily periodicity on close-to-close basis from January 3, 2003 to December 29, 2014. The findings indicate the presence of non-linear relationships between some African stocks and returns on global commodities. Thus, global commodity market investors react differently towards investment potentials in African stocks during tranquil and crisis periods in the commodity markets. Additionally, from the mean-variance stand-point, including African equities in a diversified portfolio has the effect of lowering risk whiles simultaneously increasing expected returns. However, such investment strategies must be informed by volatility persistence, as well as past and present market conditions

Key words: African stocks, global commodities, safe haven, mean-variance, hedging.

JEL Classification Codes: G10, G11, G15,

1 Introduction

"As more money has chased (. . .) risky assets, correlations have risen. By the same logic, at moments when investors become risk-averse and want to cut

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their positions, these asset classes tend to fall together. The effect can be particularly dramatic if the asset classes are small – as in commodities. (. . .) This marching-in-step has been described (. . .) as a 'market of one'." The Economist, March 8, 2007.

Africa's development agenda over the years has been ingrained on the need to attract high private capital flows (PCFs).[1] However, although the early days of the 21^{st} century saw increases in private capital flows into Sub-Saharan Africa (SSA), the advent of the 2008-2009 global financial crisis (GFC) registered some declines due to increased investor risk-aversion, tighter global credit conditions, and developments in the bond markets (Simatele, 2014). The post-crisis declines may also be attributable to international investors' failure to see investments in Africa as safe-havens.[2]

The uncertainty about earning higher expected pay-offs in Africa have been a major contributing factor to why Africa appears not to be receiving large portfolio investment flows. Meanwhile, recent crashes in the global economy are offering investors with fresh means to diversify their investments portfolios across diverse geographical regions. The ability of Africa to identify and benefit from such possible international cross-border portfolio investment flows and diversification opportunities requires an understanding of the nature and extent of correlations between its financial markets and the global economy. For this reason, to ascertain whether equities in Africa can act as sure hubs for international portfolio investors, we ask the questions: are African stock markets in a position to attract large portfolio investments flows during extreme global commodity markets conditions? Again, how can African stocks be deemed viable to offer hedge or act as safe-havens during varying periods of global commodity markets crashes, uncertainty and volatility? Answers for the above questions remain virtually non-existent for most developing markets including those in Africa.

At the same time, increasing susceptibility of financial markets to various forms of economic shocks has led to the resurgence of investors' appetite to look for alternative means to hedge their downside market related risk. In the last decade, investors have considered commodities as highly liquid financial assets other than a means to support 'real' economic activity through hedging and risk management (Vivian and Wohar, 2012; Cheng and Xiong, 2014). A report by the US Commodities Futures Trading Commission (CFTC) in 2008 showed that investment inflows to various commodity futures markets rose to US$200 billion from 2000 to 2008 (CFTC, 2008). This figure had jumped to about US$210 billion by the end of 2012.[3] Similarly, significant number of commodities across the energy, metal, and agricultural sectors saw harmonized boom and bust cycles just around the global financial crisis (GFC) in 2008-2009 (Cheng and Xiong,

[1] We define private capital flows to include foreign direct investments (FDIs), portfolio capital flows and debt flows.

[2] Although there appears to be some recovery from Africa's bond and equity markets post-crisis, the gains still remain a minuscule proportion of the overall global equity and bond markets (see also AfDB, 2013; Simatele, 2014).

[3] See CFTC Index Investment Data. http:/www.cftc.gov/MarketReports/IndexInvestmentData/index.htm

2014). This huge inflow is necessitated by the believe that investors potential to diversify can better be enhanced with the inclusion of commodity futures in portfolios since commodities show equity-like returns and low correlation with traditional assets (Gorton and Rouwenhorst, 2006). The process of speculative market participants' consideration of commodities as investment assets is referred to as the "financialization" of commodities.[4] Including commodities in investors' portfolios therefore appears to be a glowing venture generating higher interest. Commodities, just like all assets (such as stocks and bonds) show sensitivity to changing economic conditions and tend to correlate with asset returns, regardless of what explains such correlations. Establishing evidence to expound how increased investor appetite for commodities reflects the pricing of financial securities and facilitate the commodity-equity cross linkages have always attracted the attention of analyst and scholars.

Evidence abounds to suggest that "financialization" of commodities partly explains the increases in cross-market correlations between commodities and equities during crisis (Olson *et al.,* 2014; Buyuksahin and Robe, 2014), even though the existence of commodity financialization is in serious doubt (see for example, Demirer *et al.,* 2015). The commodity-equity correlations may also be driven by herd behavior (Demirer *et al.,* 2015). Empirical evidence on the impact of financialization produces interesting results albeit inconclusive. Earlier studies by Bodie and Rosansky (1980); and Anson (1998) give evidence that adding commodities in portfolios enhances investors' chances of reducing risk. However, recently, Daskalaki and Skiadopoulos (2011) do not show diversification benefits in out-of-sample setting. In their application of the mean-variance optimization framework to examine the significance of commodities in investors' portfolios, Yan and Garcia (2014) reports that even though commodities can slightly reduce risk in portfolios, this effect becomes negligible in well balanced portfolios. Buyuksahin *et al.,* (2008) report that there are no significant increases in co-movement during extreme periods of commodity and equity returns.

It is clear from the above that extant studies looking at the commodities-stocks cross-market nexus and the implications for hedging and diversification have done so from the perspective of investors already holding positions in equity markets. This leaves huge gaps in the literature from the standpoint of investors with positions in the commodities market seeking to diversify across equity markets. Even in the case of the former, the gap in the literature on emerging markets (including Africa's nascent markets) is harrowing.

Our results confirm findings of earlier studies that the rate of return on commodities is generally more volatile than that on equities. The cross-market correlation between global commodities and stocks in Africa is seen to be influenced by the recent global financial crisis, with more intensity around 2008 and 2009. Of all the commodities analyzed in the study, diversification or hedging opportunities into Africa's equities are noticed to be more achievable for investors in the gold and oil spot markets. Essentially, for risk-return trade-

[4] See also Cheng and Xiong (2014) and Olson et al., (2014).

off, international oil and/or gold investors holding or seeking to hold assets in Africa, may generally have to allocate on average, about 50:50 weight to African stocks and the commodities. It follows that, all stock-oil or stock-gold hedged portfolios with less than 50% African stock components do not offer effective hedges. The results further show that global commodity investors react differently towards investment potentials in Africa during market calmness and crisis. Finally, it is obvious from the mean-variance standpoint that including African equities in a diversified portfolio has the effect of lowering risk whiles simultaneously increasing expected returns.

The remaining sections of the paper are as follows: Section 2 outlines the data and research design (methodology); Section 3 presents results and discussions; and Section 4 concludes the paper.

2 Data and research design

2.1 Data

Data for the study comprise indices of eleven (11) African stock markets (South Africa, Egypt, Ghana, Botswana, Tunisia, Mauritius, Morocco, Namibia, Kenya, Cote D'Ivoire and Nigeria)[5] and spot prices of five (5) global commodities (gold, oil, silver, platinum, and cocoa). The African markets included in the sample represent the largest stock markets by market size and volume, and could proxy for stock markets in the rest of the African continent. The choice of the above commodities also reflects their high importance in the world economy and to international investors. Additionally, gold, oil, and cocoa are major export products in most of the countries considered in our sample. We also include an aggregate commodity price index (i.e. the Bloomberg Commodities Index – BCOM). The data are collected on a daily close-to-close basis falling in the period 3 January 2003 to 29 December 2014 (a total of 3,056 observations).

All data are gleaned from Bloomberg and expressed in US dollars (US$) ostensibly to eliminate the effect of domestic inflation and ease comparison. We therefore assume that hedging, diversification, and/or safe haven opportunities are viewed from the perspective of international investors. The indicated variables for the study are transformed into returns computed as the logarithmic difference between two consecutive prices or indices, given as:

$$r_t = [\ln(p_t) - \ln(p_{t-1})] * 100 \tag{1}$$

where r_t = returns at time t; p_t and p_{t-1} are respectively current price/index and one-period lagged price/index.

In order to capture the dynamic behaviour of the markets in the period after the GFC in our models, we disaggregate the data into full sample and sub-sample (post global financial crisis) periods. In line with Lean and Nguyen (2014) the global financial crisis (GFC) period is considered to have commenced

[5] All eleven (11) markets sampled are open to international portfolio investment despite disparities in the level of openness (see for example, Odongo and Kalu, 2011).

on 15 September 2008. Our disaggregated data then comprise (a) full sample period from 3^{rd} January, 2003 to 29^{th} December, 2014; and (b) a sub-sample period covering 15^{th} September 2008 to 29^{th} December 2014.

2.2 Dynamic conditional correlations

We estimate time-varying dynamic conditional correlations (DCC) between the African stocks and global commodities using the Engle (2002) DCC-GARCH model. Particularly, we seek to examine the hedging and diversification opportunities across the eleven African markets. The DCC-GARCH model will also help to estimate the volatility cross-effects and their persistence – a key issue with implications for investors' portfolio selection and allocation decisions. The Engle (2002) DCC model can be estimated in two phases (using the Maximum Likelihood Estimation - MLE): first by estimating univariate GARCH (1,1) parameters and second estimating the coefficients of the conditional correlations. Thus, the model allows for the separate specification of the conditional variances on one hand, and the conditional correlation matrix on the other hand.

