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Relationship between Risk and Returns In the Saudi Stock Exchange

Abdullah A. Alshebel*

Abstract

This paper examines the relationship between beta and returns on the whole sectors for the Saudi stock exchange (Tadawul) using monthly data from April 2008 to September 2012. The constant beta estimated by the OLS method is found to be significant for all sectors. We also employ the multivariate GARCH (1, 1) model to estimate the time-varying beta, and find that the average beta differs from the constant beta for the most sectors. For this, we test the Fama and MacBeth model (1973), and conclude that their views are not valid for the Saudi stock exchange market. In addition, we test the model of Pettengill et al. (1995), conditional on segmenting the up and down market, where we find that the results do not support this model, especially for the reward for risk condition (positive risk-return tradeoff). Therefore, this study concludes that the Capital Asset Pricing Model (CAPM) might not work in this small emerging market.

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Relationship between Risk and Returns In the Saudi Stock Exchange

1. Introduction

One of the fundamental concepts in finance and financial economics is the relationship between risk and return. Such relationship is considered quite important for investors who are interested in the estimation of investment risk related to asset pricing. The most popular computational equation for the estimation of investment risk is the CAPM, developed by Sharpe (1964) and Lintner (1965). CAPM argues that beta, or the systematic risk, is the only relevant risk measure for investment and the relationship between returns of any asset. However, many criticisms were pointed by the academics and practitioners to its validity as a model for asset pricing. The question is whether the inconsistent evidence on the relationship between beta and average returns is sufficient to conclude that the movements of realized returns are not systematically related to their betas.

Over this controversy, we are going to examine the relationship between risk and returns in the Saudi Stock Exchange market (TASI), and explain the difference between constant beta and time-varying betas. We also present empirical evidence on the relationship between realized risk premium and betas, and whether they are related conditionally or unconditionally.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes data, and presents initial assessment of data. Section 4 presents the empirical methodology used in the study. Section 5 reports and discusses the obtained results. Section 6 concludes the paper.

2. Literature review

Many empirical studies have documented the predictability of stock returns using a bundle of forecasting variable. Some of the studies in this research strand are presented in what follows.

Fama (1970) provided a comprehensive review of the market efficiency literature, and predicted that all assets were correctly priced. Since then, less favorable evidence for the CAPM began to appear in the literature of financial inconsistencies. Fama and MacBeth (1973) tested the relationship between the expected security returns and its risk market according to the assumption that the capital market is perfect; the relationship is linear, and no information or transaction cost incurred by investor. They found that risky portfolios with higher betas normally tend to have higher returns than the less risky portfolios. However, the linearity assumption was challenged by others, such as Ross (1976) who developed the Arbitrage Pricing Theory (APT). He suggested that beta is not the only component that could measure the systematic risk or undiversified stock returns of other securities. Fama and French (1992) employed the methodology of Fama and McBeth (1973) to explain average returns. They carried regression for the *cross-sectional of stock returns on a number of hypothesized variables, where they found an insignificant relationship between beta and average returns. They concluded that the CAPM could not describe the average stock returns, whereas market capitalization and the ratio of book value to market value have significant explanatory power for portfolio returns. Fama and French (1996) used their three-factor model to explain stock market differences, and argued that many of the CAPM average return anomalies are related and captured by the three-factor model.*

Other studies, such as Jagannathan and Mcgrattan (1995), and Jagannathan and Wang (1996) supported the CAPM model and found that it remains a useful measure for risk. Based on Tokyo Stock Exchange, Nimal and Horimoto (2005) reported that the beta-return relationship is not significant in all months, and even it is negatively significant in non-January months in some periods. In the Sri Lankan context, Samarakoon (1997) found negative beta-return relationship, and Anuradha (2008) reported insignificant beta-return nexus in the Colombo Stock Exchange.

Pettengill, Sundaram and Mathur (1995) presented an alternative approach to test the conditional relationship between risk and returns in the US market by separating between the positive and negative market excess returns periods. They found that betas and returns are significantly and positively related when market excess returns are positive (up market), while significantly and negatively related when market excess returns are negative (down market). Isakov (1999) followed the

Pettengill et al.'s model to examine the Swiss stock market for the period 1983–1991, and he found that beta is significantly related to the realized returns that depend on the expected sign of the market. Therefore, he concluded that beta is a good measure of risk and is still alive and applicable. Tests of Nimal and Fernando (2013) reveal that beta-return relationship is significant and positive during up markets and significant and negative during down markets in both Tokyo Stock Exchange and Colombo Stock Exchange. Both tests on realized market premium and estimated market premiums support the argument that beta calculated on ex-ante basis can be used as a measure of systematic risk of a stock. In conclusion, their results suggest that, given the market premium, there is a systematic relationship between beta and portfolio realized returns, thus justifying the continued use of beta as a measure of market risk.

Despite the successes and popularity of the Pettengill et al.'s (1995) model, many studies have criticized it. Indeed, Cooper (2009) argued that there is much bias in the calculation of the coefficients and, hence, it could not help us more to prove the relationship between beta and returns. In addition, other studies had showed that beta tends to vary over time. Blume (1975), Huang and Cheng (2007), and Jagannathan and Wang (1996) showed that conditional CAPM with a time-varying beta outperforms the unconditional CAPM with a constant beta. While there were many studies on the conditional CAPM in the developed markets, there were also other studies on emerging markets which tried to answer the question whether conditional CAPM is a valid model for these markets. Karacabey and

Karatepe (2004) studied the beta-return relationship for Istanbul Stock Exchange, and their results showed that there is a conditional relationship between beta and returns, and that beta is still a useful risk measure in this emerging market.

In the Arab World and the Gulf States financial markets, there are many studies that empirically test the relationship between risk and returns. Within this context, Al Refai (2009) tested this relationship for Jordan, and concluded in favor of the rejection of the unconditional relationship. However, he applied the Pettengill et al.'s (1995) model, and found that during up markets, there is a conclusive statistical evidence for a positive relationship between beta and the realized returns for all industries, while the negative relationship is only evident for a few number of industries in down markets. Therefore, he concluded that the CAPM model might not work in Jordan. Al-Rjoub, Al Yousef and Ananzeh (2010) investigated the cross-sectional behavior of stock returns in Egypt, Jordan, Morocco, and Saudi Arabia, in which they used "the "between estimator" panel data regression to test whether price-earnings ratio, book-to-market ratio, market capitalization, and beta can predict stock market returns variations". Their results supported the belief that Beta has a significant explanatory power in predicting stock market returns, whereas, other variables, Price-Earning, book-to-market, and Market Capitalization (MCAP) failed to capture any power in predicting stock returns. Abdullah, Al-jafri, Al Tai, and Al Ahmad (2011) also tested this relationship for Kuwait stock exchange, and found that the CAPM model might not work for Kuwait.

Abdalla (2012) examined empirically the trade-off between risk, as being measured by conditional volatility, and expected returns for the Saudi Arabian and Egyptian stock markets. The results showed that the dynamic risk-return relationship is positive but insignificant. Mustafa (2012) examined the dynamic linkages between sector indices of the Saudi Exchange market (Tadawul) using weekly data. He found that there is a long-run relationship between the sector indices, and a long-run causality running from all sector indices to the TASI index and finance indices. In addition, he found that there is univariate causality among some of the stock sectors.

Yet, one of the leading financial markets in the Arab World is the Saudi Stock Exchange that has not been fully studied. Saudi Arabia is the biggest oil-exporter in the world, has the largest stock market, with 167 listed companies. It was exposed to several turbulent market-moving events, related to financial, economic and political upheavals, and global uncertainty. This incentivizes us to derive its importance.

3. Data*:*

In this study, we use monthly closing prices on sector indexes from April, 2008 to September, 2012, with a total number of 54 observations. Furthermore, the General Index is used as a proxy for the market portfolio, and we use the averages of the interest rates on 3-months T-bills as a proxy for risk free rate. Data on stock indexes are collected from the Tadawul Stock Exchange database, and data on the three *months T-bills are extracted from the Saudi Arabian Monetary Agency (SAMA). The returns are obtained as follows:*

$$R_{it} = log\ (\ P_{it}/P_{it-1}\ ) \qquad (1)$$

Table (A) in the appendix presents descriptive statistics. The highest average returns are observed in the retail sector (0.73%), while the lowest is for Building and Construction sector with -1.75%. In fact, most of stock sectors experienced negative average returns, except of the Agriculture and Food Industries, Hotel and Tourism, Industrial Investment, and Retail sectors. In terms of volatility, the standard deviation suggests that some sectors are relatively more volatile than others. For instance, the Insurance and Petrochemical Industries sectors are the most volatile, while Retail, and Agriculture and Food Industries sectors are around about 2 times less volatile compared to the most volatile sectors. All return series are skewed to the left, except for Energy and Utilities, and Banks and Financial Services sectors are skewed to the right. Investors in positively skewed markets would be willing to accept smaller returns than investors in negatively skewed markets when the market is up, provided that the losses are not too serious when the market is down.[1] All return series, except of Building and Construction, and Industrial Investment sectors, exhibit considerable excess kurtosis and, consequently, they do not conform to the normal distribution. These insights are in line with the findings of the Jarque–Bera test that strongly rejects the null hypothesis of normality for most sectors. In addition, half of the sectors show

[1] *See Malik and Hammoudeh (2007).*

serial correlation in the residuals, as measured by the Ljung-Box Q-statistic which rejects the null hypothesis of no autocorrelation. Finally, ARCH-LM test provides evidence of ARCH effects in the residuals. This initial assessment provides some empirical support for suggesting that GARCH process is suitable to model the volatility dynamics of the considered stock sectors.

Stationarity is fundamental in implementing the hypothesis of market efficiency. To that effect, unit root tests are conducted (see Said & Dickey, 1984; and Kwiatkowski, Phillips, Schmidt, and Shin, 1992).

