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Analysing Monthly Bulk Electricity Sold by Uganda Electricity Transmission Company Limited Using ARIMA Model

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Abstract

The Uganda Electricity Transmission Company (UETC) has the monopoly for buying bulk electricity from generating companies within Uganda and selling it to local distributors and other distributors within the East African region. However, up to now, monthly units of electricity sales are reported in tables or graphs and forecasts are mainly judgmental. This limitation fails to provide the quantitative input data required for management planning and forecasting based on sales. The purpose of this study was to identify the main characteristics in the trends of the monthly sales, analyse the sales using simple linear regression and Auto Regressive Integrated Moving Average (ARIMA) models to determine a good fit estimate model, which was thereafter evaluated in an interactive analysis. The study used Eviews 3.1 econometric package covering the period February 2006 to July 2011.

It revealed a general upward trend in sales with variations from one month to another without any recognisable seasonality. A simple linear regression estimate model was found to be unsuitable for representing the sales since most actual values were outside one standard confidence limits of the estimated model. However, using the ARIMA model estimate and analysis through identifying and carrying out predictive and diagnostic tests, a good fit was ARIMA(1,1,0), represented by the equation $Y_e = 0.9675 + Y_{(t-1)} - 0.6004Y_{(t-1)} + 0.6004Y_{(t-2)}$ *showing that its estimate depended mainly on the last two most recent lag monthly sales after first order differencing. Furthermore, an evaluation forecast showed that the actual sales fitted in the one standard confidence limits*

of the model, thus confirming that the model could be used for forecasting sales beyond July 2011.

This study provides managers of UETC with a practical and yet simple tool to describe, explain, intervene in and forecast monthly electricity sales that are required by management for planning.

Keywords: *ARIMA, auto correlation function, differencing, Gigawatt Hours, monthly electricity sales, non-stationary, stationary, partial autocorrelation function.*

Introduction

Energy is one of the key drivers in any economic development. It is vital therefore for achieving full integration of the East African Community. Since colonial days, Uganda has exploited its abundant natural hydropower potential for local use and for export to member countries within the community. UETC is the company licensed to sell this bulk electricity to distributors. However, extant literature reveals that the company presents monthly electricity sales using only tables and graphs. However, by its nature, this business varies from one month to another and a simple linear model could possibly be poor in providing a good fit estimate of the sales required for planning. Many scholars like Himanshu & Lester (2007) in a study of electricity sales in Sri Lankan and Li & Zhang (2010) in a similar study in China found that a non-stationary time series approach provides a good estimate model for explaining, describing and forecasting trends in electricity sales because they exhibit non-stationary time series.

Non-stationary time series is a collection of data points recorded as a

function of time, Box & Jenkins (1976). Studies by Cranage (2003) among other scholars confirm that most human activities exhibit non-stationary time series and cover areas like economic forecasting, sales forecasting, budgetary analysis, process and quality control, workload projections, population growth and utility services, and they exhibit varying values. Box, Jenkins & Reinsel (1994), Makridakis, Wheelwright & Hyndman (1998) concur that in non-stationary time series current values are dependent on their lag values.

Different methodologies exist in analysing non-stationary time series such as the moving average and weighted smoothing. However, Box & Jenkins (1976) suggested that ARIMA modelling is one of the most efficient methodologies for analysing such series and it has been used by scholars like (Ching-Hsue & Liang-Ying, 2009; Granger, 2007; Dunis, Laws & Evans, 2006; Robinson, 2000; Himanshu & Lester, 2007 and Granger, 2007) for modelling different economic trends. Unfortunately, Himanshu & Lester's (2007) study of electricity sales in Sri Lanka and another study by Li & Zhang (2010) concur that there has been little modelling of electricity using ARIMA, although it is simple, efficient and effective in forecasting short-term sales.

Problem Statement

In Uganda, extant literature indicates that no study has been done to describe, explain and forecast energy sales by UETC using the quantitative approach. This has made the company apply judgemental input information for planning and forecasting. This study used a simple linear regression approach in line with the extension of works by Himanshu & Lester (2007) and Robinson (2000), who used the ARIMA modelling approach to analyse monthly electricity sales of UETC covering the period February 2006 to July 2011 to identify a good fit estimate model.

Specific Objectives

The specific objectives of this research were to:

1. Identify the main patterns in the monthly sales of electricity;
2. Develop a linear regression model using the monthly sales of electricity;
3. Develop an ARIMA model for the monthly sales of electricity;
4. Evaluate the estimated ARIMA model using in-sample monthly electricity forecasting.