The Engle (2002) DCC model is specified as:

$$H_t = D_t R_t D_t \tag{2}$$

where,

$D_t = diag\left(h_{11t}^{1/2} \dots h_{NNt}^{1/2}\right)$ and $R_t = diag\left(q_{11\,t}^{-1/2} \dots q_{NN\,,t}^{-1/2}\right)$

$Q_t\, diag\left(q_{11\,,t}^{-1/2} \dots q_{NN\,,t}^{-1/2}\right)$

The $N\,x\,N$ symmetric positive definite matrix $Q_t = (q_{i\,j\,,\,t})$ is given by:

$$Q_t = (1 - \phi_1 - \phi_2)\,\bar{Q} + \phi_1 \mu_{t-1} \mu_{t-1}' + \phi_2 Q_{t-1} \tag{3}$$

where, $\bar{Q}$ is the $N\,x\,N$ unconditional variance matrix of μ_t, and $\phi_1 \phi_2$are non-negative scalar parameters satisfying $\phi_1 + \phi_2 < 1$

The Engle (2002) DCC expression of the correlation coefficient (ρ_{12t}) can be specified as:

$$\rho_{12\,,\,t} = \frac{(1 - \phi_1 - \phi_2)\ \tilde{q}_{12} + \phi_1\, \mu_{1\,,\,t-1}\, \mu_{2\,,\,t-1} + \phi_2\, q_{12\,,\,t-1}}{\sqrt{\begin{array}{c}\left[(1 - \phi_1 - \phi_2)\ \tilde{q}_{11} + \phi_1\, \mu_{1\,,\,t-1}^2 + \phi_2\, q_{11\,,\,t-1}\right] \\ \left[(1 - \phi_1 - \phi_2)\ \tilde{q}_{22} + \phi_1\, \mu_{2\,,\,t-1}^2 + \phi_2\, q_{22\,,\,t-1}\right]\end{array}}} \tag{4}$$

2.3 Econometric approach to the hedge and safe haven analysis

This section provides detail insights on the examination of whether African stocks can act as diversifiers, hedges, and safe havens in extreme conditions of the commodity markets. Particularly, we examine whether African stocks can strategically serve as viable investment hubs for international investors during sell offs or crashes in international commodity markets. We assume that returns

on Africa's stocks are dependent on the general price trends in the commodity futures/spot markets. Additionally, we contemplate that the relationship is not constant but driven by some extreme market conditions. In line with Baur and Lucey (2010) and Baur and McDermott (2010) we term this the 'safe haven' hypothesis analysis and apply their regression model given by equations (3a – 3c) to test the safe haven property of African stocks. We in-turn model the behaviour of African stocks (AFSTOCKs) as follows - (*each other variable [EOV] specific co-efficients are suppressed for brevity of exposition*).

$$r_{AFSTOCKt} = a + b_t r_{(EOV)}, t + \varepsilon_t \tag{5}$$

$$b_t = d_0 + d_1 D\left(r_{EOV} q_{10t}\right) + d_2 D\left(r_{EOV} q_{5t}\right) + d_3 D\left(r_{EOV} q_{1t}\right) \tag{6}$$

$$h_t = \pi + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j}^2 \tag{7}$$

Equation (3a) models the relations between the African stocks and global commodities. The parameters for estimation are a and b, with the error term given by ε_t.The parameter b_t is modeled as a dynamic process given by equation (3b). In equations (3a) and (3b), $r_{AFSTOCKt}$ refers to the returns on the considered stock markets in Africa (individually); r_{EOVt} indicates the returns of the regressors (all the commodities) at time t. The parameters of interest in equation (3b) are the constant term, d_0 (which measures the average effect of the predictor variables on the response variable – and in this case our statistic for determining a hedge property); and dummy variable coefficients $d_1, d_{2,} and\ d_3$. The dummy variables denoted as $D(\dots)$ capture extreme market behaviour of the regressors and are coded 1 if the commodity returns go beyond a certain threshold given by the 10%, 5%, and 1% quantile (q) of the return distribution.[6] The quantiles account for asymmetries of positive and negative (extreme) shocks and are included to focus on declining moments of the commodity markets. For instance we are interested in finding out whether declining moments in these markets propel international portfolio investors to consider African stocks as safe destinations for their investments. The intuition here is that considering the weak level of integration[7] between African stocks and the global financial environment, there may be the possibility of Africa's decoupling from global shock contagion leading to lower or negative cross-assets correlation between Africa and the international markets.

The structure in equation (3b) assumes that returns on African stocks are dependent on the contemporaneous return on each other asset (cocoa, gold, oil, silver, platinum, and BCOM). This is consistent with the safe haven hypothesis. It is additionally assumed that African equity returns do not drive changes in prices on the global markets under consideration. This strikes out any feedback effect in the model formulated under Section (2.3). The evidence is limited in

[6] To some extent, the choice of a quantile is arbitrary. However, Baur and McDermott (2010) and Hood and Malik (2013) all used the same quantiles.

[7] See Alagidede (2010) on Africa's financial markets integration.

contradiction of this assumption. The possibility of even weak feedback effect may be present for developed markets in Europe, North America, and or some parts of Asia with sizeable numbers of companies or institutional investors who have large holdings in the commodity markets.

We dwell on equation (3*b*) to examine the 'safe haven' hypotheses. If any of the parameters $d_1, d_2, and\, d_3$ is significantly different from zero, there is evidence of a non-linear relationship between an African stock and the returns on commodities. Evidence of non-linear relationship shows how investors react differently to extreme market conditions relative to tranquil periods. A significant non-positive $d_0, d_1, d_2, or\, d_3$ indicates that African stocks are weak safe havens for the variable under consideration. If any of the parameters $d_1, d_2, or\ d_3$ is negative and significantly different from zero, then African equities in the model can be described as having a strong safe haven property. An African equity can act as a hedge if the parameter d_0 is zero (weak hedge) or significantly negative (strong hedge) and the sum of the parameters d_1 to d_3 are not jointly positive exceeding the value of d_0. Further, we specify a univariate GARCH (1,1) model to account for hetereoscedasticity in the data as shown in equation (3c).

3 Empirical results

3.1 Preliminary test analysis

In Table 1 we begin our preliminary analysis with descriptive statistics and unit roots test. The last three columns show augmented Dickey-Fuller (ADF) test for unit roots rejecting the null hypothesis of non-stationarity for all series at the 1% significance level at the first difference. The results in Table 1 also reject the null hypothesis of normality for all series as indicated by the Jacque-Berra (JB) statistics. The descriptive statistics further show that all series exhibit leptokurtic features indicating high peakedness. The skewness values are both negative and positive for the African markets and commodities. The probability of an investor seeing positive returns from positively skewed assets is higher than those which are negatively skewed. While the commodities appear to have lower mean returns from -0.00% to 0.04%, they also possess higher volatilities (with gold and oil leading with respectively 2.15% and 2.38%) relative to the African markets with average mean returns from 0.02% to 0.08%. This corroborates the findings by Buyuksahin and Robe (2014) and Creti *et al.,* (2013) that the rate of return on equities is generally less volatile than that on commodities. The result is expected given that prices of commodities (especially gold and oil) relatively often reflect the real-time equilibrium between demand and supply, with contingencies that change on daily basis.

In Table 2 we report results of autoregressive conditional hetereoscedasticity (ARCH) test for examining the null of "no ARCH" effects and Ljung-Box test. Except for Botswana, Cote D'Ivoire and Ghana, we can reject the null of "no ARCH" effect for all other series. The presence of ARCH effects makes the estimation of a GARCH-type model more appropriate in modeling the conditional

correlation among the variables. The Ljung-Box test statistics identifying the presence of autocorrelation indicates the existence of significant temporal linear dependencies at the 1% significance level for most of the variables.

In Table 3, we show how the African stocks behave relative to the commodities and stock markets in their worst 10% (0.1), 5% (0.05), and 1%(0.01) performing days. Generally, it can be observed that though on the worst 1% days of the commodities, average daily returns are lower than those of most of the African equity markets, they all yield positive returns. The same directional movement (or same sign) of the asset classes condenses any diversification effectiveness. However, a more robust test for the hedging and safe haven hypothesis can be achieved by executing the econometric model in equations (2 and 3).

3.2 Dynamic conditional correlations

Tables 4.1 and 4.2 show results estimated from the Engle (2002) DCC-GARCH(1,1) model for the full sample and sub-sample periods respectively. Close observations of the results in both tables generally show similar patterns of correlations between the African stocks and global commodities, since all significant correlations are non-negative, except that between Ghana and oil (see Table 4.2). However, the magnitudes of the correlation coefficients from markets to markets and across regimes (i.e. full sample and sub-sample) do not show any definite pattern to warrant trend analysis. The coefficients associated with the ARCH (ϕ_1) and GARCH (ϕ_2) parameters similarly show mixed results. However, very few of them follow some patterns. It appears clear that in the full sample period, the ARCH and GARCH parameters are highly significant for the following market pairs: Morocco-gold; Egypt-oil; Tunisia-oil, gold; Kenya-BCOM ; Ghana-gold; South Africa-gold, oil; Nigeria-cocoa; and Namibia-oil, gold. Similarly, in the sub-sample period, the correlations between Morocco-gold, oil; Tunisia-gold, oil; Mauritius-cocoa; South Africa-gold, oil; Cote D'Ivoire-oil; and Botswana-gold, oil; show substantial volatility persistence. The generally small sizes of the ARCH coefficients suggest slow changing conditional volatilities under the effects of return innovations. They however evolve with time on the effects of past volatility, as indicated by the close to unity GARCH coefficients in many instances. On the basis of this, investors seeking to trade across the above indicated market pairs may have to focus on active investment strategies informed by volatility persistence and present market conditions. Advisedly, the proportion of portfolio investments may have to be increased (decreased) in bullish (bearish) markets. Additionally, such strategies must take into account the stability and performances of successive periods.

Focusing specifically on the correlation coefficients, our results suggest that African equity returns generally have low correlations with returns on commodities. Similar to Choi and Hammoudeh (2010) and Creti *et al.,* (2013), our results show high volatilities for the correlations between the African equities and commodities indicated in the previous paragraph. From the graphical plots of the conditional correlations (*though unreported due to space constraint but available upon request*) it is observed that the correlations become intense just

at the time of the global financial crisis around 2008 and 2009.