Table 1: Unit root and stationarity tests

Test Method / Variables	*ADF*		*KPSS*		*P (Z-A)*
Level	*a*	*b*	*a*	*b*	*c*
Market index	-3.780*	-3.571**	0.272	0.098	-3.492
Building and Construction	-2.629***	-3.806**	0.172	0.043	-3.752
Cement	-1.528	-3.144	0.47**	0.102	-3.846
Agriculture and Food	-0.535	-2.153	0.182	0.078	-2.995
Banks and Financial Services	-4.588*	-4.055**	0.238	0.095	-4.004
Energy and Utilities	-2.732***	-1.777	0.168	0.126	-4.192
Hotel and Tourism	-0.544	-0.718	0.169	0.046	-2.864
Insurance	-2.903***	-3.417	0.225	0.058	-5.597**
Industrial	-2.014	-3.735**	0.137	0.053	-4.667
Multi-Investment	-3.626*	-3.656**	0.35***	0.065	-4.338
Media and Publishing	-0.968	-0.224	0.632**	0.058	-3.467
Petrochemical	-2.583	-2.922	0.197	0.118	-3.332
Real Estate	-3.899*	-3.142	0.367***	0.05	-3.968
Retail	0.409	-2.739	0.258	0.059	-4.134
Tele	-3.027**	-3.227***	0.28	0.058	-3.817
Transport	-2.018	-1.43	0.359***	0.06	-2.578

Continue table 1…

Test Method / Variables	*ADF*		*KPSS*		*P (Z-A)*
First-difference	*a*	*b*	*a*	*b*	*c*
Market index	*-4.383**	*-4.657**	*0.024*	*0.02*	*-6.209**
Building and Construction	*-4.687**	*-4.804**	*0.033*	*0.027*	*-5.830**
Cement	*-4.889**	*-5.514**	*0.033*	*0.033*	*-6.687**
Agriculture and Food	*-5.701**	*-5.908**	*0.025*	*0.025*	*-6.507**
Banks and Financial Services	*-4.536**	*-4.654**	*0.036*	*0.022*	*-6.579**
Energy and Utilities	*-7.752**	*-3.12*	*0.029*	*0.023*	*-9.323**
Hotel and Tourism	*-4.996**	*-4.721**	*0.019*	*0.019*	*-5.772**
Insurance	*-4.811**	*-5.175**	*0.028*	*0.021*	*-6.382**
Industrial	*-5.426**	*-5.078**	*0.025*	*0.022*	*-6.006**
Multi-Investment	*-4.602**	*-4.392**	*0.025*	*0.023*	*-5.527***
Media and Publishing	*-1.042*	*-4.239**	*0.031*	*0.025*	*-6.177**
Petrochemical	*-4.104**	*-2.921*	*0.025*	*0.023*	*-6.069**
Real Estate	*-4.610**	*-4.344**	*0.022*	*0.021*	*-6.164**
Retail	*-5.966**	*-6.469**	*0.021*	*0.017*	*-7.158**
Tele	*-5.750**	*-6.120**	*0.023*	*0.018*	*-6.919**
Transport	*-4.942**	*-5.584**	*0.044*	*0.04*	*-6.006**

Notes: *(a) indicates a model with only a constant term; (b) model with constant and deterministic trend; and (c) Model with structural breaks in the level and slope of trend function. *, ** and *** indicate rejection of the null hypothesis at the 1%, 5% and 10% levels, respectively.*

As seen from Table 1, the ADF test indicates that the results conclude in favor of unit root for most level series, and stationarity for first-differences. Regarding the KPSS test, all return series are stationary, except for the Cement, Multi-Investment, Media and Publishing, Real Estate Development, and Transport sectors for the specification with constant term. However, they are stationarity for first-differences series. Since the variables may be instable due to the last turbulent years, and that the ADF and KPSS tests suffer from power loss in the presence of potential breaks in the variables, we also apply a GLS-based unit root test proposed by Carrion-i-Silvestre, Kim, *and Perron (2009). Structural changes are allowed in the level and slope of trend function under both the null and alternative hypotheses, and are endogenously selected. The results show evidence of unit root for the level series, except for the Insurance, but stationarity for first-differences series.*

4. Methodology

4.1. Constant Beta Model

The linear relationship between risk and expected returns of a risky asset is explained by the following equation:

$$R_{it} - R_f = \alpha_0 + \beta_{it}\left(R_m - R_f\right) + \varepsilon_t \quad : \quad \varepsilon_t \sim IID\ N\ (0, \sigma^2) \qquad (2)$$

$$\beta_{it} = \frac{Cov(R_i, R_m)}{\sigma_m^2} \qquad (3)$$

where R_{it} - R_f is the excess returns on a sector portfolio, and R_m - R_f is the excess returns on a market portfolio, ε_t is an unsystematic error diversifiable risk. We use the OLS method to estimate the constant beta. In economic terms, β_{it} is proportional to the risk of each riyal invested in a sector portfolio i contributes to the market portfolio.[2]

[2] Since the market beta of sector i is also the slope in the regression, a common interpretation of beta is that it measures the sensitivity of the sector's return to variation in the market return. Using equation 1 is superior over formula 2 for obtaining additional information.

4.2. Time-varying Beta Model

For the purpose of estimating the time-varying beta, we use the following bivariate GARCH (1, 1):[3] model

$$R_{it} = \alpha_i + v_{it} \qquad v_{it} \sim / \Omega_{t-1}(0, H_t) \quad \text{For } i = 1, 2 \quad (4)$$

where $R_{it} = (r_{it}, r_{mt})$ *is a 2×1 vector of the excess sector and the market portfolio returns,* v_{it} *is a 2×1 vector of random errors at time t,* H_t *is the 2×2 conditional variance-covariance matrix defined as*

$$H_t = C'C + A'v_t v_{t-1} A + B' H_{t-1} B \qquad (5)$$

where the time-varying beta is measured as: $\beta_t = \widetilde{H}_{12,t} / \widetilde{H}_{22,t}$ *with* $\widetilde{H}_{12,t}$ *the covariance between the excess industrial's returns and the excess market portfolio returns, and* $\widetilde{H}_{22,t}$ *the variance of the excess market portfolio returns. The quasi-maximum likelihood method is employed to estimate the model (see Bollerslev and Wooldridge, 1992).[4]*

4.3. Conditional Relationship between Beta and Returns

In the standard test of the relationship between beta and returns, betas are estimated by regressing excess share returns on excess market returns as follows:

$$R_{it} - R_f = \alpha_0 + \beta_{it} (R_{mt} - R_f) + u_{it} \qquad (6)$$

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[3] Elyasiani and Mansur (1998) discuss the benefits from multivariate GARCH models.
[4] See Engle and Kroner (1995) for more details

where R_{it} are the returns on share i in period t, R_{mt} are the returns on the market index, R_f is the risk free rate. The statistic used to test the relationship between beta and expected returns comes from; a period-by-period, by cross-sectional regression of returns on beta, as in Fama and MacBeth (1973):

$$R_{it} - R_f = \gamma_0 + \gamma_{1t}\beta_{it} + \varepsilon_{it} \qquad (7)$$

β_{it} is the systematic risk of portfolio that is estimated based on a multivariate GARCH(1, 1) model. The validity of the CAPM model depends on γ_1, so the prediction of the CAPM is that $\gamma_1 > 0$. To carry this test, the time-series mean of γ_{1t} is examined. Because of the large amount of noise in returns, the power of this test tends to be low. As a result, such tests have generally been inconclusive. To increase the power of the test, Pettengill et al. (1995) suggested a conditional test, and proposed splitting the data into periods where the excess market returns were positive and those where it were negative, and running the cross-sectional regression:

$$R_{it} - R_f = \gamma_0 + \gamma_{1t}D_t\beta_{it} + \gamma_{2t}(1 - D_t) + \varepsilon_{it} \qquad (8)$$

where β_{it} is as before; the systematic risk. D_t is a dummy variable that takes one when the market excess returns are positive, and zero otherwise. Thus, the test is implemented by estimating in each month of the test period either γ_1 or γ_2, depending on the sign for excess market returns. The test statistics $\overline{\gamma}_1$ and $\overline{\gamma}_2$, are the time-series means of the estimated *parameters. The test of whether there is a cross sectional relationship between returns and beta according to Pettengill (1995) corresponds to the following hypotheses* ($H_0 : \overline{\gamma}_1 = 0$, $H_1 : \overline{\gamma}_1 > 0$) *and* ($H_0 : \overline{\gamma}_2 = 0$, $H_1 : \overline{\gamma}_2 < 0$)*, and* ($H_0$: $\mu = 0$, H_1: $\mu > 0$)*, the mean market risk premiums should be positive. The null hypothesis must be rejected to support the CAPM validity, and the standard t-test is used to test the above relationship.*

5. Empirical Evidence

5.1. Constant vs. Time-varying Beta

Table 2 reports the results of the constant beta, which is estimated by the OLS method, and the mean of the time-varying betas, which are estimated by the above GARCH (1,1) model,[5] *for the all sectors. The results show that the OLS regression yields a statistically significant beta at the 1% level for all portfolios, and all of these betas are significant. The comparison between the mean of time-varying betas with the OLS beta shows that the betas for Building and Construction, and Retail sectors are not clearly variable, and that the mean of time-varying betas does not differ from the OLS beta in these two sectors. However, for the other sectors, there is a difference between constant beta and mean of time-varying betas, thus implying that the constant beta may underestimate/overestimate the risk of portfolios.*

[5] *Using different specifications for the GARCH model, such as GARCH (2,1), GARCH(1,1), and GARCH (2,2), we don't find any significant change in the results. Moreover, our selection for GARCH (1,1) is based on the Akaike Information Criterion (AIC) and the Schwarz Criterion (SC).*

Graphs B in the appendix show the time-paths of β_{it} obtained through state-space estimations. In weak-form efficiency properties of a developed mature market, β_{it} coefficient is expected to be very close to zero and goes towards zero, without being sensitive to any of the contemporaneous crises. In contrast, Saudi stock sector's indices behave differently, indicating a clear departure from weak-form efficiency, since