Literature Review

Modelling using ARIMA requires transforming the series into a stationary trend as through differencing (Francis 2004 and Shang & Hyndman, 2009) and this was done in this study. According to Box & Jenkins (1976), Simon (1999) and Ogbuagu & Ubi (2009), the first order differencing is $D^1_t = D_t - D_{t-1}$ and the second order differencing is $D^2_t = D^1_t - D^1_{t-1}$. Ching-Hsue & Liang-Ying, 2009 and Dunis et al, 2006 explain that stationary time series has constant mean, variance and autocorrection. However, when the raw data shows a changing variance, it would need to be transformed using logarithms or square roots of the series first before considering its statationarity. The ARIMA model can be considered a combination of the Autoregression (AR) and Moving Average (MA) models and expressed as:

$$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \ldots\ldots a_p y_{t-p} - b_1 u_{t-1} - b_2 u_{t-2} - \ldots\ldots - b_q u_{t-q} + u_t$$

where $a_1 y_{t-1} \ldots$. is the AR component while $b_1 u_{t-1} \ldots$. is the MA component (Box Jenkins, 1976).

According to the ARIMA model, when a time series depends purely on previous outputs it is an AR estimate, when it depends purely on inputs it is

an MA estimate and when it combines the two it is an autoregressive-moving-average estimate (ARIMA). According to Iqbal, Bakhsh, Maqbool & Ahmad (2005), the ARIMA model is denoted as ARIMA(p,d,q), where p is an AR value, d is an Integration or Differencing factor and q is an MA component. Parameters for each are determined using plots of ACF (Autocorrelation Function) and PACF (Partial Autocorrelation Function). An ARIMA model is therefore a special regression model in which a stationarised dependent variable uses all its lags and/or errors as independent variables (Box-Jenkins, 1976).

According to Francis (2004), ARIMA modelling requires a minimum of 50 data points in order to give a reliable analysis, while Han Lin Shang & Hyndman (2009), Iqbal, Bakhsh, Maqbool & Ahmad (2005) and Robinson (2000) say that identifying a model estimate involves determining the main characteristics of its raw data and investigating whether the series is non-stationary. Predicting a model, according to Iqbal, Bakhsh, Maqbool & Ahmad (2005), can involve testing for its accuracy through normality unit root and Augmented Dickey-Fuller (ADF) tests, while one way of diagnosising it is to prove that the correlagram of the residuals is not significant. In this study, most of these tests were carried out to reconfirm the best fit choice of the model. In conclusion, ARIMA modelling provides a simple but powerful modelling tool, despite the need to stationarise the data first and identify any seasonality, and despite the failure of most of the business community to comprehend modelling concepts and estimate equations.

Methods and Materials

In this study, the methodology covered linear regression and ARIMA modelling, both carried out using Eviews 3.1 because of its flexibility and ease of analysing time series. The collected data had 66 observations made

from February 2006 to July 2011, as shown in Table 1. The modelling (testing) data consisted of 59 series (February 2006 to December 2010 and forecasting (evaluation) data had seven cases (January 2011 to July 2011).

Table 1: *Monthly Sales Data in Gigawatt Hours*

	Sales (GwH)					
Months	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
January		157	167	179	196	217
February	112	148	154	165	179	193
March	122	159	165	184	198	222
April	122	145	159	178	194	204
May	126	155	170	186	203	216
June	123	151	165	185	200	211
July	129	165	168	197	205	207
August	133	164	172	195	206	
September	124	157	171	185	201	
October	135	165	172	193	207	
November	138	170	171	172	204	
December	144	169	177	178	208	

Linear regression modelling had monthly sales as the dependent variables, while a dummy variable, called mthregress, was the independent variable with values 1, 2, 3, …. for monthly periods February 2006, March 2006, April 2006, … The regression was based on the hypothesis that:

H_o: *As the months go by it has no effect on the monthly sales of electricity*

The hypothesis was tested, and the results plotted and interpreted.