Since most significant correlations and high volatility persistence were observed between African equities on one hand and each of gold and oil on the other hand, there is the need to shed some light on the development. First, it is important to note that oil and gold were observed to have the highest volatilities among the commodities and global indices considered in this study (see Table 1). The importance of oil in the development of financial markets can be registered in the litany of studies that focus on the relationship between oil and stock markets (see for example, Jones and Kaul, 1996; Bastianin and Manera, 2014, etc.). Theoretically, rising crude oil prices affect the prices of equities through either the discount rate or cash flow effect.

In our particular instance, rising crude oil prices (up to about $147 a barrel) in 2008 gradually decreased firm's marginal costs of production in Africa resulting in significant losses. Since the value of a stock is a function of firms' expected future cash flows, losses in cash flows caused asset prices to decline in Africa. However, this could not drive the correlations between the African equities and crude oil prices to negative, limiting possible portfolio diversification effectiveness. As the crisis begun to ease from 2009 with the plummet of oil prices below the $100 mark, equity returns in Africa started to rise gradually as in the case of South Africa, Tunisia, Mauritius, and Cote D'Ivoire until somewhere in 2011 when oil prices started increasing slightly for a short period and assumed a stable trend. Equity prices then begun to move slowly along the level of increases for oil, hence the positive correlation. The rate of change of equity returns in Africa relative to shifts in crude oil prices, however, appears to be slow.

On the part of gold, literature has largely found evidence of negative correlation with asset classes supporting the safe-haven characteristics of gold (e.g. Baur and McDermott, 2010; Beckmann *et al.,* 2014). However, the rather positive relationship established for gold and some African stocks corroborates Baur and McDermott (2010) which found similar results for emerging markets, and Arouri *et al.,* (2015) for China. In view of the generally lower (less than 0.5) significant cross-market correlations between each of gold and oil on one hand and some of the African stocks on the other hand, it is natural to assume that having both asset pairs in a single portfolio may better the lot of investors. However, judging from the significant volatility cross-effects (shown in Tables 4.1 and 4.2), it will be more prudent for portfolio investors to estimate the prime weights and hedge ratios of African stocks in a considered hedged portfolio in order to suitably account for the prudence of the hedge.

3.3 Optimal hedge ratios (OHR) and portfolio weights of African stocks

A diversifier is an asset that is positively (but not perfectly correlated) with another asset or portfolio on average. Also provided correlation rises in absolute terms, increased correlations would mean that commodities/stocks can offer better diversification or hedging avenues (Oslon *et al.,* 2014). On the basis of

this, we argue that since hedging entails taking a long position in one asset (as in stocks) and a short position in another (say a commodity), a surge in correlations means that a price fall in the commodities futures/spot market would be better offset by a long position in the stock markets, thereby making the hedge effective. In view of the above and our week cross-market correlations found for gold and oil; and some African stocks, we proceed to examine the implications of the DCC-GARCH(1,1) results on a stock-gold and stock-oil optimal portfolios. The objective is to derive a hedged portfolio in which the international investor seeks cover from exposure to gold or oil price declines with investment in African stock markets. In which case, the investor's prime objective is to maintain higher expected returns whilst minimizing risk.

For illustrative purposes, we assume the practical situation of an international oil firm seeking shield from Africa's equities away from exposure to price volatilities in the crude oil market. The hedge ratio on the oil firm's portfolio of African equities and crude oil position is defined as:

$$\gamma = \frac{r_{0il} - r_t}{r_s} \tag{8}$$

where γ is the hedge ratio – representing the dollar amount of crude oil that the hedger (oil firm) must short for each share price in Africa; r_t is the return on holding the portfolio between $t-1$ and t; r_s and r_{oil} are the returns on holding the equities and crude oil positions respectively, between t and $t-1$.

From the DCC GARCH (Engle, 2002) model framework, the OHR is computed as:

$$\gamma_t^* | \Omega_{t-1} = \frac{h_{oil,s}}{h_s}, \tag{9}$$

given that $h_{oil,s}$ and h_s are the conditional covariance of crude oil and stock returns; and conditional variance of stock returns respectively; and Ω_{t-1} is information available at $t-1$.

In order to establish the required optimal portfolio structure that minimizes risk subject to a no- shorting constraint, we apply Kroner and Ng (1998) methodology to compute the optimal holding weight (w) of African stocks in a \$1 portfolio of stock/oil at time t as:

$$w = \frac{h_{s_t} - h_{(oil,s)_t}}{h_{oil,t} - 2h_{(oil,s)t} + h_{s,t}} \tag{10}$$

where $h_{oil,t}$ is the conditional variance of crude oil returns at time t. All others are as defined in equation [8].

Assuming a mean-variance (MV) utility function in the absence of short-selling, the following constraint is imposed on the optimal weight of the stocks through optimization:

$$w_t^{oil,s} = \begin{cases} 0, & if \quad w_t^{oil,s} < 0 \\ w_t^{oil,s}, & if \quad 0 \leq w_t^{oil,s} \leq 1 \\ 1, & if \quad w_t^{oil,s} > 1 \end{cases} \tag{11}$$

where $\left(1 - w_t^{oil,s}\right)$ determines the proportion of dollar amounts that the investor puts into the crude oil market at time t.

We present results of the optimal hedge ratios, portfolio weights, and hedge effectiveness in Table 5. By way of strategy, an investor seeking to hedge his/her price risk in the crude oil or gold (hereafter referred to as OG) market would take a risk-minimizing position in order to realize the highest average expected return from the stock-OG portfolio. Practically, taking a \$1 long position in an African equity can be offset with a $\$\gamma^*$ short position in the OG market.

The optimal weights of Africa's equities in a stock-oil (so) and stock-gold (sg) portfolios effectively accentuate the cent amount of a \$1 portfolio that should be allocated to a stock in Africa in order to minimize risk without lowering expected rewards. For instance, the 51.54% optimal weight for South Africa in the stock-oil portfolio (see Panel A) means that the proportion of the \$1 portfolio to be allocated to the JSE/FTSE All-Share-Index and oil are 51.54 and 48.46 cents respectively. The results generally show that international oil and/or gold investors holding or seeking to hold assets in Africa, may have to allocate on average, about 50:50 weight each to an African stock and a commodity to be able to maximize their risk-return trade-off, since average optimal weights in both the full and sub-sample periods are respectively 51.34% and 51.37%.

The optimal average hedge ratios are relatively low ranging from 0.0418 to 0.4452 in the full sample period and 0.0865 to 0.3709 in the sub-sample period. In all, South Africa and Egypt record the highest and lowest hedge ratios, respectively. The results indicate that in the full-sample period, a \$1 long (buy) in the South African stock market (FTSE/JSE) should be accompanied by a short (sell) of 28.47 cents and 44.52 cents in the oil and gold spot markets respectively. Analogously, in the sub-sample period, a \$1 dollar buy in the FTSE/JSE should be shorted by 37.09 cents and 27.21 cents of oil and gold respectively. In sum, our results point to the direction that African stocks can form an integral part of a diversified portfolio with commodities to reduce the risk of the hedged portfolio whilst increasing expected returns.

Though results from our optimal portfolio weights and hedge ratios indicate the relevance of including equities from Africa in a stock-gold or stock-oil hedged portfolios, the critical question that remains unanswered is how effective would the hedge be to enhance the portfolio's risk-adjusted performance? This leads us to the examination of the hedging effectiveness of the portfolios under consideration. Generally, an accurate conditional volatility should be able to offer superior hedge effectiveness (HE) - Ku *et al.,* (2007). We calculate HE as the variance reduction for a hedged portfolio compared with an unhedged portfolio. Mathematically, the HE index can be computed as:

$$HE = \left[\frac{Var_{unhedged} - Var_{hedged}}{Var_{unhedged}}\right] * 100 \tag{12}$$

where $Var_{unhedged}$ denote the variance of the unhedged portfolio's (African equities) returns; Var_{hedged} refers to the variance of the hedged portfolio's returns. The portfolio with the highest HE offers the best hedging strategy for

constructing a stock-oil or stock-gold portfolio.

It can be observed from the HEs (Table 5) that all portfolios with optimal weights below 50% do not offer effective hedges (as their HEs are negative). For a portfolio with positive HE, the effectiveness of the hedges is low (with less than 15% HEs). Thus, even though realized optimal portfolio weights and hedge ratios indicate the need for a well-diversified stock-oil or stock-gold portfolio to include African stocks, the effectiveness of such hedging strategies may not be substantially active.

Despite this, international investors seeking to hedge their price risk in gold or crude oil markets with equities in Africa may have to look at the market in Cote D'Ivoire. The *HE*s of Cote D'Ivoire inclusive portfolio hedges are not only higher (11.88% and 11.24% for the stock-oil and stock-gold respectively) but also have relatively lower variance (risk) to *HE* ratios (in absolute terms) and possess the highest optimal portfolio weights.

3.4 Analysis of the 'safe haven' hypothesis

Although the conditional correlation results in Tables 4.1 and 4.2 provide useful information on the dynamic relations between the variables, it falls short at pointing out possible risk mitigating properties of African stocks in extreme unfavourable conditions of the commodities markets.[8] To be able to ascertain whether or not equities in Africa offer significant shield for losses in the commodity spot markets, we evaluate the "safe haven" hypothesis developed by Baur and Lucy (2010) and present the results in Table 6. An asset with a safe haven feature does not assume a negative or positive correlation on average but only takes a zero or negative correlation in specific periods. In this case, negative correlation in turbulent market conditions explains the "haven's" ability to compensate investors for their losses.