Table 2: *Constant and time-varying betas*

Sector portfolio	OLS beta [a]	GARCH beta [b]	SD
Building and Construction	1.173* (10.88)	1.173 (2.254 /-0.067)	0.365
Cement	0.721* (08.71)	0.673 (1.047 / 0.054)	0.181
Agriculture and Food Industries	0.681* (10.36)	0.751 (1.023 /-0.059)	0.195
Banks and Financial Services	0.901* (14.96)	0.981 (1.057 / 0.429)	0.117
Energy and Utilities	0.461* (04.56)	0.499 (0.780 / 0.174)	0.168
Hotel and Tourism	0.922* (08.46)	0.926 (1.178 / 0.528)	0.112
Insurance	1.475* (11.20)	1.881 (2.032 / 1.183)	0.177
Industrial Investment	1.028* (11.38)	0.883 (2.310 / 0.507)	0.266
Multi-Investment	1.108* (10.99)	1.181 (1.459 / 0.131)	0.201
Media and Publishing	0.689* (05.94)	0.795 (1.250 / 0.337)	0.250
Petrochemical Industries	1.393* (18.82)	1.219 (2.212 / 1.086)	0.191
Real Estate Development	0.862* (11.39)	0.866 (1.858 /-0.162)	0.358
Retail	0.602* (07.73)	0.602 (0.862 /-0.176)	0.209
Tele Communication and Information Technology	0.765* (13.46)	0.795 (0.961 / 0.594)	0.086
Transport	0.819* (07.27)	0.935 (1.565 / 0.433)	0.264

Notes: *a: the figures between parenthesis are t-statistic of OLS beta.*
b: the figures between parentheses are highest/lowest betas after excluding the first observation.
** Significance at the 1% level.*

β_{it} are significantly different from zero, in spite of market enhancement regulations, but less for Industrial Investment and Petrochemical Industries indices. Indeed, nine of the βit's move in the wrong direction away from zero after the 2006 local crises and world financial crises. Overall, all stock sectors are found to be weak-form inefficient. Inefficiency does not improve towards the last quarter of 2012. This reveals the ineffectiveness of the reforms undertaken during these years, which calls for a serious reflection on the way forward to redress the situation.

This inefficiency could be lying in the lack of liquidity given the thinness of this market, and in the nature of the traders (essentially individuals; 90%), with poor equity investment culture given the short life of this type market. In fact, such traders could not have easy access for high quality and reliable information as institutional traders can do. In sum, their ability to correctly analyze news may be seriously detrimental by introducing lots of noise and increasing volatility, especially in crises periods. Thus, the traders learning process is clearly in its infancy, and needs to be improved by better investment culture and channeled by institutional trading.

5.2. Beta and the Realized Returns

First, we test the relationship between risk and returns given by equation (7). Table 3 shows a negative value for the coefficient y_2 in a nine sectors for this market. The coefficient is statistically different from zero only for the Hotel and Tourism, Industrial Investment, Media and Publishing, Petrochemical Industries sectors; but it is not statistically different from zero for the

Building and Construction, Cement, Agriculture and Food Industries, Multi-Investment, and Retail sectors. Therefore, the relationship between beta and average returns is not valid in these sectors. The results also show a positive value for the coefficient γ_2 in six sectors. This coefficient is significant at the 5% for only two of them (Banks and Financial Services, and Tele Communication and Information Technology). However, it is not significant for the other sectors, and hence, the relationship between beta and average returns is limited for these two sectors.

Table 3: *Regression results of the model:* $R_{it} - R_f = \gamma_1 + \gamma_2 B_{it} + \varepsilon_{it}$

Portfolio	γ_1	γ_2	P-value
Building and Construction	4.428	-5.272	0.1862
Cement	1.286	-2.160	0.6880
Agriculture and Food Industries	4.021	-4.767	0.2794
Banks and Financial Services	-19.398	18.795	0.0313
Energy and Utilities	-2.524	4.746	0.3711
Hotel and Tourism	25.497	-27.325	0.0123
Insurance	-0.801	0.284	0.9781
Industrial Investment	8.267	-9.242	0.0483
Multi-Investment	4.134	-4.125	0.5475
Media and Publishing	7.040	-8.978	0.0421
Petrochemical Industries	23.618	-20.089	0.0111
Real Estate Development	-3.604	3.100	0.2948
Retail	2.436	-2.854	0.4865
Tele Communication and Information Technology	-17.663	21.681	0.0363
Transport	-5.325	5.382	0.2338

This result is not enough to judge the rejection or the validation of the CAPM in this market. Pettengill et al. (1995) criticized this biased aggregation of regression of positive and negative market risk premium, as in Fama and MacBeth (1973), in that it does not give enough support to the positive relationship between risk and returns. So, we test the relationship between risk and returns during the up (positive risk premium) and down (negative risk premium) markets, as Pettengill et al. (1995) advocated, to have enough evidence whether the CAPM is truly valid in this emerging market.

Table 4 shows the results for the regression given by equation (8). It is noticed that the coefficient γ_1 is positive only for eleven sectors, and only two of them are statistically different form zero; namely the Real Estate Development, and Transport sectors. Their estimated risk priced per monthly unit of beta is 5.28 and 11.69, respectively. These results suggest rejecting the null hypothesis of no relationship between risk and returns during up markets for the two sectors. The results also show that the estimation of coefficient γ_2 is negative only for ten sectors, where only for four of them; namely the Hotel and Tourism, Industrial Investment, Media and Publishing, relationship, Petrochemical Industries; have a coefficient γ_2 which is statistically different from zero, so this result suggests a clear rejection for the null hypothesis of no relationship between risk and returns during down markets only in these four sectors, where their estimated reduction of priced risk per monthly unit *of beta is (-32.08, -11.17, -10.02, -25.08). These results explain why the model of Fama and MacBeth (1973) are not valid for these four sectors, although they have significant coefficients.*

Furthermore, the estimation of γ_2 *is positive and statistically different from zero for the Banks and financial services sector, suggesting that the first condition postulated by Pettengill et al. (1995), which states that betas and excess returns are significantly and negatively related when market excess returns are negative (down market), is not applied in this sector. The coefficients for this sector are positive and close to each other in the two cases of the market; up and down. So, it maybe has a stability risk. One of explanation could be that this sector is secured by Saudi Arabian Monetary Agency (SAMA).*

Table 4: *Relationship between risk and returns in up and down markets*

Portfolio	Up Market γ_1	Down Market γ_2
Building and Construction	1.85083	-8.06024
Cement	2.08499	-8.50455
Agriculture and Food Industries	0.33301	-9.95427
Banks and Financial Services	15.25453	16.88018**
Energy and Utilities	1.43194	4.22430
Hotel and Tourism	-8.27442	-32.08777***
Insurance	-10.83855	7.42765
Industrial Investment	7.93215	-11.17529***
Multi-Investment	1.51446	-8.20583
Media and Publishing	-4.10655	-10.02828***
Petrochemical Industries	7.68383	-25.08372*
Real Estate Development	5.28430***	1.87256
Retail	-1.87499	-3.73164
Tele Communication and Information Technology	13.00382	13.84856
Transport	11.69972**	-0.47468

*Note: * Significance at the 1%,*
*** Significance at the 5%.*
**** Significance at the 10%.*

We also test the second condition postulated by Pettengill et al. (1995), which states that the mean market risk premiums should be positive. The results reported in Table 5 show that the mean excess market returns are negative and not significantly different from zero. This might be caused by the market correction of its 2006's peak. Here, the excess market returns are in excess of 3-month interest rate on T-bills, and are positive for 27 months and negative for 26 months. The t-statistics show that the mean excess returns are equal to zero. Overall, these *results do not seem to support the relationship between betas and returns, as argued by Pettengill et al. (1995). These results do not also support the continued use of beta as a measure of risk in this market.*

Table 5: *Average market excess returns*

	Up months	Down months	Mean	SD	t-statistics	p-value
2008-2012	27	26	-0.6814	7.4295	-0.6677	0.5073

6. Conclusion

In this paper, we investigated the risk-return relationship in the Saudi stock exchange. Using the time-varying betas estimated by the multivariate GARCH (1, 1) model, the results show that there is some variability of beta compared to the OLS beta in most sectors. Our findings about the validity of the CAPM according to Fama and MacBeth do not support this relationship because we could not reject the null hypothesis of average risk premium in most sectors. Furthermore, our results have shown some of shortcomings of Fama and MacBeth that may be covered by Pettengill et al. (1995), and we are suggesting additional study for examining this issue.

When we tested the model of Pettengill et al. (1995) model, the findings do not also support this model because we could not reject the null hypothesis for most sectors in either up or down markets. Therefore, this would not support the model of Pettengill et al. (1995), and hence, would not support the validity of the CAPM for this market. These findings for the Saudi stock *exchange market are similar to those of another study for Jordan (see Al Refai, 2008) and Kuwait (see Abdullah et al., 2011), where the authors found that the CAPM would not work well in these small emerging markets.*

It should be noted that there are some limitations for our analysis, since it is conducted based on monthly data (54 observations), which may not better capture the interactions between equity markets.[6] *Therefore, a possible expansion of this paper is to extend the analysis using other data frequencies (daily and weekly) or lengthy of monthly data. However, we believe that our analysis led to interesting result and it is important to continue analyzing statistics data for validating and clarifying the applicability of the CAPM hypotheses for the Saudi stock exchange market by either extending the span of monthly data or using other data frequencies (daily and weekly) with linking to some macroeconomic variables as a possible expansion of this paper. This is particularly important to policy makers in designing economic policies to have an efficient market - lowering market imperfection - that is consistent with the behavior of the national economy.*