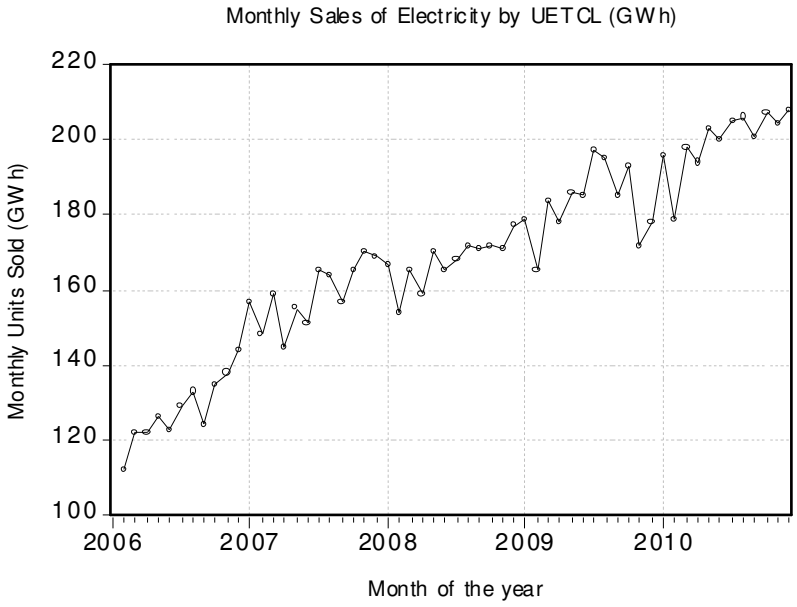
ARIMA modelling is interactive, analytical and exploratory through using plots of ACF and PACF. It involved identifying the characteristics in the original series, thereafter stationarising the data from which the value for d

in the model equation was determined. The existence of seasonality was investigated and thereafter values for p and q were determined through interpreting the correlagram plots. A diagnostic test was done on the model before an evaluation forecast of the sales was carried out.

Results and Discussion

An "Eyeball Metric" of the raw data (Figure 1) shows an upward trend of the series without outstanding peaks or troughs. However, between August and October, September reflected low sales and December high sales between November and January, using a 12-month business cycle, and these two months were more likely to be outliers, as was proved later in the study. The trend was a typical non-stationary time series, most likely being influenced by the fact that more bulk electricity is generated from both hydro and thermal sources due to the continuous increase in the manufacturing and fabricating sectors, urbanisation, more socialisation centres, the construction of high-rise buildings, rural electrification and the acquisition of more electronic gadgets for use by consumers. Variations in monthly sales could be attributed partly also to a difference in the length of months and the effects of weekends, holidays and cultural festivals like Christmas. Furthermore, the data did not reflect any increase in the variance of the trends, suggesting that in ARIMA modelling the data would not require initial transformation before it was stationarised, as was proved later in the study.

Figure 1: *Monthly Sales of Electricity by Uganda Electricity Transmission Company Limited in Gigawatt Hours*



A simple linear regression was carried out on the data and the output is shown in Table 2. An interpretation of the output shows that the linear regression equation between the monthly sales and the successive months using February 2006 as the base month is:

Monthly Sales = 126.8 + 1.367mthregress

The uncertainty in the constant and the variable mthregress were 1.9898 and 0.0516, respectively. Furthermore, the standard error of the regression in the model was 7.9911 and the passage of time in months contributed about 92% of the monthly sales. A t-statistic showed at 95% confidence

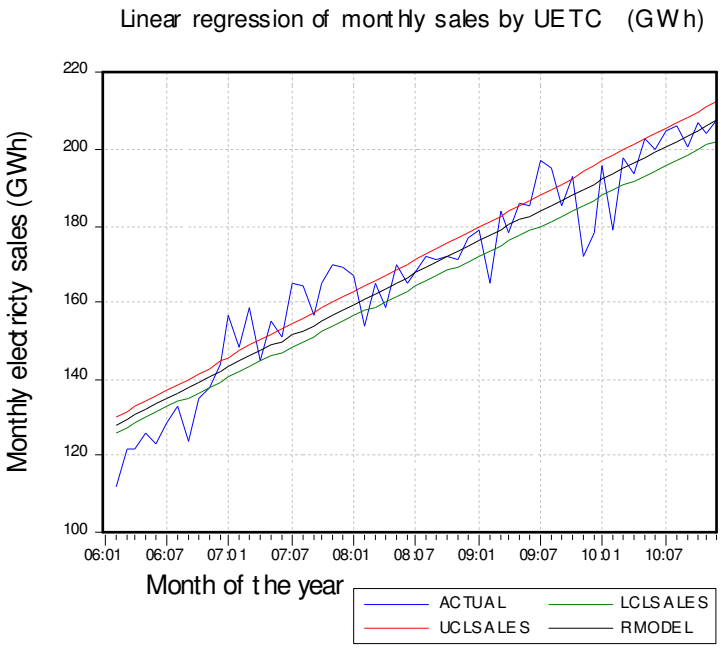
that these two parameters are part of the equation (t-value > critical value) and that their coefficients are not zero since the p-values of the t-statistic were less than 0.05. In conclusion, the null hypothesis was rejected.