Table 6 depicts the hedge determining coefficient, d_0; the safe-haven determining parameters, $d_1, d_2,$ *and* d_3;and the total effects for extreme market behaviours, *Sum* (d_1, d_2, d_3) for the different quantiles. Estimates from the GARCH (1,1) model reveal high significance for the ARCH (α) and GARCH (β) parameters across board. Except for the regression estimates involving Cote D'Ivoire, South Africa, Botswana and Namibia, the degree of short-run persistence are very high (greater than 0.1) for all other markets. Estimates for South Africa, Nigeria, Mauritius, Kenya, and Tunisia are seen to have the highest long-run volatility persistence (with $\alpha+\beta$ close to unity). Analysis of the ARCH-LM test for lags 2 and 12 suggest that except for the model involving Mauritius, the presence of remaining ARCH effects is substantially minimized. In contrast to estimates from the DCC model, results from Table 6 indicate that no equity market in Africa provides a hedge for any of the considered commodities.

This supports the opinion held by Baur and Lucey (2010) that an asset that offers a hedge in normal periods may fail to exhibit similar characteristics in

[8] Generally, correlations hold only on average and may be positive or negative in tranquil or crisis periods.

periods of market turbulence. The result is suggestive of the fact that global commodity investors react differently towards investments in Africa in periods of market calmness and crisis. A plausible explanation of this is that, saddled with significant losses and heightened uncertainty about their investments in international assets during extreme market meltdowns, international investors become doubtful about the prospects of emerging or developing markets to provide cushions for their losses. Alternatively, they may prefer to shift their portfolios towards the relative safety of developed world markets.

In spite of the African stocks' failure to offer hedging features for commodities during market turbulence, some provide considerable safe haven characteristics. The save haven hypothesis is seen to be applicable for the following market pairs: Morocco-Platinum, Egypt-Cocoa, Egypt-Platinum, Tunisia-Cocoa, Tunisia-Silver, Kenya-Platinum, Kenya-S&P 500, Mauritius-Oil, South Africa-Cocoa, South Africa-Platinum, Botswana-Oil, Namibia-BCOM, Namibia-Oil, and Namibia-Gold.

Examining the above reveals that four markets (Morocco, Egypt, Kenya, and South Africa); three markets (Egypt, Tunisia, and South Africa); and two markets (Mauritius and Botswana) offer safe haven properties for Platinum, Cocoa, and Oil respectively. In each set Egypt (for platinum), South Africa (Cocoa), and Botswana (for oil) are noted to offer the strongest safe havens since their safe haven parameters are more statistically different from zero. On account of the relatively stronger safe haven characteristics of the above stock market-commodity pairs, we in turn proceed to evaluate the pairs in a diversified portfolio within the mean-variance framework. The implication of the stronger safe haven properties for the above market pairs is that, investors who purchase African stocks during periods of crisis in the global commodity markets are compensated for loses from their global investments through positive returns.

3.5 Mean-variance portfolio selection and optimization with stocks in Africa

In this section, we examine within the mean variance portfolio optimization framework, the best portfolio combinations that will optimize returns whilst reducing variances. Particularly, we analyze varying portfolio mixes of stocks and commodities that produce the minimum variance without lowering returns. Figure 1 depicts the mean-variance portfolios for the first ten percentiles of portfolios that range from 0% (100%) in stocks (commodities) to 100% (0%) in stocks (commodities). The first panels of each set (A1, B1, and C1) show the risk and return of including African stocks in a stock-commodity portfolio without minimizing the variance. The second panels (A2, B2, and C2) show the set of all portfolios with economically meaningful risk-return trade-off (i.e. the efficient frontier). The upper blue lines in Panels A2, B2, and C2 indicate the efficient frontiers. Practically, the choice between any two portfolios on the efficient frontier requires trading a higher expected portfolio risk for a higher expected return.

A close observation from the plots shows that for a 100% investment in platinum, an international commodity investor could achieve a daily average return of 2.35% at a standard deviation of 1.42% (see Panel A1). However, by diversifying 61.60% into the Egyptian stock market, the investor could increase his daily expected portfolio returns to 5.86% whilst lowering the standard deviation to 1.23% (see Panel A2). Panel B1 reveals that a 100% investment in the cocoa spot market could earn an investor daily mean return of 1.23% with a risk component of 1.93%. Meanwhile, from the mean-variance standpoint, the daily mean return and risk probability could respectively be increased (decreased) from 2.77% (1.37%), with the inclusion of 46.88% of portfolio amount into the South African equity market (see Panel B2). Finally, within the mean-variance framework, including 11.29% of equities from Botswana is able to increase expected daily mean return from 1.72% to 1.85% whilst reducing portfolio standard deviation from 2.38% to 2.13% (see Panels C1 and C2). From the foregoing, it is clear that judging from the mean-variance point of view, adding African stocks to a diversified portfolio of stocks and commodities has the effect of lowering risk whiles simultaneously increasing expected returns. The performances of the three portfolio mixes thus show that Botswana offers a relatively meaningful average risk-return trade-off in the stock-oil portfolio at a relatively lesser cost.

4 Conclusion

The paper examines the relative capacity of African stocks to offer hedging, diversification, and safe haven properties for international investors in the commodities markets. The analysis is carried out from 3^{rd} January 2003 to 29^{th} December 2014 with focus on examining how the portfolio hedge, diversifier, and safe haven capabilities of equities in Africa have been over time.

The results show that African equities can be considered as integral part of a diversified portfolio of stocks and commodities to reduce risk whilst maintaining higher expected returns. It however follows that portfolios having less than 50% of African stocks may not offer effective hedges. It is clear that the save haven hypothesis is seen to be applicable for the following market pairs: Morocco-Platinum, Egypt-Cocoa, Egypt-Platinum, Tunisia-Cocoa, Tunisia-Silver, Kenya-Platinum, Kenya-S&P 500, Mauritius-Oil, South Africa-Cocoa, South Africa-Platinum, Botswana-Oil, and Namibia-BCOM, Namibia-Oil, and Namibia-Gold. Examining the above reveals that four markets (Morocco, Egypt, Kenya, and South Africa), three markets (Egypt, Tunisia, and South Africa), and two markets (Mauritius and Botswana) offer safe haven properties for Platinum, Cocoa, and Oil respectively. In each set Egypt (for platinum), South Africa (Cocoa), and Botswana (for oil) are noted to offer the strongest safe havens since their safe haven parameters are more statistically different from zero. It is observed from the mean-variance point of view that adding African stocks to a diversified portfolio has the effect of lowering risk whiles simultaneously increasing expected returns. The performances of the three portfolio mixes thus show that stocks

in Botswana offer a meaningful average performance in the stock-oil portfolio hedge at a relatively lesser cost.

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Table 1: Descriptive statistics for daily returns *(full sample period)*

	Mean (%)	SD (%)	Skewness	Kurtosis	JB @ 1% Sign. level	ADF @ 1% 1st diff		
						τ	C.V	I(d)
TUNISIA	0.0389	0.6973	-0.1931	8.7326	4196.634	-21.192	-3.433	I(0)
SOUTH AFRICA	0.0463	1.8240	-0.2636	8.6211	4052.103	-23.584	-3.433	I(0)
NIGERIA	0.0254	1.3229	-0.2992	8.4972	3887.203	-18.230	-3.433	I(0)
NAMIBIA	0.0549	1.2676	1.2366	50.4353	287198.4	-19.721	-3.433	I(0)
MOROCCO	0.0155	1.3147	-0.0691	7.4497	2522.765	-24.369	-3.433	I(0)
MAURITIUS	0.0511	0.8613	0.0168	15.7450	20676.83	-21.029	-3.433	I(0)
KENYA	0.0377	1.1784	-0.0298	24.2293	57368.81	-16.130	-3.433	I(0)
GHANA	0.0226	1.0095	0.8322	39.8584	173283.2	-18.814	-3.433	I(0)
EGYPT	0.0804	1.8002	-0.6109	10.2633	6905.414	-22.024	-3.433	I(0)
COTE D'IVOIR	0.0681	1.3606	4.0323	58.6650	402704.7	-40.999	-3.432	I(0)
BOTSWANA	0.0282	1.0004	1.7613	62.2022	447723.9	-39.585	-3.432	I(0)
SILVER	0.0409	2.1162	-0.8063	9.0775	5026.128	-19.974	-3.433	I(0)
PLATINUM	0.0239	1.4197	-0.7734	8.6216	4321.624	-23.094	-3.433	I(0)
OIL	0.0186	2.3819	0.0391	13.5518	14231.71	-20.099	-3.433	I(0)
GOLD	-0.0028	2.1457	-0.0824	9.8936	6052.505	-23.463	-3.433	I(0)
COCOA	0.0123	1.9338	-0.3544	18.8676	32113.48	-43.319	-3.432	I(0)
BCOM	-0.0037	1.1164	-0.2570	5.5069	833.58	-24.573	-3.433	I(0)

Notes: *Daily data for the full sample period from 3/1/2003 to 29/12/2014 are used. JB is the* χ^2 *statistic for testing normality. The JB rejects normality at the 0.01 significance level. SD denotes standard deviation and ADF is the augmented Dickey-Full test for unit root.* τ *and CV are respectively the test statistic and critical values for the ADF test. I(0) indicates the series is stationary at the first difference (1st diff).*

Table 2: Hetereosecedasticity and autocorrelation tests results

Diagnostics	**TUN**	**SA**	**NIG**	**NAM**	**MOR**	**MAU**	**BOT**	**EGY**	**COT**
LBQ[12]	0.000	0.001	0.000	0.522	0.000	0.000	0.882	0.000	0.843
LBQ^2[12]	0.000	0.000	0.000	1.000	0.000	0.000	1.000	0.000	0.986
ARCH[12]	0.000	0.000	0.000	1.000	0.000	0.000	**0.999**	0.000	**0.985**
	GHA	**KEN**	**BCOM**	**COC**	**GOL**	**OIL**	**PLT**	**SIL**	
LBQ[12]	0.000	0.000	0.087	0.002	0.000	0.000	0.012	0.934	
LBQ^2[12]	0.377	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
ARCH[12]	**0.387**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Notes: *shows test of autoregressive conditional hetereoscedasticity (ARCH) and Ljung-Box test for autocorrelation for the series (LBQ) and squared series (LBQ^2) for 12 lags. The series is made up of Tunisia (TUN), South Africa (SA), Nigeria (NIG), Namibia (NAM), Morocco (MOR), Mauritius (MAU), Botswana (BOT), Egypt (EGY), Cote D'Ivoire (COT), Ghana (GHA), Kenya (KEN), Bloomberg Commodity Index (BCOM), Cocoa (COC), Gold (GOL), OIL, Platinum (PLT), and Silver (SIL).*