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[6] *See Jouini (2015).*

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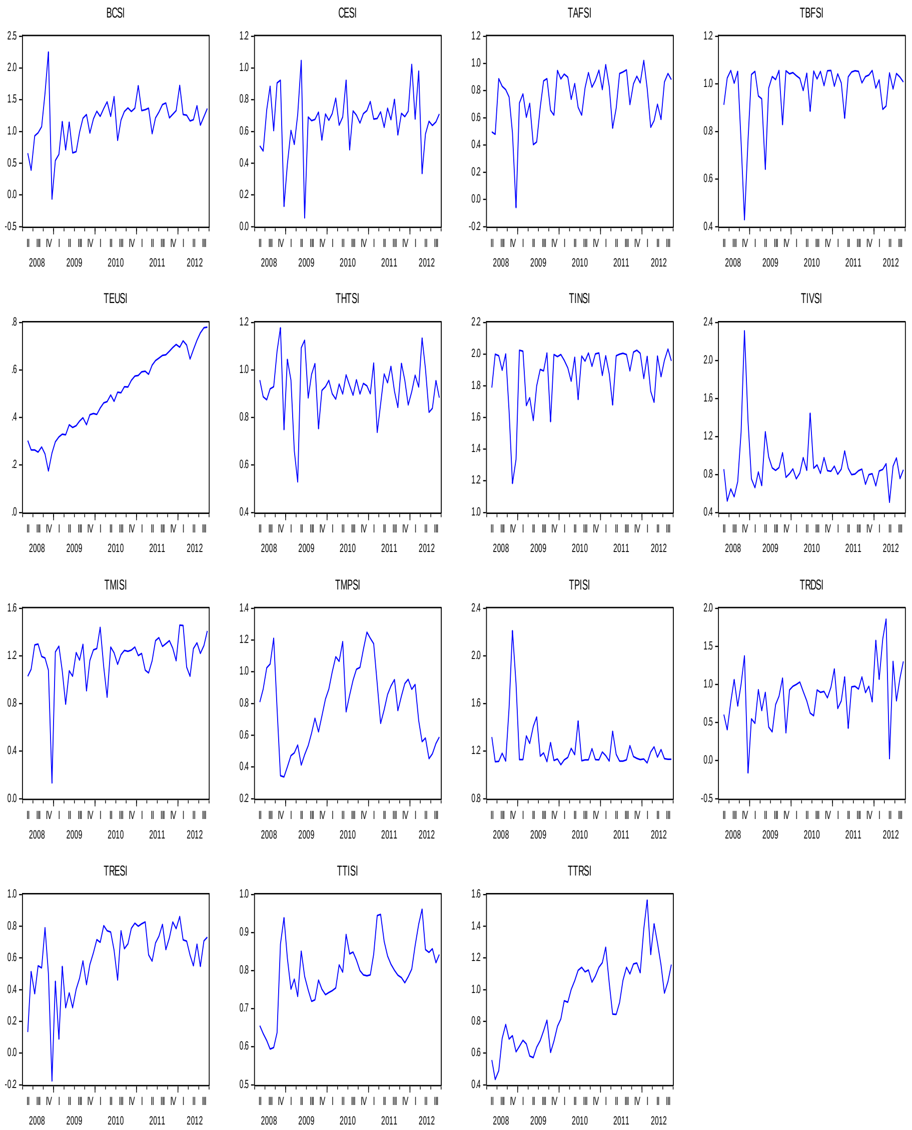
Appendices

A. Descriptive statistics

		Mean	Std. Dev.	Skewness	Kurtosis	JB	LB	ARCH
Tadawul All Share Index	Returns	-0.6721	7.4235	-1.0673	6.6116	38.8664*	8.7455***	
	Excess return	-0.6814	7.4295	-1.0702	6.6183	18.8599*	3.8324	
Building and Construction Sector	Returns	-1.7477	10.4237	-2.4955	14.0721	325.732*	3.9621	18.7434***
	Excess return	-1.7570	10.4284	-2.4975	14.0835	326.3784*	3.9635	
Cement Sector	Returns	-0.1583	6.9310	-0.5093	6.0744	23.1649*	11.073**	10.2605
	Excess return	-0.1676	6.9377	-0.5130	6.0763	23.2234*	11.16**	
Agriculture and Food Industries Sector	Returns	0.4490	6.1394	-1.4053	6.0509	37.9991*	4.9419	7.9399
	Excess return	0.4397	6.1442	-1.4087	6.0655	38.2809*	4.9666	
Banks and Financial Services Sector	Returns	-0.9583	7.4158	0.4559	4.2848	5.4812***	2.8374	18.8717***
	Excess return	-0.9676	7.4204	0.4525	4.2836	5.4469***	2.8401	
Energy and Utilities Sector	Returns	-0.1445	6.3641	0.1070	3.4506	0.5495	0.3174	27.8777*
	Excess return	-0.1538	6.3677	0.1063	3.4474	0.5419	0.3096	
Hotel and Tourism Sector	Returns	0.1967	8.9674	-0.9067	6.3829	32.5345*	7.5415	20.3541***
	Excess return	0.1874	8.9718	-0.9100	6.3908	32.7052*	7.5403	
Insurance Sector	Returns	-0.2583	12.9962	-0.5808	6.4525	29.3017*	7.7134	11.4251
	Excess return	-0.2676	13.0010	-0.5831	6.4565	29.3866*	7.7119	
Industrial Investment Sector	Returns	0.1117	9.0144	-2.2849	11.9779	224.115*	8.7449***	12.4127
	Excess return	0.1024	9.0195	-2.2872	11.9887	224.637*	8.7472***	
Multi-Investment Sector	Returns	-0.7266	9.8106	-0.9051	5.7565	24.0150*	5.3372	13.6649
	Excess return	-0.7359	9.8161	-0.9069	5.7624	24.1169*	5.3626	
Media and Publishing Sector	Returns	-0.0853	8.0032	-0.4019	3.7601	2.7025	5.8252	3.8717
	Excess return	-0.0946	8.0081	-0.4037	3.7640	2.7285	5.8621	
Petrochemical Industries Sector	Returns	-0.8578	11.0682	-1.5872	7.9465	76.2850*	11.931**	16.9378***
	Excess return	-0.8671	11.0742	-1.5889	7.9517	76.4491*	11.971**	
Real Estate Development Sector	Returns	-0.9094	7.5583	-0.8042	7.5525	51.4825*	10.329**	14.9868***
	Excess return	-0.9187	7.5636	-0.8070	7.5599	51.6699*	10.361**	
Retail Sector	Returns	0.7273	6.0890	-1.3667	7.1389	54.3284*	11.039**	5.9641
	Excess return	0.7180	6.0938	-1.3709	7.1549	54.7237*	11.018**	
TeleCommunication and Information Technology Sector	Returns	-0.4209	6.4316	-0.5884	4.3311	6.9708**	7.9187***	13.8778
	Excess return	-0.4302	6.4362	-0.5914	4.3376	7.0408**	7.9207***	
Transport Sector	Returns	-0.2856	8.5251	-0.5951	4.1105	5.8513***	7.8919***	9.8421
	Excess return	-0.2948	8.5302	-0.5973	4.1159	5.9011***	7.9316***	

*Notes: JB is the Jarque–Bera test for normality based on skewness and excess kurtosis; LB is the Ljung-Box test for autocorrelation of order 4; and ARCH refers to the test for conditional heteroscedasticity of order 12 in the residuals when specifying a mean equation with simple constant. *, ** and *** indicate the rejection of the null hypothesis of the associated tests at the 1%, 5% and 10% levels, respectively.*

B. Beta by using Multivariate GARCH (1, 1) model



العلاقة بين المخاطر والعوائد في السوق المالي السعودي

عبد الله بن عبد الرحمن الشبل

الملخص

تناولت هذه الورقة العلاقة بين المخاطر المنتظمة (بيتا) والعائد على قطاعات سوق الأسهم السعودية (تداول) باستخدام البيانات الشهرية من أبريل ٢٠٠٨ إلى سبتمبر ٢٠١٢م. وباستخدام طريقة المربعات الصغرى فقد تم تقدير قيمة بيتا الثابتة لجميع قطاعات السوق حيث كانت معنوية. ومن خلال استخدام نموذج *GARCH (1,1)* متعدد المتغيرات لتقدير قيم بيتا المتغيرة زمنياً، وجدنا انها مختلفة عن قيم بيتا الثابتة لمعظم القطاعات. وبتطبيق اختبار نموذج *Fama (1973)* و *MacBeth* ، وجدنا أن وجهة نظرهم غير متحققة في السوق المالي السعودي. إضافة إلى ذلك، سعت الدراسة الى اختبار نموذج *Pettengill* ، *Sundaram (1995)* و *Mathur*، المشروط بتجزئة السوق صعوداً وهبوطاً، حيث نجد أن النتائج لم تدعم هذا النموذج، وخاصة بالنسبة لعائد حالة الخطر الشرطي (التبادلية الايجابية بين الخطر والعائد). ولذلك، فإن هذه الدراسة تخلص إلى أن نموذج تسعير الاصول الرأسمالية (*CAPM*) قد لا يعمل في مثل هذه الاسواق الناشئة الصغيرة.

The Moment Approximation of First – Passage Time for the Wright-Fisher GNP Diffusion Process to a Linear Determined Value

Anwar Alshriaan* **Mohammad Zainal**

Abstract

The time duration to hit the threshold for the first time is very important issue in physics, chemistry, biology, ecology and economics. Researchers use stochastic models to calculate how long it takes to pass the threshold for the first time. For this reason the first-passage problems arise. Therefore, the first-passage time play an important role in the area of applied probability theory especially in stochastic modeling. This paper considers the Wright and Fisher Gross National Product GNP diffusion process when the GNP is a linear determined value or moving linear barriers and describes an accurate method of approximating the moments of the first-passage time for it. This was done by approximating the differential equations by equivalent difference equations. Also, the first two moments as well as the variance for first-passage time are approximated for such a process, which are very important in estimation problems and in studying the behaviour of the process.

Keywords: *First-passage time, Wright and Fisher GNP diffusion process, Moving Linear barrier, Difference equations, Mean and Variance Approximation.*

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(1) Introduction:

The development of mathematical models in the area of applied probability especially in stochastic modelling is of great importance in many fields such as physics, ecology, demography, genetics and economics. Theoretical models in financial economics are typically set up with continuous-time Brownian motion processes for their mathematical convenience and tractability. Unfortunately, mathematical convenience does not necessarily chime with the convenience of the econometric estimation. It is difficult to estimate continuous-time processes, mainly because the processes that adequately capture stylized facts also lead to complex filtering problems. This discord between theory and applications is especially striking in modelling duration times between different events.