The findings would mathematically present a good model, but most of the actual sales when plotted were outside the confidence limits of the estimated model, thus making it unsuitable for the trends as shown in Figure 2 at 95% confidence level.

Table 2: *Linear Regression Results*

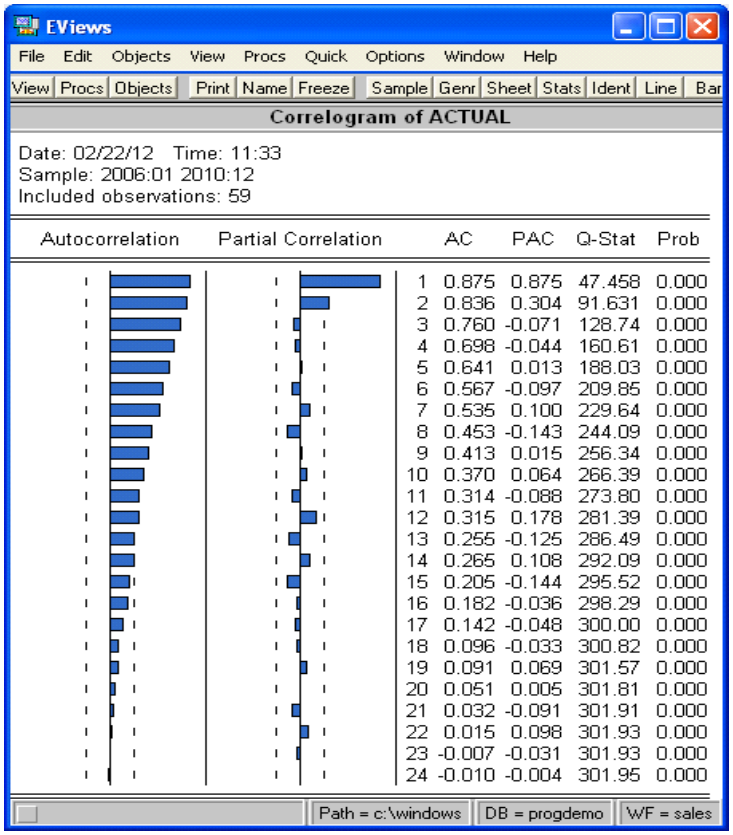
Dependent Variable: ACTUAL				
Method: Least Squares				
Date: 05/07/12 Time: 09:37				
Sample(adjusted): 2006:02 2011:07				
Included observations: 66 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	126.8131	1.989845	63.73010	0.0000
MTHREGRESS	1.366955	0.051634	26.47419	0.0000
R-squared	0.916327	Mean dependent var		172.6061
Adjusted R-squared	0.915020	S.D. dependent var		27.41245
S.E. of regression	7.991111	Akaike info criterion		7.024371
Sum squared resid	4086.903	Schwarz criterion		7.090724
Log likelihood	-229.8042	F-statistic		700.8825
Durbin-Watson stat	1.589158	Prob(F-statistic)		0.000000

Figure 2: *Linear Regression of Monthly Sales by Uganda Electricity Transmission Company Limited in Gigawatt Hours*



The study focused on identifying a good fit estimate for modelling UTEC's monthly sales of electricity. Therefore the data was also analysed using ARIMA modelling. A graphical pattern of the data is shown in Figure 3 using 24 lags which was greater than 59/4, (Box-Jenkins, 1976). The ACF had an exponential decline of up to 14 spikes and PACF had 2 spikes at lags one and two. Furthermore, the ACF did not show any seasonality within the business cycle of 12 months, thus confirming that the variations in September and December sales were just outliers.