Table 3: Assets behaviour in falling commodities and African markets

Variables	**Quantiles**		
	0.10(%)	**0.05(%)**	**0.01(%)**
MOROCCO	25.68	17.21	8.82
EGYPT	42.35	31.17	15.61
TUNISIA	15.79	11.62	6.58
KENYA	23.49	17.50	9.06
GHANA	17.96	14.04	7.27
MAURITIUS	19.61	15.21	8.91
COTE D'IVOIR	25.05	19.84	11.90
BOTSWANA	17.71	13.52	7.36
SOUTH AFRICA	37.99	26.39	11.66
NIGERIA	26.67	18.18	7.49
NAMIBIA	24.14	18.65	11.04

OIL	44.55	29.56	10.89
GOLD	38.25	24.63	8.08
SILVER	44.84	31.08	13.36
PLATINUM	29.72	20.56	8.50
COCOA	36.19	24.16	9.36
BCOM	20.51	12.91	3.79

The table presents the average returns of all assets for the worst 10%, 5%, and 1% days. Sample is made up of 3,056 daily returns on a close-to-close basis from 3rd January 2003 to 29 December 2014.

Table 4.1: Dynamic conditional correlation results (*full sample period*)

	OIL	GOLD	SILVER	PLATINUM	COCOA	BCOM
MOROCCO						
ρ	0.120***	0.171***	0.014	0.042**	0.014	0.028
ϕ_1	0.009	0.013**	0.000	0.012	0.000	0.018
ϕ_2	0.981***	0.979***	0.832	0.799***	0.844	0.720
L-L	-11374.27	-11119.31	-11243.04	-9927.99	-10944.53	-9263.93
AIC	7.45	7.198	7.221	6.340	6.961	6.072
EGYPT						
ρ	0.057***	0.043*	0.006	0.006	0.020	0.029
ϕ_1	0.017*	0.007	0.011	0.000	0.000	0.000
ϕ_2	0.813***	0.960***	0.949***	0.840	0.858***	0.823***
L-L	-12464.55	-12242.89	-12311.03	-11001.52	-12014.47	-10335.34
AIC	7.937	7.827	7.792	6.982	7.525	6.773
TUNISIA						
ρ	0.156***	0.297	0.023	0.002	0.032	0.013
ϕ_1	0.007**	0.009**	0.010	0.017	0.014*	0.000
ϕ_2	0.983***	0.991***	0.728***	0.573***	0.961***	0.820
L-L	-9425.13	-9129.20	-9307.48	7996.03	-9003.43	-3898.74
AIC	6.103	5.932	6.008	5.175	5.756	4.884
KENYA						
ρ	0.014	0.046**	-0.023	0.004	0.036	0.006
ϕ_1	0.000	0.055**	0.000	0.018*	0.004	0.015*
ϕ_2	0.834**	0.000	0.840	0.000	0.989***	0.955***
L-L	-10543.46	10310.07	-10383.93	-9072.16	-10081.28	-4066.42
AIC	6.753	6.637	6.612	5.797	6.359	5.094
GHANA						
ρ	-0.011	0.023	0.025	0.015	0.025*	-0.005
ϕ_1	0.000	0.006*	0.000	0.000	0.000	0.000
ϕ_2	0.874**	0.982***	0.844	0.851*	0.863***	0.847***
L-L	-10723.73	-10496.06	-10563.92	-9252.49	-10265.41	-4339.34
AIC	6.306	6.192	6.053	5.285	5.723	5.435
MAURITIUS						
ρ	0.007	0.055***	0.035*	0.032	0.043**	0.031
ϕ_1	0.018	0.015	0.000	0.001	0.000	0.006
ϕ_2	0.778***	0.000	0.830	0.833	0.840**	0.886***
L-L	-9522.55	-9293.47	-9363.47	-8051.72	-9063.98	-3821.93
AIC	6.105	5.994	5.967	5.143	5.702	4.788
SOUTH AFRICA						
ρ	0.291***	0.452***	0.027	0.010	0.063***	0.002
ϕ_1	0.027*	0.021***	0.008	0.003	0.000	0.004*
ϕ_2	0.964***	0.975***	0.964***	0.993***	0.863***	0.988***
L-L	-12002.74	-11489.89	-12002.81	-10692.09	-11700.73	-10026.39
AIC	7.794	7.483	7.773	6.955	7.532	6.571

Table 4.1 continued.

	OIL	GOLD	SILVER	PLATINUM	COCOA	BCOM
NIGERIA						
ρ	0.019	-0.007	0.027	0.001	0.009	-0.013
ϕ_1	0.011	0.082***	0.000	0.049**	0.000***	0.000
ϕ_2	0.505	0.086	0.825***	0.000	0.859***	0.836***
L-L	-11189.31	-10954.31	-11029.97	-9715.79	-10731.91	-9053.89
AIC	7.259	7.133	7.121	6.288	6.872	5.934
NAMIBIA						
ρ	0.108	0.163	0.004	-0.008	0.042*	0.017
ϕ_1	0.014***	0.012***	0.007	0.000	0.020*	0.000
ϕ_2	0.985***	0.988***	0.968***	0.856	0.942***	0.868
L-L	-11440.72	-11195.23	-11362.22	-10051.79	-11058.57	-9386.52
AIC	6.791	6.658	6.626	5.867	6.298	6.152
COTE D'IVOIRE						
ρ	0.000	0.000	0.000	-0.000	0.000	-0.000
ϕ_1	0.000	0.000	0.000	0.004	0.059	0.000
ϕ_2	0.997***	0.999***	0.995***	0.979***	0.904***	0.961***
L-L	-35352.90	-35240.94	-34890.16	-33835.83	-34114.29	-33412.51
AIC	23.152	23.079	22.85	22.16	22.34	21.81
BOTSWANA						
ρ	0.000	0.000	-0.000	0.000	0.000	-0.000
ϕ_1	0.000	0.000	0.069	0.002	0.000	0.050
ϕ_2	0.999***	0.963***	0.912***	0.982***	0.999***	0.900***
L-L	-33152.18	-33040.21	-32689.43	-311635.11	-31913.58	-31211.78
AIC	21.711	21.638	21.408	20.718	20.900	20.441

Notes: *The table shows results of Engle (2002) DCC-GARCH (1,1) estimations. The model is estimated using the Student t-distribution.* ϕ_1 *and* ϕ_2 *are respectively the ARCH and GARCH parameters under the restrictive assumptions of non-negativity and* $\phi_1 + \phi_2 < 1$. *L-L is log-likelihood, AIC is the Alkaike Information Criterion, and* ρ *is a measure of correlation. ***, **, * indicate statistical significance at the 0.01, 0.05, and 0.10 level, respectively.*

Table 4.2: Dynamic conditional correlation results *(Sub-sample period)*

	OIL	GOLD	SILVER	PLATINUM	COCOA	BCOM
MOROCCO						
ρ	0.171***	0.123**	-0.003	0.012	0.017	0.043
ϕ_1	0.015***	0.015**	0.000	0.006	0.000	0.038*
ϕ_2	0.973***	0.971***	0.830	0.817***	0.851	0.687***
L-L	-5966.056	-6119.365	-6169.93	-5459.704	-5761.456	-4974.11
AIC	7.468	7.658	7.721	6.834	7.211	6.227
EGYPT						
ρ	0.088***	0.035	-0.005	-0.036	0.014	0.035
ϕ_1	0.021	0.012*	0.003	0.000	0.000	0.000
ϕ_2	0.647***	0.953***	0.980***	0.841	0.843	0.831*
L-L	-6239.103	-6333.998	-6557.37	-5846.531	-6149.203	-5365.10
AIC	7.809	7.928	8.205	7.317	7.695	6.716
TUNISIA						
ρ	0.194***	0.168***	0.001	0.017	0.053	0.013
ϕ_1	0.012**	0.007**	0.008	0.031	0.011	0.000
ϕ_2	0.975***	0.988***	0.696***	0.382**	0.963***	0.820
L-L	-4890.523	-5027.761	-5090.26	-4327.991	-4677.674	-3898.74
AIC	6.124	6.295	78.65	5.422	5.857	4.884
KENYA						
ρ	0.038	0.059**	-0.026	-0.016	0.060**	0.006
ϕ_1	0.005	0.000	0.000	0.031*	0.026	0.015*
ϕ_2	0.967***	0.842	0.794*	0.000	0.731***	0.955***
L-L	-5182.915	-5224.53	-5178.72	-4500.305	-4848.662	-4066.42
AIC	6.488	6.540	6.484	5.637	6.071	5.094
GHANA						
ρ	-0.036*	-0.002	0.004	0.008	0.019	-0.005
ϕ_1	0.000	0.008*	0.000	0.000	0.000	0.000
ϕ_2	0.847	0.983***	0.857	0.853	0.828	0.847***
L-L	-5453.454	-5495.10	-5530.858	-4820.806	-5122.340	-4339.34
AIC	6.826	6.878	6.923	6.036	6.413	5.435
MAURITIUS						
ρ	0.030	0.058**	0.020	-0.016	0.058	0.031
ϕ_1	0.018	0.005	0.000	0.008	0.006**	0.006
ϕ_2	0.763***	0.866***	0.842	0.047	0.992***	0.886***
L-L	-4936.386	-4977.95	-4936.496	-4304.228	-4599.418	-3821.93
AIC	6.180	6.232	6.182	5.391	5.759	4.788
SOUTH AFRICA						
ρ	0.368***	0.269*	-0.006	-0.023	0.076*	0.002
ϕ_1	0.038***	0.020**	0.011	0.000	0.010	0.012
ϕ_2	0.946***	0.978***	0.930***	0.834	0.968***	0.856***
L-L	-6225.18	-6258.42	-6462.663	-5753.173	-6049.271	-5271.34
AIC	7.790	7.832	8.087	7.201	7.571	6.599

Table 4.2 continued.