On the one hand, theoretical models in economics and finance use first-passage-time (FPT) densities (alternatively called first-hitting-models) and they define duration as the first time when a stochastic process crosses a specialized threshold. Also, econometricians usually choose a different route by modelling duration time, as a new stochastic process. But, in fact, first-passage-time densities and duration models define the same concept - the length of time separating different stochastic events. More specifically, first passage time problems to diffusion and non-diffusion processes to moving barriers are of great importance too. Several examples of such problems are the extinction time of absorbing process, the exogenous factors in *economics, or the cycle lengths of a certain vehicle actuated traffic signals. Also, the first-passage time to a moving barrier for diffusion and other Markov processes arises in economics modeling (cf. Gutierrez et.al.(1997), (1999)), in biological modeling (cf. Ewens (1979)), in statistics (cf. Darling and Siegert (1953) and Durbin (1971)) and in engineering (cf. Blake and Lindsey (1973)).*

In econometric literature, with a recent exception of Mixed Hitting Time (MHT) models (Abbring (2010)), there are hardly any papers using FPT distributions. More specifically, Abbring (2012) (see also Abbring and Salimans (2012) for a detailed description of the MLE estimation) has recently introduced into the econometric literature a mixed hitting time model, which uses spectrally negative Levy processes (a spectrally negative Levy process is a Levy process that has no positive jumps) which have convenient Laplace transforms. This approach, however, also does not provide closed form solutions, especially as inversion of Laplace transforms also need to be evaluated numerically.

Larralde (2004) shows formally that the universal features of the FPT density for an Ornstein-Uhlenbeck process under the assumption of continuous-time do not extend to the discrete-time O-U process. There is a simple explanation for this difference. Continuous-time processes based on a standard Brownian motion move slowly towards the threshold and the FPT event happens when the continuous time process "gently" *touches the boundary. This is not the case for discrete-time processes. In discrete time, for processes with continuous support of their innovations, the probability that a process at time _ finishes exactly at the boundary is equal to zero. In fact, first-passage time for a discrete time process will always be equivalent to overshooting the boundary.*

Many important results related to the first-passage time have been studied from different points of view of different authors. For example, McNeil (1970) has derived the distribution of the integral functional $W_x = \int_g^{Tx} \{X(t)\}\, d$ *where* T_x *is the first-passage time to the origin in a general birth and death process with* $X(o) = x$ *and* $g(i)$ *is an arbitrary function. And, Iglehart (1965), McNeil and Schach (1973) have been shown a number of classical birth and death process upon taking diffusion limits to asymptotically approach the Ornstein-Uhlenbeck (O. U.).*

Many properties such as a first-passage time to a barrier, absorbing or reflecting, located some distance from an initial starting point of the O. U. process and the related diffusion process such as the case of the first passage time of a wiener process to a linear barrier is a closed form expression for the density available is discussed in Cox and Miller (1965).

Zainal and Alshriaan (2014) describe the moment's approximation of the first passage time for the birth and death gross national product (GNP) to a fixed determined value by *approximating the differential equations by equivalent difference equation.*

Mei et. al. (1999) have calculated the mean first-passage time (MFPT) and found from numerical computations that the MFPT of the system is affected by both the correlation time τ *and the correlation strength* λ.

Gutierrez et. el. (1999) presented a methodology to build a log normal diffusion process with exogenous factors that models economic variables. They studied the problem of forecasting as first passage times and applied to the GNP of Spain. Thomas (1975) describes some mean first-passage time approximation for the Orenstein-Uhlenbeck process.

Tuckwell and Wan (1984) have studied the first-passage time of a Markov process to moving barriers as a first-exit time for a vector whose components include the process and the barrier.

Capocelli and Ricciardi (1971) obtained a diffusion equation for the transition p.d.f. describing the time evolution of the membrane potential for a model neuron, subjected to a Poisson input, without breaking up the continuity of the underlying random function. Also, they obtained the Laplace transform of the first passage time p.d.f. then in terms of Parabolic Cylinder Functions as solution of a Weber equation, *satisfying suitable boundary conditions. A continuous input model is finally investigated.*

Also, others such as, Karlin and Taylor (1981), Ferebee (1982), Alawneh and Aleideh (2002), Patie (2005), Redner (2007), Grenadier (1996), Song (2001), Nyberg etal. (2016), etc. have been discussed the first passage time from different points of view. In particular, Alawneh and Aleideh (2002) have discussed the problem of finding the moments of the first-passage time distribution for the Orenstein-Uhlenbeck process with a single absorbing barrier using the method of approximating the differential equations by difference equations.

In this paper, we consider the Wright and Fisher GNP diffusion process as an example of continuous time stochastic process and study the first-passage time for such a process to a linear determined value or moving linear barrier. More specifically, the moment approximations are derived using the method of difference equations. These moments are very important in estimation problems and in studying the behaviour of the process.

(2) Moment approximation of first-passage to the Wright-Fisher GNP diffusion process:

Consider the simplest Wright and Fisher diffusion Process $\{X(t): t \geq 0\}$ *with infinitesimal mean* $bx(1-x)$ *and variance* $x(1-x)$ *starting at some* $x_0 > 0$*, where b is the* *selection coefficient and satisfies the Ito stochastic differential equation*

$$dX(t) = bX(t)(1 - X(t))dt + \sqrt{X(t)(1 - X(t))}dW(t)$$

Where $\{W(t) : t \geq 0\}$ *is a standard Wiener process with zero mean and variance t. Assume that the existence and uniqueness conditions are satisfied (Cf. Gihman and Skorohod (1972)). The Wiener process is a continuous-time stochastic process and often called standard Brownian motion, which is a stochastic processes with stationary independent increments and occurs frequently in pure and applied mathematics, economics, quantitative finance, and physics. The Wiener process has applications throughout the mathematical sciences, for example, it is prominent in the mathematical theory of finance, in particular the Black–Scholes option pricing model. The Wiener process W(t) is characterized by the following properties:*

1. *W(0) = 0 almost surely.*
2. *W(t) has independent increments: W(t+u) – W(t) is independent for u ≥ 0*
3. *W(t) has Gaussian increments: W(t+u) – W(t) is normally distributed with mean 0 and variance u, W(t+u) – W(t) ~ N(0, u).*
4. *W(t) has continuous paths: With probability 1, W(t) is continuous in t.*

Note $\{X(t): t \geq 0\}$ *is a Markov procees with state – space S = [0, 1] . Notice that 0 and 1 are absorbing states. Denote the first – passage time of a process* $X(t)$ *to a linear determined value (moving linear barrier)* $Y(t) = ct + \beta$ *by the random variables*

$$T_Y = \inf\{t \geq 0 : X(t) \geq ct + \beta\}$$

with probability density function

$$g(t; x_0) = -\frac{d}{dt}\int_{-\infty}^{ct+\beta} p(x_0; x; t)\, dx$$

Here $p(x_0; x; t)$ *is the probability density function of* $X(t)$ *conditional on* $X(0) = x_0$.

Let $M_n(x_0, Y; t)$ *; n = 1,2,3,…… , be the n-th moment of the first – passage time* T_Y *, i.e.*

$$M_n(x_0, Y; t) = E(T_Y^n) \quad ; n = 1,2,3,...,$$

It follows from the forward Kolmogorov equation that the n-th moment of T_Y *must satisfy the ordinary differential equation*

$$x(1-x)\, M_n''(x_0, Y; t) + bx(1-x) M_n'(x_0, Y; t) + cM_n'(x_0, Y; t) = -nM_{n-1}(x_0, Y; t) \quad \text{..........(1)}$$

Or equivalently

$$M_n''(x_0, Y; t) + bM_n'(x_0, Y; t) + \frac{c}{x(1-x)} M_n'(x_0, Y; t) = -\frac{n}{x(1-x)} M_{n-1}(x_0, Y; t) \quad \text{..........(2)}$$

Where $M'_n(x_0,Y;t)$ *and* $M''_n(x_0,Y;t)$ *are the first derivatives of* $M_n(x_0,Y;t)$ *with respect to* x $(x_0 \le x \le Y)$, *with appropriate boundary conditions for n=1,2,3,…….Note that* $M_0(x_{0,}Y;t)=1$.

Now, rewrite the equation in (2), we obtain

$$M''_n(x_0,Y;t) = -\frac{n}{x(1-x)}M_{n-1}(x_0,Y;t) - \left(b+\frac{c}{x(1-x)}\right)M'_n(x_0,Y;t) \quad ....(3)$$

Let Δ *be the difference operator. Then we defined the first order difference of* $M_n(x_0,Y;t)$ *as follows:*

$$\Delta M_n(x_0,Y;t) = M_{n+1}(x_0,Y;t) - M_n(x_0,Y;t) \quad ....(4)$$

(cf. Kelley and peterson (1991)).