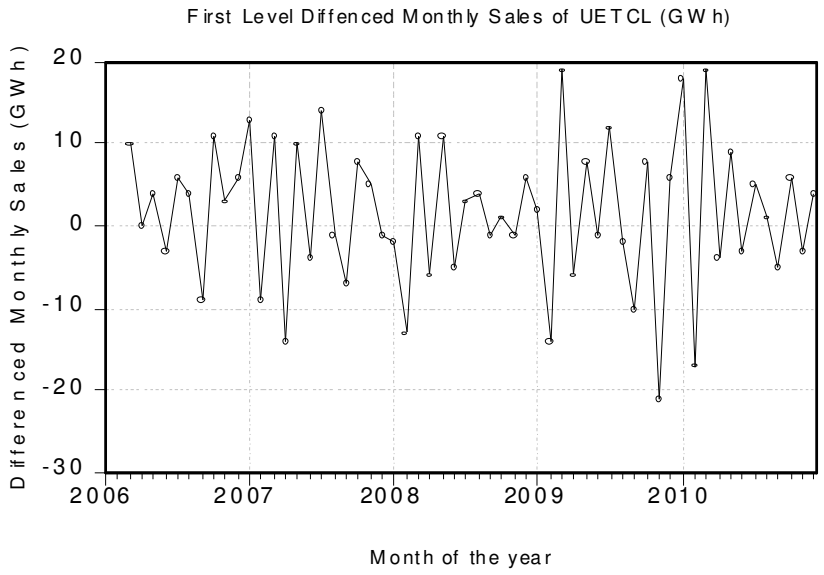
Figure 3: *Correlogram of Actual Sales in Gigawatt Hours*



From the PACF, it was possible to make an initial guess of an AR(2,0,0) model estimate, although the ACF indicating varying means and autocorrelation suggested the need to difference the data as a way of stationarising it. After first differencing, the line graph plot was found to be stationary, as shown in Figure 4, suggesting that a better model for the series would be ARIMA(p,1,q) rather than the initial ARIMA(2,0,0).

Consecutive patterns in the sales demonstrated a symmetrical variation about point 0 (an assumed mean) without increasing the variance and no systematic peaks or troughs were found within each business cycle.

Figure 4: *First Level of Differenced Monthly Sales by Uganda Electricity Transmission Company Limited in Gigawatt Hours*



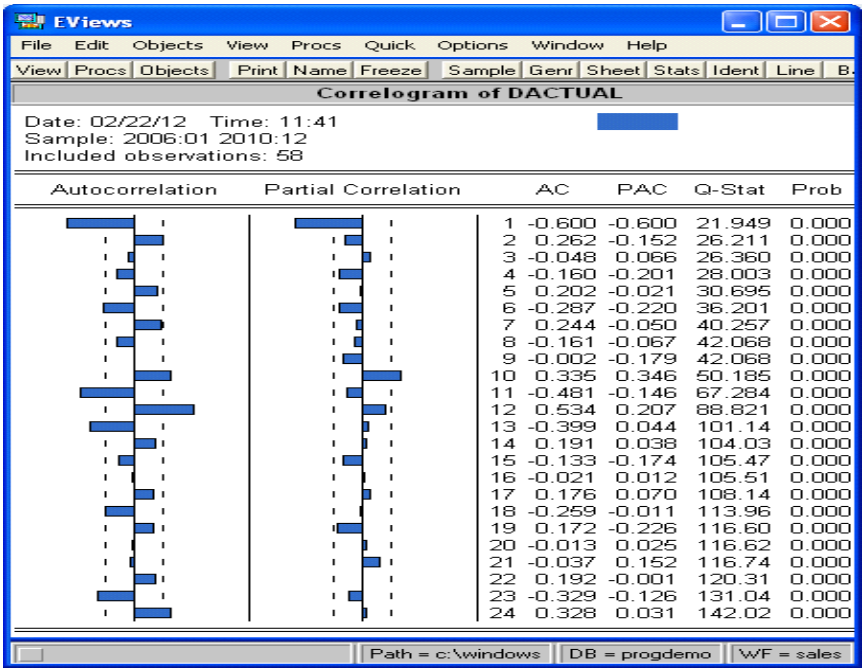
A correlogram of the stationary data shown in Figure 5 revealed an exponentially declining pattern in ACF and one spike in the PACF at lag 1, suggesting an AR(1) signature, which improves the model from just being an ARIMA(2,0,0) or ARIMA(p, 1, q) to ARIMA (1,1,0). The equation for ARIMA(1,1,0) according to Box & Jenkins (1976), Granger (2007) and Iqbal, Bakhsh, Maqbool & Ahmad (2005) is:

$$Y_e = \mu + Y_{(t-1)} + \emptyset Y_{(t-1)} - \emptyset Y_{(t-2)} + \epsilon ;$$

where m is a constant,

where μ is a constant,
Ø is the coefficient of the ARIMA variable,
Y_e is the model value at time t,
$Y_{(t-1)}$ is the observed value one lag and
$Y_{(t-2)}$ is the value two lags of the current value and ϵ is a random error in the model.