	OIL	GOLD	SILVER	PLATINUM	COCOA	BCOM
NIGERIA						
ρ	0.010	-0.026	0.028	0.025	0.022	-0.009
ϕ_1	0.000	0.068***	0.000	0.053	0.000	0.000
ϕ_2	0.818***	0.042	0.816***	0.097	0.817***	0.820***
L-L	-5922.99	-5961.13	-5998.779	-5286.931	-5590.779	-4807.83
AIC	7.413	7.461	7.508	6.618	6.998	6.020
NAMIBIA						
ρ	0.255***	0.226**	-0.001	-0.008	0.065	0.018
ϕ_1	0.013**	0.014***	0.010	0.005	0.010	0.000
ϕ_2	0.978***	0.982***	0.825***	0.948***	0.974***	0.831*
L-L	-5566.60	-5590.33	-5722.066	-5012.029	-5308.344	-4530.54
AIC	6.967	6.997	7.162	6.275	6.645	5.673
COTE D'IVOIRE						
ρ	0.000	0.184***	-0.033	-0.009	0.038	-0.004
ϕ_1	0.000	0.041**	0.008	0.019	0.000	0.013
ϕ_2	0.997***	0.874***	0.840***	0.792***	0.813**	0.935***
L-L	-35352.9	-5828.30	-5892.921	-5183.210	-5484.573	-4700.93
AIC	23.152	7.295	7.375	6.489	6.865	5.886
BOTSWANA						
ρ	0.181**	0.174*	-0.027	-0.017	0.075*	-0.000
ϕ_1	0.008**	0.012**	0.020	0.000	0.008	0.006
ϕ_2	0.991***	0.987***	0.441	0.834***	0.985***	0.832***
L-L	-5164.45	-5203.82	-5298.147	-4588.84	-4883.328	-4107.522
AIC	6.465	6.514	6.632	5.746	6.114	5.145

See notes under Table 4.1

Table 5: Optimal portfolio weights, hedge effectiveness and ratios for Africa's equities and commodities

	MOROCCO	EGYPT	TUNISIA	SOUTH AFRICA	NAMIBIA	COTE D'IVOIRE	BOTSWANA
			Panel A: Stock-Oil Portfolio (Full sample period)				
Portfolio Optimal Weights (w^{so})	0.5182	0.5176	0.4979	0.5154			
Average OHR (γ^{so})	0.1162	0.0551	0.1566	0.2847			
Portfolio variances	2.0144	2.0170	1.9429	1.9931			
Hedge Effectiveness (%)	6.20	6.43	-0.73	4.26			
			Panel B: Stock-Gold Portfolio (Full sample period)				
Portfolio Optimal Weight (w^{sg})	0.5157	0.5143		0.5144			
Average OHR (γ^{sg})	0.1666	0.0418		0.4452			
Portfolio Variances	2.0260	2.0286		2.0050			
Hedge Effectiveness (%)	5.09	5.32		3.13			
			Panel C: Stock-Oil Portfolio (Sub-sample period)				
Portfolio Optimal Weight (w^{so})	0.5151	0.5093	0.4849	0.4939	0.4914	0.5376	0.4897
Average OHR (γ^{so})	0.1668	0.0865	0.1988	0.3709	0.2583	0.1502	0.1841
Portfolio Variances	2.1138	2.0964	2.0119	2.0451	2.0347	2.1999	2.0266
Hedge Effectiveness (%)	4.88	3.34	-4.99	-1.55	-2.61	**11.88**	-3.44
			Panel D: Stock-Gold Portfolio (Sub-sample period)				
Portfolio Optimal Weight (w^{sg})	0.5122		0.4832	0.4922	0.4893	0.6922	0.4875
Average OHR (γ^{sg})	0.1204		0.1728	0.2721	0.2298	0.1734	0.1776
Portfolio variances	2.1213		2.0195	2.0527	2.0422	2.2074	2.0342
Hedge Effectiveness (%)	4.18		-5.76	-2.30	-3.37	**11.24**	-4.20

Results are for both full sample (03/01/2003 to 29/12/2014) and sub-sample (15/09/2008 to 29/12/2014) periods. The table shows the average optimal weights of African stocks (w), hedge ratios (OHR) for stock-oil (γ^{so}) and stock-gold (γ^{sg}) portfolios, portfolio variances, as well as the hedge effectiveness of the portfolios. The abbreviations so and sg refer to stock-oil and stock-gold respectively

Table 6: Results of hedge and safe haven assessments using contemporaneous returns

	BCOM	COCOA	OIL	PLATINUM	SILVER	GOLD
MOROCCO						
d_0	-0.207	-0.231	0.057	0.144	-0.430	-0.716**
$d_1(q10)$	0.089	-0.004	0.026	0.076	0.147	0.032
$d_2(q5)$	0.105	-0.018	-0.022	0.111	0.134	0.221
$d_3(q1)$	0.365	0.659**	-0.245	**-0.636****	-0.233	-0.147
Sum (d_1, d_2, d_3)	0.559	0.637	-0.241	-0.449	0.048	0.106
α	0.135***	0.138***	0.136***	0.136***	0.134***	0.142***
β	0.809***	0.805***	0.809***	0.807***	0.813***	0.799***
ARCH-LM[2]	2.468[0.085]	2.426[0.089]	2.610[0.074]	2.335[0.097]	2.449[0.087]	2.334[0.097]
ARCH-LM[12]	1.145[0.319]	1.139[0.323]	1.181[0.290]	1.140[0.322]	1.144[0.319]	1.164[0.303]
EGYPT						
d_0	-0.697*	-0.048	1.149***	0.007	-0.376	-1.859***
$d_1(q10)$	0.086	0.486	0.091	0.112	-0.043	0.152
$d_2(q5)$	0.116	**-0.456****	0.392*	-0.101	-0.109	0.139
$d_3(q1)$	0.336	-0.089	-0.231	**-0.770***	0.303	0.714*
Sum (d_1, d_2, d_3)	0.538	-0.059	0.252	-0.759	0.151	1.005
α	0.111***	0.109***	0.131***	0.168***	0.120***	0.112***
β	0.827***	0.836***	0.438***	0.526***	0.803***	0.813***
ARCH-LM[2]	0.159[0.853]	0.188[0.829]	0.098[0.907]	0.272[0.762]	0.178[0.837]	0.292[0.747]
ARCH-LM[12]	1.320[0.199]	1.370[0.173]	3.081[0.000]	2.087[0.015]	1.091[0.363]	1.402[0.157]
TUNISIA						
d_0	-0.189	-0.046	0.292*	0.015	-0.071	-0.288*
$d_1(q10)$	-0.050	0.154**	-0.090	0.086	**-0.143****	-0.095
$d_2(q5)$	0.155*	**-0.152***	0.027	-0.069	0.145	0.014
$d_3(q1)$	-0.037	0.341**	-0.029	-0.108	-0.146	-0.068
Sum (d_1, d_2, d_3)	0.068	0.343	-0.092	-0.091	-0.144	-0.149
α	0.122***	0.122***	0.196***	0.193***	0.190***	0.184***
β	0.811***	0.811***	0.770***	0.773***	0.774***	0.781***
ARCH-LM[2]	4.323[0.013]	5.354[0.005]	0.136[0.873]	0.114[0.892]	0.176[0.839]	0.110[0.896]
ARCH-LM[12]	1.463[0.131]	1.689[0.063]	0.165[0.999]	0.169[0.999]	0.181[0.999]	0.178[0.999]

Table 6 continued.

	BCOM	COCOA	OIL	PLATINUM	SILVER	GOLD
KENYA						
d_0	-0.648**	-0.721***	0.820***	0.210	0.107	-0.803***
$d_1(q10)$	0.021	0.121	-0.096	0.021	0.152	-0.080
$d_2(q5)$	0.014	-0.197	0.270*	-0.197	-0.233	0.201
$d_3(q1)$	0.505**	0.833***	-0.310	**-0.747*** **	0.072	0.731***
Sum (d_1, d_2, d_3)	0.540	0.833	-0.136	-0.923	-0.009	0.852
α	0.199***	0.203***	0.196***	0.193***	0.190***	0.184***
β	0.762***	0.758***	0.770***	0.773***	0.774***	0.781***
ARCH-LM[2]	0.134[0.874]	0.118[0.889]	0.136[0.873]	0.114[0.892]	0.176[0.839]	0.110[0.896]
ARCH-LM[12]	0.159[0.999]	0.166[0.999]	0.165[0.999]	0.169[0.999]	0.181[0.999]	0.178[0.999]
GHANA						
d_0	-0.111	0.110	-0.314	0.144	0.023	-0.226
$d_1(q10)$	0.013	-0.035	0.108	-0.096	-0.071	0.138
$d_2(q5)$	-0.068	0.026	-0.184	0.223*	-0.054	-0.049
$d_3(q1)$	0.034	0.065	0.027	-0.077	-0.271	0.064
Sum (d_1, d_2, d_3)	-0.021	0.056	-0.049	0.060	-0.396	0.153
α	0.107***	0.113***	0.112***	0.115***	0.109***	0.113***
β	0.571***	0.568***	0.565***	0.563***	0.569***	0.564***
ARCH-LM[2]	0.243[0.784]	0.248[0.780]	0.255[0.775]	0.257[0.773]	0.251[0.778]	0.256[0.774]
ARCH-LM[12]	0.250[0.996]	0.241[0.996]	0.248[0.995]	0.248[0.996]	0.248[0.996]	0.248[0.996]
MAURITIUS						
d_0	-0.152	-0.244	0.001	-0.838***	-0.492**	-1.436***
$d_1(q10)$	0.093	0.050	**-0.231*** **	0.152*	-0.018	-0.048
$d_2(q5)$	-0.111	0.019	0.260**	-0.174	0.095	0.177*
$d_3(q1)$	0.173	-0.227	-0.135	0.718***	0.260	0.753***
Sum (d_1, d_2, d_3)	0.155	-0.158	-0.106	0.696	0.337	0.882
α	0.126***	0.125***	0.126***	0.129***	0.135***	0.124***
β	0.871***	0.872***	0.870***	0.869***	0.862***	0.872***
ARCH-LM[2]	15.858[0.000]	17.283[0.000]	16.253[0.000]	17.104[0.000]	16.027[0.000]	21.119[0.000]
ARCH-LM[12]	4.108[0.000]	4.345[0.000]	4.349[0.000]	4.353[0.000]	4.196[0.000]	5.315[0.000]