Note that equation (3) can be approximated by

$$M''_n(x_0,Y;t) = -\frac{n}{x(1-x)}M_{n-1}(x_0,Y;t) - \left(b+\frac{c}{x(1-x)}\right)\Delta M_n(x_0,Y;t) \quad ....(5)$$

By applying equation (4) to equation (5) we get:

$$M''_n(x_0Y;t) = -\frac{n}{x(1-x)}M_{n-1}(x_0,Y;t) + \left(b+\frac{c}{x(1-x)}\right)M_n(x_0,Y;t) - \left(b+\frac{c}{x(1-x)}\right)M_{n+1}(x_0,Y;t) \quad ....(6)$$

Now, we will use the matrix theory to solve the differential equation defined in equation (6). If we let

$$\vec{M}(x_0,Y;t)=[M_1(x_0,Y;t),M_2(x_0,Y;t),......]'$$

Then we get

$$\frac{d^2\vec{M}(x_0,Y;t)}{dx^2}=A\vec{M}(x_0,Y;t)\text{.......................................(7)}$$

Where

$$A=\begin{bmatrix} \left(b+\frac{c}{x(1-x)}\right) & -\left(b+\frac{c}{x(1-x)}\right) & 0 & 0 & ...... \\ -\frac{2}{x(1-x)} & \left(b+\frac{c}{x(1-x)}\right) & -\left(b+\frac{c}{x(1-x)}\right) & 0 & .... \\ 0 & -\frac{3}{x(1-x)} & \left(b+\frac{c}{x(1-x)}\right) & -\left(b+\frac{c}{x(1-x)}\right) & .... \\ . & . & . & . & \\ . & . & . & . & \\ . & . & . & . & \end{bmatrix}$$

Now let

$$\frac{d\vec{M}(x_0,Y;t)}{dx}=\vec{R}(x_0,Y;t)\text{............................(8)}$$

This imply

$$\frac{d^2\vec{M}(x_0,Y;t)}{dx^2}=\frac{d\vec{R}(x_0,Y;t)}{dx}\text{.......................................(9)}$$

Apply to equation (7), we get

$$\frac{d}{dx}\begin{bmatrix} \vec{R}(x_0,Y;t) \\ \vec{M}(x_0,Y;t) \end{bmatrix} = \begin{bmatrix} 0 & \mathrm{A} \\ \mathrm{I} & 0 \end{bmatrix} . \begin{bmatrix} \vec{\mathrm{R}}(\mathrm{x}_0,Y;t) \\ \vec{M}(x,Y;t_0) \end{bmatrix} \text{..............(10)}$$

Where ***I*** *is the identity matrix and 0 is the zero matrix.*

Thus, the solution of the system of equation in (10) is then given by

$$\begin{bmatrix} \vec{R}(x_0,Y;t) \\ \vec{M}(x_0,Y;t) \end{bmatrix} = \mathrm{e}^{\begin{bmatrix} 0 & \mathrm{A}^* \\ \mathrm{D} & 0 \end{bmatrix}} . \begin{bmatrix} \vec{R}(\mathrm{x}_0,Y;t) \\ \vec{M}(x,Y;t_0) \end{bmatrix} \text{................(11)}$$

Where $\mathrm{D} = [d_{ij}];\ i, j \geq 1$ *is the diagonal matrix with entries*

$$d_{ij} = \begin{cases} (ct + \beta - x_0) & ;\ \mathrm{j = i} \\ 0 & ;\mathrm{Otherwise} \end{cases} \text{..(12)}$$

And $A^* = [a^*_{ij}];\ i, j \geq 1$ *is the matrix with entries*

$$a_{ij}^{*} = \begin{cases} -\dfrac{i}{x(1-x)}\ln\left(\dfrac{ct+\beta}{x_0}\right) & ;\ j=i-1 \\ \left(b+\dfrac{c}{x(1-x)}\right)(ct+\beta-x_0) & ;\ j=i \\ -\left(b+\dfrac{c}{x(1-x)}\right)(ct+\beta-x_0) & ;\ j=i+1 \\ 0 & ;Otherwise \end{cases} \qquad ...(13)$$

Note that the matrix e^B *where* $B=\begin{bmatrix} 0 & A^{*} \\ D & 0 \end{bmatrix}$ *is defined by*

$$e^{B} = I + B + \frac{B^2}{2!} + \frac{B^3}{3!} + ...$$

This series is convergent since it is a cauchy operator of equation (2.6) (cf. Zeifman (1991)).

(3) Mean and Variance Approximation for the First-Passage Time:

Now for approximating the moments of the first-passage time for such a process using the first and the second order difference operators to the differential equation in (6), we define the operators as follows:

Let Δ^2 *be the second order difference operators. Then we defined the second order differences of* $M_n(x_0, Y; t)$ *and as follows:*

$$\Delta^2 M_n(x_0,Y;t) = M_{n+2}(x_0,Y;t) - 2M_{n+1}(x_0,Y;t) + M_n(x_0,Y;t) \qquad (14)$$

(Cf. Kelley and Peterson (1991)).

Note that equation (6) can be approximated by

$$\Delta^2 M_n(x_0,Y;t) = -\frac{n}{x(1-x)} M_{n-1}(x_0,Y;t) + \left(b + \frac{c}{x(1-x)}\right) M_n(x_0,Y;t) - \left(b + \frac{c}{x(1-x)}\right) M_{n+1}(x_0,Y;t) \qquad (15)$$

By applying equation (14) to equation (15) we get:

$$M_{n+2}(x_0,Y;t) - 2M_{n+1}(x_0,Y;t) + M_n(x_0,Y;t) = -\frac{n}{x(1-x)} M_{n-1}(x_0,Y;t) + \left(b + \frac{c}{x(1-x)}\right) M_n(x_0,Y;t) - \left(b + \frac{c}{x(1-x)}\right) M_{n+1}(x_0,Y;t) \qquad (16)$$

Now rewriting equation (16) we get:

$$M_{n+2}(x_0,Y;t) = \left(2 - \left(b + \frac{c}{x(1-x)}\right)\right) M_{n+1}(x_0,Y;t) + \left(\left(b + \frac{c}{x(1-x)}\right) - 1\right) M_n(x_0,Y;t) - \frac{n}{x(1-x)} M_{n-1}(x_0,Y;t) \qquad (17)$$

Through equation (17), the first moment $M_1(x_0,Y;t)$ and the second moment $M_2(x_0,Y;t)$ of the first –passage time can be approximated by

And

$$M_2(x_0,Y;t)\cong\left(2-\left(b+\frac{c}{x(1-x)}\right)\right)M_1(x_0,Y;t)+\left(\left(b+\frac{c}{x(1-x)}\right)-1\right) \quad .....(19)$$

Therefore the variance $V(x_0,Y;t)$ can be approximated by

$$V(x_0,Y;t)\cong\left(\left(b+\frac{c}{x(1-x)}\right)-1\right) \quad ....(20)$$

Note that these results are of great importance for the statistical inference problems.

(4) Conclusion:

In conclusion the system of the solutions in equations (11) gives an explicit solution to the first-passage time moments for the Wright and Fisher GNP diffusion process to a linear determined value (moving linear barrier) of GNP using an accurate method of approximating the ordinary differential equation by the equivalent difference equation since it is the discretization of the ODE. Also, the mean and the variance of the first-passage time for such a process are approximated which *are useful for statistical inference problems. Therefore this increases the applicability of the diffusion process in stochastic modeling in the area of applied probability especially in economics.*

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العزم التقريبي لزمن لحظة المرور الاولى لنموذج رايت – فيشر المتهيج للناتج القومي الإجمالي لقيمة خطية محددة

أنور الشريعان محمد زينل

المدة الزمنية لتصل إلى عتبة للمرة الأولى هي قضية هامة جدا في الفيزياء والكيمياء والبيولوجيا والبيئة والاقتصاد. ويستخدم الباحثون نماذج عشوائية لحساب الزمن الذي يستغرقه لاجتياز عتبة للمرة الأولى. لهذا السبب، فإن مشاكل المرور الأولى تنشأ. ولذلك، فإن زمن المرور الاأول يلعب دورا هاما في مجال نظرية الاحتمالات التطبيقية خصوصا في النمذجة العشوائية. وتناقش هذه الورقة نموذج رايت وفيشر المتهيج للناتج القومي الإجمالي *GNP* عندما يمثل الناتج القومي الإجمالي قيمة خطية محدده أو حاجز خطي متحرك. وقد تم ذلك عن طريق تقريب المعادلات التفاضلية بما يعادلها من معادلات الفروق. أيضا، يتم تقريب العزم الأول والثاني وكذلك التباين لزمن المرور الأول لمثل هذه العملية، والتي هي مهمة جدا في مشاكل التقدير وفي دراسة سلوك هذه العملية.

SESAME EXPORT PERFORMANCE AND CONSTRAINTS IN SUDAN

Imad Eldin Elfadil Abdel Karim Yousif *

ABSTRACT

This paper analyzes sesame export performance and competitiveness and its main constraints in Sudan. A vector error correction model was applied using data from 1970-2014. The results show that low yield, area variation and the fluctuating exchange rate are the main factors affecting sesame export earnings in the long run, while area variation is the constraining factor in the short run. Improving sesame yield and stabilizing exchange rate will have positive impact on sesame export value in the long run, while expansion of area under sesame production could have negative influence on sesame exports value due to Sudan's large share of sesame world exports. In order to improve foreign exchange earnings from sesame export, Sudan should address the problem of low yield, area variation and fluctuating exchange rate especially in the long run. The paper recommends the adoption of economic policies to improve sesame yield, control of area under sesame production, and stabilization of the exchange rate of Sudanese currency.

Keywords: *Sesame export, Competitiveness, Constraints, Sudan.*

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SESAME EXPORT PERFORMANCE AND CONSTRAINTS IN SUDAN

INTRODUCTION

The agricultural sector is a significant contributor to the Sudanese economy; it is the backbone of economic growth, poverty reduction, and sustainable development, especially after the drastic fall in oil resources following the secession of South Sudan. Sesame, gum Arabic, and livestock are the most important exports of the Sudan. Sesame is a major cash crop both for export and domestically, and the country is one of the world's largest producers and exporters. Sesame is mainly produced under semi-mechanized and traditional farming systems. It is grown entirely under rain-fed conditions, and is grown with little or no use of machinery or modern inputs under the traditional farming system. The major sesame growing areas in the Sudan are located in Kordofan, Sinnar, Kassala, and Blue Nile states.

Sudan exports about two third of its sesame production, and is among the main exporters of sesame seeds worldwide. Other sesame exporters worldwide include India, Ethiopia, Nigeria, China, Paraguay, Myanmar, and Mexico. Sudan ranks second after India in cultivated area, but Sudanese sesame yields are lower than any of the above-mentioned countries. In 2010 Sesame yield in

Sudan represented about 18%, 27%, 58%, and 51% of the yield in China, Ethiopia, India and Nigeria, respectively. With a 10% share in total world exports Sudan ranked fourth after Nigeria, India, and Ethiopia who respectively held 38%, 20%, and 16% of the market in 2010 (FAO Statistics).