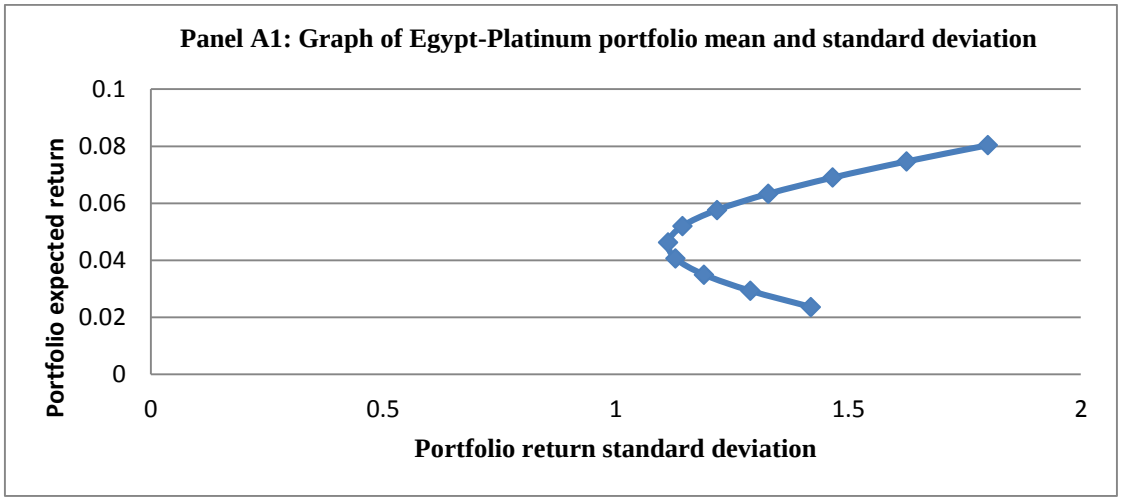
Table 6 continued.

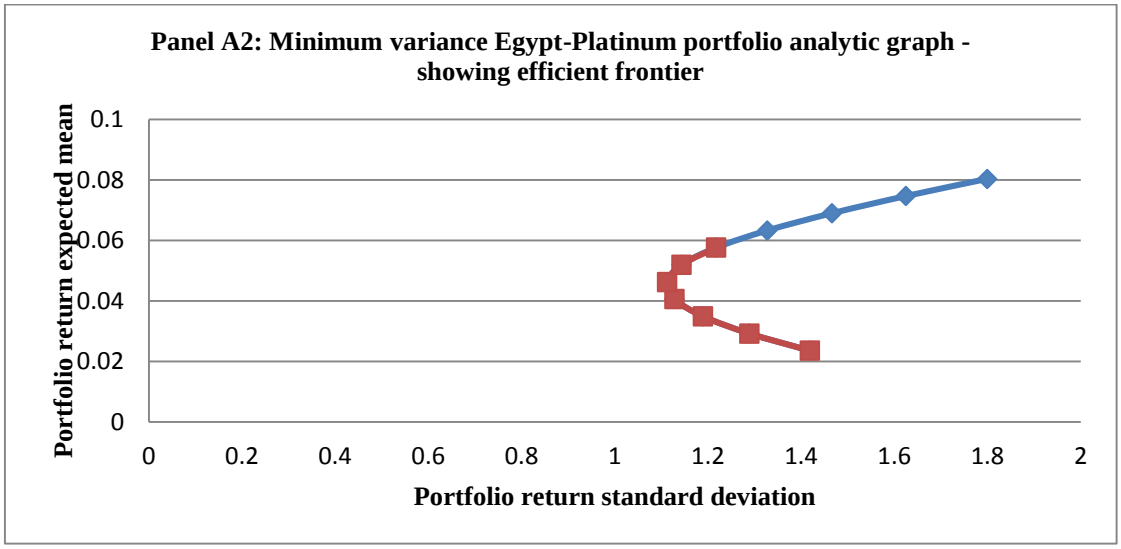
	BCOM	COCOA	OIL	PLATINUM	SILVER	GOLD
COTE D'IVOIRE						
d_0	-0.190	-0.143	-0.059	-0.381	-0.138	-0534
$d_1(q10)$	0.115	0.132	-0.031	0.028	0.055	-0.000
$d_2(q5)$	0.034	-0.159	0.010	0.393**	0.126	-0.060
$d_3(q1)$	0.226	-0.160	-0.197	0.167	-0.275	0.130
Sum (d_1, d_2, d_3)	0.375	-0.187	-0.218	0.588	-0.094	0.070
α	0.004***	0.006***	0.004***	0.005***	0.005***	0.004***
β	0.708***	0.895***	0.915***	0.919***	0.889***	0.927***
ARCH-LM[2]	0.704[0.495]	0.689[0.502]	0.664[0.515]	0.649[0.523]	0.652[0.521]	0.651[0.521]
ARCH-LM[12]	0.402[0.963]	0.351[0.979]	0.335[0.983]	0.338[0.982]	0.353[0.979]	0.337[0.983]
SOUTH AFRICA						
d_0	-0.020	0.274	0.455	0.072	-0.428	-1.056***
$d_1(q10)$	0.181	0.479***	-0.025	0.180	-0.149	0.210
$d_2(q5)$	0.114	**-0.756*** **	0.676***	0.123	0.539**	-0.203
$d_3(q1)$	0.006	0.153	-0.581	**-0.692***	-0.538	0.972***
Sum (d_1, d_2, d_3)	0.301	-0.124	0.070	-0.389	-0.148	0.979
α	0.066***	0.0666***	0.052***	0.066***	0.065***	0.070***
β	0.925***	0.925***	0.943***	0.926***	0.928***	0.923***
ARCH-LM[2]	0.355[0.701]	0.269[0.764]	2.704[0.067]	0.281[0.755]	0.550[0.577]	0.077[0.926]
ARCH-LM[12]	0.966[0.479]	0.897[0.550]	0.863[0.585]	0.960[0.485]	1.090[0.364]	0.810[0.641]
BOTSWANA						
d_0	-0.449**	-0.094	0.075	-0.335	-0.137	-0.683***
$d_1(q10)$	0.058	0.195**	0.105	0.230***	0.053	-0.083
$d_2(q5)$	0.120	-0.079	0.270**	-0.070	0.012	0.130
$d_3(q1)$	0.120	-0.103	**-0.366***	0.159	-0.206	0.464**
Sum (d_1, d_2, d_3)	0.291	0.013	0.009	0.319	-0.141	0.511
α	0.006***	0.004***	0.004***	0.005***	0.006***	0.005***
β	0.598**	0.678***	0.920***	0.597**	0.589**	0.590*
ARCH-LM[2]	0.124[0.883]	0.127[0.881]	0.138[0.871]	0.138[0.871]	0.124[0.884]	0.221[0.802]
ARCH-LM[12]	0.152[0.999]	0.139[0.999]	0.148[0.999]	0.152[1.000]	0.143[0.999]	0.241[0.996]

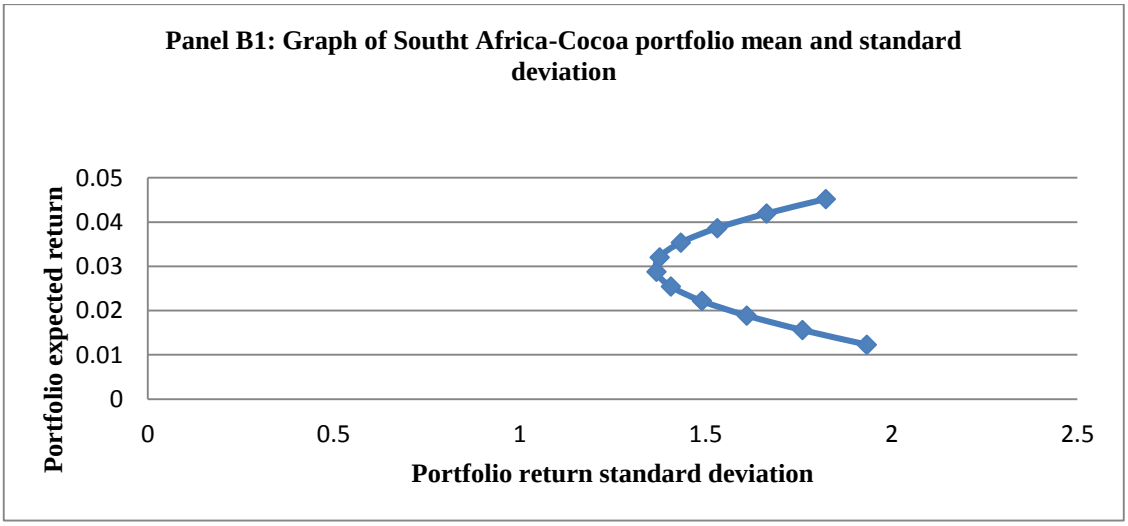
Table 6 continued.

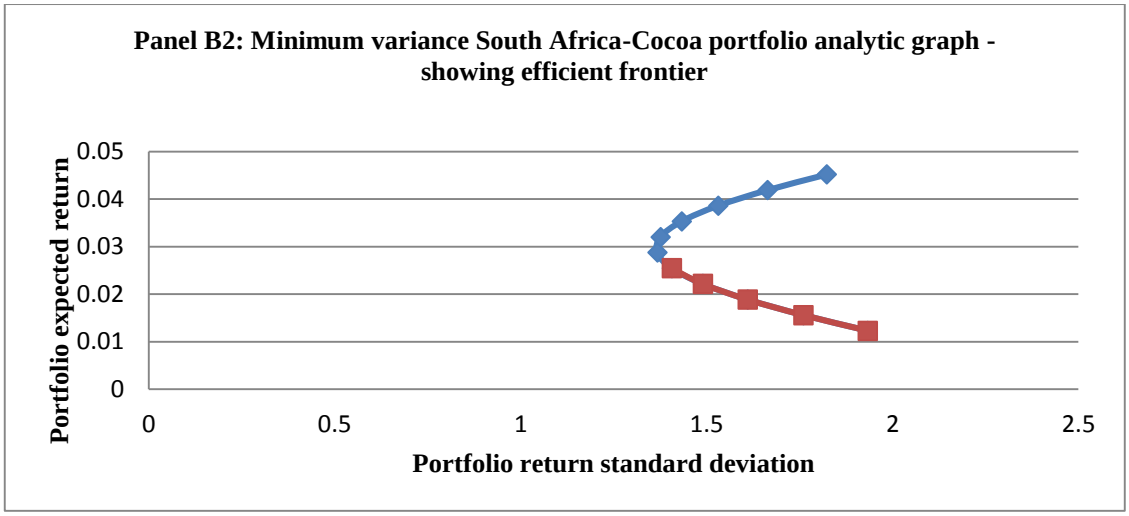
	BCOM	COCOA	OIL	PLATINUM	SILVER	GOLD
NIGERIA						
d_0	-0.827*******	-1.125*******	-1.414***	-1.349***	-0.316	-1.354***
$d_1(q10)$	-0.038	0.093	-0.063	-0.171	0.042	0.121
$d_2(q5)$	0.017	0.331*	0.365**	0.212	0.109	-0.111
$d_3(q1)$	0.412	-0.022	-0.190	1.066***	0.174	0.104
Sum (d_1, d_2, d_3)	0.391	0.402	0.112	1.107	0.325	0.114
α	0.292***	0.272***	0.290***	0.304***	0.297***	0.293***
β	0.664***	0.672***	0.662***	0.655***	0.661***	0.664***
ARCH-LM[2]	1.806[0.165]	2.301[0.100]	1.006[0.366]	1.508[0.222]	1.573[0.208]	1.404[0.246]
ARCH-LM[12]	1.723[0.056]	1.546[0.101]	1.768[0.048]	1.591[0.087]	1.636[0.075]	1.984[0.022]
NAMIBIA						
d_0	0.015	0.081	0.531*	0.003	-0.198	-0.423
$d_1(q10)$	0.045	0.139	-0.024	0.244**	-0.126	**-0.298*****
$d_2(q5)$	0.316**	-0.094	0.499***	-0.188	0.245	0.260*
$d_3(q1)$	**-0.491***	-0.130	**-0.680****	0.002	-0.157	0.670**
Sum (d_1, d_2, d_3)	-0.130	-0.085	-0.205	0.058	-0.038	0.632
α	0.282***	0.162***	0.038***	0.072***	0.064***	0.091***
β	0.421***	0.548***	0.696***	0.450***	0.522***	0.552***
ARCH-LM[2]	0.346[0.707]	0.320[0.726]	0.373[0.689]	0.399[0.671]	0.392[0.676]	0.392[0.676]
ARCH-LM[12]	0.340[0.982]	0.328[0.985]	0.381[0.971]	0.359[0.977]	0.345[0.981]	0.419[0.957]

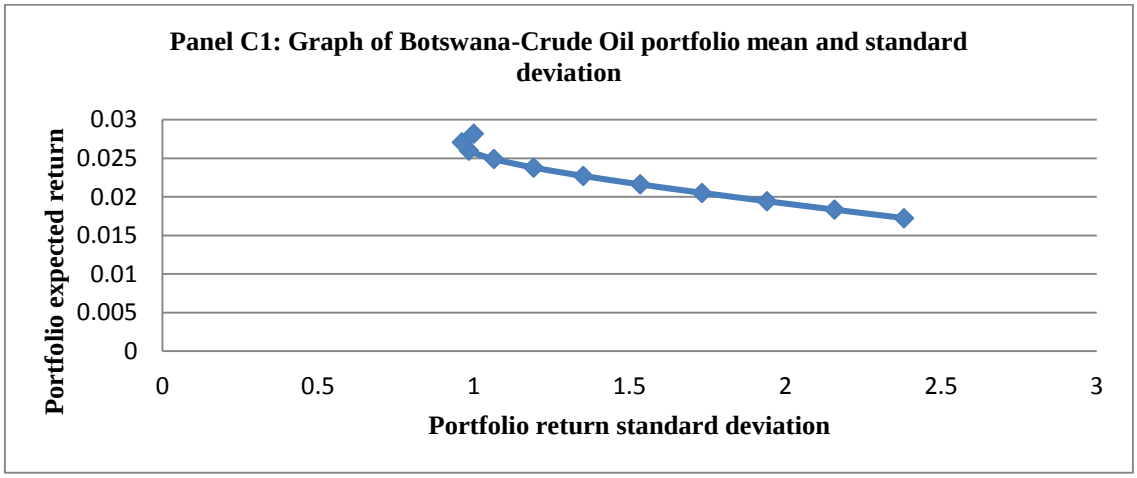
*The table shows results of a sample of 3,056 daily contemporaneous returns of African stocks, commodities and BCOM from 6 January, 2003 to 29 December, 2014 on a close-to-close basis. Columns 2-7 represent the regressors. Each equity market (in bold caps) in a row is a dependent variable. The coefficients d_0, d_1, d_2, d_3 are the parameters in eqn. 2b. Zero d_0 suggest a weak hedge and negative d_0 accompanied by negative value of Sum (d_1, d_2, d_3) > d_0 (if negative) indicates that the stock is a strong hedge. Significantly zero (negative) d_1, d_2, and d_3 at q_1, q_5, and q_{10} (i.e. extreme market conditions) indicate that the associated equity market is a weak (strong) safe haven. α and β are the ARCH and GARCH parameter estimates from equation 2c indicating past shocks and volatility effects respectively. They are estimated using the Generalized Error distribution (GED) algorithm. ARCH-LM [2, 12] is the Engle (1982) test for the presence of ARCH effects in the series at lags 2 and 12. The test statistic is distributed $\chi^2(\rho)$ under the null of no ARCH effects. Figures in bold denote safe-havens. ***, **,* denote statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.*


Panel A1: Graph of Egypt-Platinum portfolio mean and standard deviation
Portfolio expected return
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
Portfolio return standard deviation


Panel A2: Minimum variance Egypt-Platinum portfolio analytic graph - showing efficient frontier
Portfolio return expected mean
0.1
0.08
0.06
0.04
0.02
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Portfolio return standard deviation


Panel B1: Graph of Southt Africa-Cocoa portfolio mean and standard deviation
Portfolio expected return
0.05
0.04
0.03
0.02
0.01
0
0
0.5
1
1.5
2
2.5
Portfolio return standard deviation





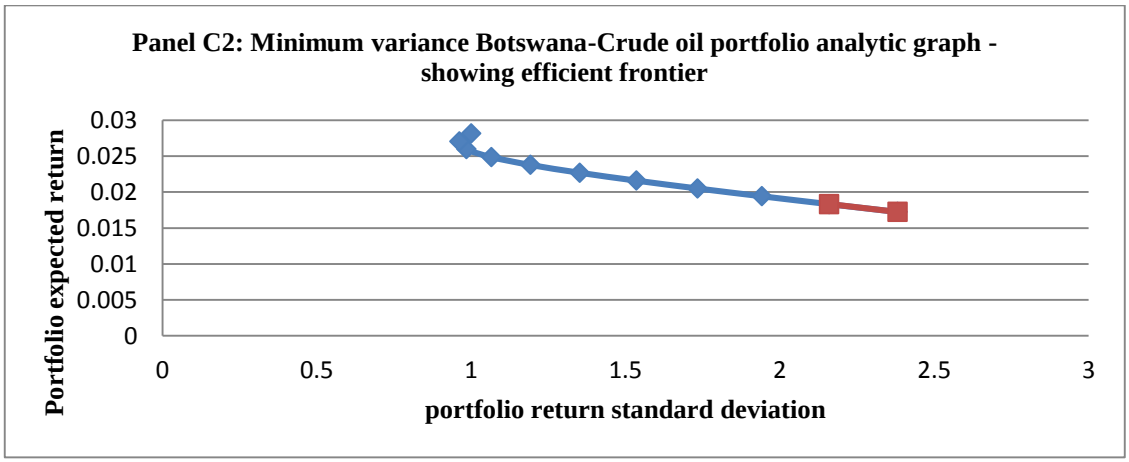


Fig. 1: Performances of African stocks-commodity portfolios mix from 3rd January, 2003 to 29th December, 2014. The graphs show the mean-variance portfolio optimization from the first ten percentiles of portfolios that range from 0% (100%) in stocks (commodities) to 100% (0%) in stocks (commodities). The upper blue lines in Panels A2, B2, and C2 indicate the efficient frontiers.