Table 1 shows that sesame exports in 2008-2013 accounted an average 32% and 3.3% of agricultural and total exports respectively. With its share in total exports increasing from 1.2% in 2008 to more than 6% in 2013, sesame is emerging as one of the leading export commodities in Sudan after the sharp fall in oil exports. Sudan's export markets are quite diversified covering China, Europe, and Africa as well as traditional markets in the Gulf and Arab countries. Gulf and Arab countries are the major importers of Sudanese sesame with a share of more than 34% in 2012 total exports, followed by China (25%).

Table 1. Sesame exports, values, and shares: 2008-2013

	Export		***Unit value***	***Share***	
	Quantity	***Value***		***Agricultural exports***	***Total exports***
	(1000 ton)	*(million US $)*	*US $/Ton*	*(percent)*	*(percent)*
2008	*96.7*	*141.9*	*1467.4*	*36.1*	*1.2*
2009	*137.6*	*143.3*	*1041.4*	*31.2*	*1.7*
2010	*224.1*	*167.3*	*746.5*	*38.2*	*1.5*
2011	*211.8*	*231.0*	*1090.6*	*30.2*	*2.4*
2012	*208.9*	*223.5*	*1069.8*	*28.5*	*6.6*
2013	*242.7*	*472.7*	*1947.6*	*29.0*	*6.6*
Average	*186.6*	*229.9*	*1227.2*	*32.2*	*3.3*

Source: Central Bank of Sudan Annual Reports

There are many obstacles restricting the potential role of sesame in the livelihood of small farmers and trade in Sudan. These obstacles are associated with rainfall fluctuation, land tenure, harvesting and post-harvesting, quality of seeds and weak links in its value chain. Other obstacles include ineffectiveness of agricultural extension systems, lack of agricultural rotation, low or no use of technology, frequent mono-cropping and used of non-certified seeds. Macroeconomic problems including high inflation and distorted exchange rates, are also constraining sesame production and exports.

This paper attempts to analyze and quantify the effect of yield, rainfall, and exchange rate on competitiveness of Sudanese *sesame exports through the application of a vector-error-correction model. These factors are the major determinants of sesame exports as they affect revenues and competitiveness in the world market.*

METHODOLOGY

The study utilized the co-integration vector-error-correction model (VECM) to examine factors affecting sesame export in Sudan. Co-integration technique is superior to other techniques due to its ability to establish the short-run and long-run relationship amongst variables, and estimate the resulting co-integration and error correction models. Granger (1986) pointed out that testing for co-integration is imperative to avoid spurious regression results.

In VECM, an equilibrium relationship exists when variables in the model are co-integrated. Two conditions must be satisfied for variables to be co-integrated. First, the data series of the variables should exhibit similar statistical properties and be integrated of the same order; and second, a stationary linear combination must exist (Malik 2010). For a time series to be stationary its variance and covariance at various lags stay the same over time.

Several studies have suggested a number of co-integration methodologies including Hendry (1986); Engle and Granger (1987); Johansen (1988); Johansen and Juselius (1990); and Goodwin and Schroeder (1991). In this paper, Johansen's VECM has been used. VECM permits the testing of co-integration as a *system of equations in one step and does not require the prior assumption of endogeneity of the variables.*

Model specification:

The study used yield (Y), area (A) and real exchange rate (RER) as the main factors affecting sesame export earnings in Sudan. The RER is a key determinant of agricultural exports across all countries. It is expected that as the domestic currency depreciates agricultural exports will increase and vice versa, thus affecting exports competitiveness. The variable yield is used as a proxy for agricultural production capacity and level of technology. The area variable indirectly captures the effect of rainfall variation as the cultivated area mostly depends on the amount and distribution of rainfall. Accordingly sesame export value is specified as a function of these variables as follows:

$$LnX = f(LnY, LnA, LnRER) \qquad (1)$$

Where Ln is the natural logarithm, X is the export value of sesame, Y is the yield, A is the cultivated area, and RER is the real exchange rate.

Real exchange rate is calculated using the following equation (see Kingu 2014):

$$RER = \frac{CPI_{sud}}{CPI_{us}} * NER \qquad (2)$$

Where CPI_{sud} is the consumer price index for Sudan, CPI_{us} is the consumer price index for the United States of America (US) and NER is the nominal exchange rate in local currency.

A VECM was used to estimate the long-run relationship among variables in equation (1). To estimate the VECM model the following steps are followed: First, a test of stationarity for the variables included in the model was conducted, both in levels and first difference forms, using the Augmented Dickey Fuller test (ADF). The variables were found to be non-stationary at level, thus using classical regression techniques to estimate equation (1) would yield spurious results. Engle–Granger (1987) pointed out that stationary regression residuals indicate the existence of long run relationship amongst the variables. Thereafter, a first difference of the variables has been taken in order to obtain stationary variables. Second, a co-integration test for selected variables was conducted using Johansen co-integration procedure. Third, the VECM model is specified and estimated.

Data Sources:

Time series data from 1970 - 2014 were used in the analysis. Data were compiled from different sources. Sesame yield, area and export value, nominal exchange rate, and consumer price index for Sudan were collected from annual reports of the Bank of Sudan, while the consumer price index of the US is collected from US Department of Labor, Bureau of Labor Statistics.

Stationarity Test:

To check the stationarity of the data, the ADF unit root test was applied with the intercept terms included in the regression. Table 1 shows the results of the ADF unit root test for the model *variables both at level and first difference form. For all variables in levels, the null hypothesis that each series has a unit root could not be rejected as the ADF statistics are below the critical value at 5% level of significance. These results indicate that a classical regression output of a model represented by equation (1) is spurious, but the regression residual for the variables at levels is stationary. This indicates the existence of a long run relationship amongst the variables. Also, Table 2 shows that all variables become stationary and have no unit root after taking first differences, therefore, we can go to the next step and conduct co-integration test.*

Table 2. Results of the unit root tests

Variables	***Augmented Dicky-Fuller Test***			
	Variables in Level	***P value***	***Variables in 1st Difference***	***P value***
LnX	*-2..3*	*0.17*	*-5.72*	*0..00*
LnA	*-2.58*	*0.11*	*-8.57*	*0.00*
LnY	*-1.17*	*0.67*	*-9.66*	*0.00*
LnRER	*-1.05*	*0.72*	*-5.10*	*0.00*

Source: Calculated in EViews 6

The Co-integration Test:

*After checking the hypothesis of non-stationarity, the time series were examined for co-integration. Co-integration analyzes the relationship between integrated series and explores whether a linear combination of integrated time series is itself stationary. For co-integration, Johansen (1995) maximum likelihood procedure was used. The procedure utilizes two statistical tests for deciding the number of co-integrating vectors: i) Trace test***:** *which tests the null hypothesis (H_o) that the number of co-integrating vectors is less than or equal to r against the alternative (H_1) that the number of co-integrating vectors is more than r; and ii) Maximum Eigenvalue test, where the null hypothesis (H_o) that the number of co-integrating vectors is r is tested against the alternative (H_1) that the number of co-integrating vectors is r+1.*

The results of the co-integration test are presented in Table 3 along with the critical values of the trace and max-eigenvalue statistics with a lag length of 3 (k=3). The first row in the upper Table tests the hypothesis of no co-integration, the second row tests the hypothesis of one co-integration relation, the third row tests the hypotheses of two co-integrating relations, and so on, all against the alternative hypotheses that there are more than r co-integrating vectors ($r = 0,1,\ldots,4$) .

As shown in Table 3, both the trace and max-eigenvalue tests indicate one co-integrating equation at 5% level of significance. Therefore, there are non-spurious long run relationships between *the model variables and hence the VECM is a valid representation of the relationships between the dependent variable (sesame exports value) and the independent variables (yield, area and real exchange rate).*

Table 3. Johansen co-integration test

Trace Test				
Number of co-integration	**Eigenvalue**	**Trace statistics**	**Critical Value (5%)**	**Prob.**
None *	0.63	62.8	47.8	0.001
At most 1	0.36	24.3	29.7	0.187
At most 2	0.15	6.8	15.4	0.598
At most 3	0.01	0.3	3.8	0.614
Maximum Eigenvalue				
Number of co-integration	**Eigenvalue**	**Max-Eigen statistics**	**Critical Value (5%)**	**Prob.**
None *	0.63	38.5	27.5	0.001
At most 1	0.36	17.5	21.1	0.149
At most 2	0.15	6.6	14.3	0.541
At most 3	0.01	0.3	3.8	0.614

Source: Calculated in EViews 6

**denotes rejection of hypothesis at 5% level of significance*

The VECM Specification:

The VECM model provides the long term relationship and short term dynamics of the endogenous variables. The model shows the achievement of long run equilibrium and the rate of change in the short run to achieve equilibrium.

Depending on the results of Johansen co-integration analysis (Table 3), we assumed only one co-integrating vector that affects only one equation. To capture both the short run dynamics between time series and their long run equilibrium relationship the following VECM model with 3 lags was estimated (see Jaupllari and Zoto 2013; Zulfiqar and Kausar, 2012):

$$D(LnX) = \propto + \gamma LnX_{(-1)} + b_1 LnY_{(-1)} + b_2 LnA_{(-1)} + b_3 LnRER_{(-1)} + c_2 DLnX_{(-1)} + c_3 DLnX_{(-2)} + c_4 DLnX_{(-3)} + c_5 DLnY_{(-1)} + c_6 C6DLnY_{(-2)} + c_7 C7DLnY_{(-3)} + c_8 C8DLnA_{(-1)} + c_9 C9DLnA_{(-2)} + c_{10} DLnA_{(-3)} + c_{11} DLnRER_{(-1)} + c_{12}\, DLnRER_{(-2)} + c_{13} DLnRER_{(-3)} \qquad (3)$$

Where $\propto$ is the constant term, γ is the error correction coefficient, b and c are the coefficients. Numbers between brackets refer to the lag order.

The first part of equation (3) represented by

$$(\propto + \gamma LnX_{(-1)} + b_1 LnY_{(-1)} + b_2 LnA_{(-1)} + b_3 LnRER_{(-1)})$$

captures the long run equilibrium relationships between the variables, while the second part (c_2-c_{13}) captures the short run equilibrium relationships. The coefficient. γ is the error correction term which shows the speed of adjustment of disequilibrium. If γ has a negative sign and is statistically significant, then that indicates the existence of a long run equilibrium relationship between the model variables (Anwar et al, 2010).

To illustrate the implication of the relationships among model variables, variance decomposition was also employed.

RESULTS AND DISCUSSION

The VECM model estimated for equation (3) is as follows:

$$D(LnX) = 2.26 - 1.01LnX_{(-1)} + 0.82LnY_{(-1)} - 1.35LnA_{(-1)} + 0.02LnRER_{(-1)} + 0.15DLnX_{(-1)} + 0.10DLnX_{(-2)} + 0.06DLnX_{(-3)} + 0.27DLnY_{(-1)} + 0.36DLnY_{(-2)} + 0.09DLnY_{(-3)} - 0.85DLnA_{(-1)} - 0.78DLnA_{(-2)} - 0.73DLnA_{(-3)} - 0.004DLnRER_{(-1)} + 0.10DLnRER_{(-2)} + 0.04DLnRER_{(-3)} \quad (4)$$

Wald test has been used to test the significance of the coefficients in equation (4), and the results are presented in Table (4). The Wald test results showed that γ is significant and has a negative sign, which is an indication of the presence of long run equilibrium relationship between the model variables. On the other hand, the coefficients c_2 through c_{13} are not significant except for c_7, c_8 and c_9, and this indicates that there is a weak short run equilibrium relationship between the model variables especially between the dependent variable, yield and real exchange rate variables. On the other hand, the area variable has significant negative impact on sesame exports value in the short run.

Table 4. Wald test results

Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
γ	-1.011	0.329	-3.065	0.005
C2	0.153	0.270	0.566	0.575
C3	0.101	0.224	0.452	0.654
C4	0.055	0.175	0.317	0.753
C5	0.266	0.338	0.786	0.438
C6	0.359	0.302	1.191	0.243
C7	0.092	0.301	0.306	0.761
C8	-0.858	0.392	-2.188	0.037
C9	-0.786	0.354	-2.219	0.035
C10	-0.727	0.306	-2.373	0.025
C11	-0.004	0.097	-0.046	0.963
C12	0.100	0.098	1.022	0.315
C13	0.037	0.092	0.407	0.686

Source: Calculated in EViews 6

A number of diagnostic tests (Table 5) were performed on the residuals to assess statistical accuracy of the estimated VECM in equation (4). As indicated by the results in Table 5, the residuals of the estimated VECM have no trace of autocorrelation or heteroskedasticity (ARCH effect) and are normally distributed. Therefore, we can consider the residual of VAR components of VECM model as a white noise (stationary and unrelated).

Table 5. Residual diagnostic tests of the estimated VECM

Autocorrelation Test	
LM(5)	*2.022*
p-value	*0.567*
Normality Test	
Jarque-Bera $\chi 2$ (2)	*5.753*
p-value	*0.056*
ARCH Test	
F value	*2.430*
p-value	*0.487*

Source: Calculated in EViews 6

Long Run Relationship:

The long run equilibrium relationship between the dependent variable (LnX) and independent variables (LnY, LnA and LnRER), is extracted from equation (4) as follows:

$$D(LnX) = 2.26 - 1.01LnX_{(-1)} + 0.82LnY_{(-1)} - 1.35LnA_{(-1)} + 0.02LnRER_{(-1)} \quad (5)$$

The coefficients of the real exchange rate and yield have the expected signs and are statistically significant (see Table 4). Thus, the real exchange rate and yield have positive impacts on sesame export value. In terms of magnitude, the effect of yield is higher than that of real exchange rate. When the yield of sesame increases by 1% the sesame export earnings will increase by 0.82%. Meanwhile, when the real exchange rate depreciates by 1% the export value will increase by only 0.02%. On the other hand, the coefficient of area is negative and statistically significant. This *means that an increase of the grown area of sesame has a negative impact on sesame export value. This can be explained by the fact that Sudan is one of the major sesame exporters in the world market; any increase in total export volume may depress world prices of sesame and hence its export value. Therefore, it is important for Sudan to have a clear policy for exports especially during good production seasons.*

As the error correction term was significant with a negative sign, the results of the VECM indicate that the adjustment in LnX is due to the error correction term (γ). The empirical findings show a greater coefficient of the over adjusting error-correcting term (-1.01); this signifies that the variables in the model are adjusting faster from the short run to the long run equilibrium. LnX adjusted almost in one year to the long run equilibrium meaning that it took almost only one year to eliminate the disequilibrium.

Short Run Relationship:

The short run equilibrium relationship between the dependent variable (LnX) and independent variables (LnY, LnA and LnRER), is extracted from equation (4) as follows:

$$D(LnX) = 0.15DLnX_{(-1)} + 0.10DLnX_{(-2)} + 0.06DLnX_{(-3)} + 0.27DLnY_{(-1)} + 0.36DLnY_{(-2)} + 0.09DLnY_{(-3)} - 0.85DLnA_{(-1)} - 0.78DLnA_{(-2)} - 0.73DLnA_{(-3)} - 0.004DLnRER_{(-1)} + 0.10DLnRER_{(-2)} + 0.04DLnRER_{(-3)} \quad (6)$$

As shown in Table (4), most of the variables included in equation (6) are statistically insignificant, which means that there is a weak short run equilibrium relationship between sesame export *value, on one hand, and real exchange rate and yield on the other hand; this finding is in line with Kingu (2014) and Diakosavvas and Kirkpatric (1990) results for some Sub Saharan Africa countries. On the other hand, the coefficient of area is negative and statistically significant which reflects the negative influence of area expansion on sesame exports value in the short run. Although the coefficients of real exchange rate and yield are not statistically significant, they are still important determinants of sesame export earnings in the short run too.*

Variance Decomposition:

Table 6 shows the results of variance decomposition of the dependent variable during 10 periods. The impulse or innovation or shock in the short run in sesame exports value accounts for 72% of the fluctuations in exports value (owned shock). Real exchange rate shock accounts for 7.9% and 7% of fluctuations in sesame exports value in the short and long run respectively. Yield shock accounts for 9% and 11.4% of fluctuations in sesame exports value in the short and long run, respectively. Area shock in the short run accounts for 10% of the variations in sesame exports value, and in the long run accounts for 18%. These results support the findings of the VECM model of the significance of real exchange rate, yield, and area for sesame export value especially in the long run.

Table 6. Variance decomposition of sesame export value

Period	*S.E.*	*X*	*RER*	*Y*	*A*
1	*0.408*	*100.00*	*0.00*	*0.00*	*0.00*
2	*0.464*	*87.19*	*5.16*	*0.08*	*7.55*
3	*0.505*	*78.05*	*6.16*	*5.63*	*10.14*
4	*0.528*	*72.49*	*7.93*	*9.02*	*10.55*
5	*0.595*	*65.86*	*6.69*	*9.86*	*17.57*
6	*0.648*	*64.34*	*6.27*	*11.03*	*18.34*
7	*0.678*	*64.58*	*6.06*	*11.21*	*18.12*
8	*0.703*	*64.53*	*6.74*	*11.25*	*17.47*
9	*0.729*	*64.26*	*7.24*	*11.17*	*17.32*
10	*0.759*	*63.43*	*7.09*	*11.42*	*18.04*

Source: Calculated in EViews 6

CONCLUSION

The paper analyzed the main factors determining sesame exports in Sudan using a vector error correction model. The results showed that low yield, area variation, and fluctuating exchange rate are the main factors affecting the sesame export earnings in the long run, while area variation is the main factor in the short run. Improvements of sesame yield and stabilization of exchange rate will have positive impact on sesame exports value in the long run, while expansion of area under sesame production could have negative influence on sesame exports value due to Sudan's large share of sesame exports in the world market. In order to improve foreign exchange earnings from sesame export, Sudan should address the problem of low yield, area variation, and fluctuating

exchange rate especially in the long run. The paper recommends adopting economic policies that lead to improvement of sesame yield, control of area under sesame production, and stabilization of the exchange rate of Sudanese currency.

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أداء ومحددات صادرات السمسم في السودان

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ملخص

تهدف هذه الورقة الي قياس الأداء والقدرة التنافسية والعوائق لصادرات السمسم في السودان. ولتحقيق اهداف الدراسة تم تطبيق نموذج متجه الانحدار الذاتي باستخدام بيانات للفترة 1970-2014م. أظهرت نتائج التحليل أن انخفاض الانتاجية، وتذبذب المساحة وعدم استقرار سعر الصرف هي العوامل الرئيسة التي تؤثر على عائدات تصدير السمسم في المدى الطويل، بينما تذبذب المساحة هو المتغير الوحيد الذي يؤثر علي عائدات تصدير السمسم في المدى القصير. اوضحت نتائج الدراسة ان تحسين انتاجية السمسم واستقرار سعر الصرف سوف يكون له تأثير إيجابي على قيمة صادرات السمسم في المدى الطويل، في حين أن التوسع في المساحات المزروعة بالسمسم يمكن أن يكون له تأثير سلبي على قيمة صادرات السمسم بسبب حصة السودان الكبيرة من تصدير السمسم في السوق العالمية. من أجل تحسين عائدات النقد الأجنبي من تصدير السمسم، يجب معالجة مشكلة الانتاجية المنخفضة، وتقلبات سعر الصرف خصوصا في المدى الطويل. عليه توصي الورقة باعتماد السياسات الاقتصادية التي تؤدي إلى تحسين انتاجية السمسم، وتحديد المساحات المخصصة لإنتاجه والعمل على استقرار سعر صرف العملة السودانية.

الكلمات المفتاحية: صادر السمسم، التنافسية، المحددات، السودان.

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