Figure 5: *Correlogram of DActual Sales in Gigawatt Hours*



An equation estimate for this model produced the output shown in Table 3. The coefficient C represented the mean trend in sales with a value of -0.6004, while the standard error of the variable y_t was 0.1066. Consequently, the estimated value of the intercept was 0.9675 and its

standard error was 0.3682, (Gardner & McKenzie 1985). According to the t-statistic output, we have 95% confidence that these two parameters are part of the equation and that their coefficients are not zero. The lag values contribute about 35% of the current monthly sales as shown by the Adjusted R-square. The estimated equation of the model was therefore given as: $Y_e = 0.9675 + Y_{(t-1)} - 0.6004Y_{(t-1)} + 0.6004Y_{(t-2)} + \epsilon$

Table 3: *Linear Regression Output on DActual*

Dependent Variable: DACTUAL				
Method: Least Squares				
Date: 02/22/12 Time: 11:53				
Sample(adjusted): 2006:04 2010:12				
Included observations: 57 after adjusting end points				
Convergence achieved after 3 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.548263	0.589237	2.627574	0.0111
AR(1)	-0.600426	0.106588	-5.633127	0.0000
R-squared	0.365864	Mean dependent var		1.508772
Adjusted R-squared	0.354334	S.D. dependent var		8.860270
S.E. of regression	7.119524	Akaike info criterion		6.798016
Sum squared resid	2787.820	Schwarz criterion		6.869702
Log likelihood	-191.7435	F-statistic		31.73212
Durbin-Watson stat	2.202898	Prob(F-statistic)		0.000001

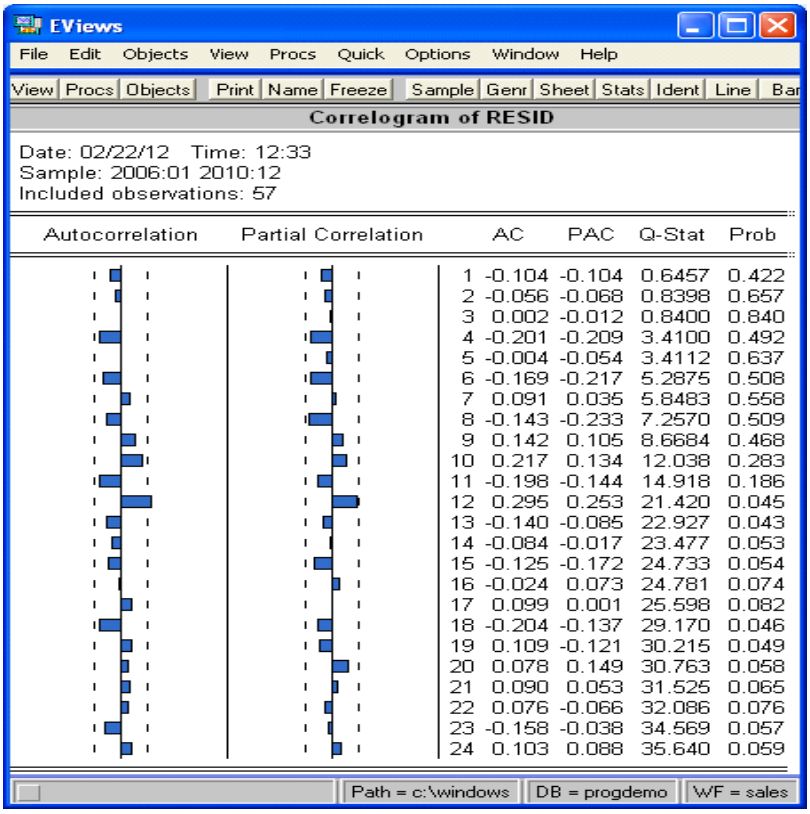
The model was predicted using a unit root test (Igbal, Bakhsh, Maqbool & Ahmad,2005), based on the ADF value. The hypothesis for prediction was that:

H_0: ADF value =1 (the series is not stationary)

An output of the analysis revealed an ADF test statistic of -7.6996 (less than the critical value of -4.1281 at 1% level of significance), predicting that the estimated model would be stationary, thus rejecting the null hypothesis.

The model was diagnosed by plotting a correlogram of the residuals of the estimated ARIMA model equation (Robinson, 2000). The ACF and PACF showed that the residuals were not significant as shown in Figure 6, thus confirming that the remaining data trends were outliers in the estimated model ARIMA (1,1,0). The residuals or outliers in each month could be attributed to variations in the number of days in a month, weekends, public holidays and cultural days in each month, among other factors.

Figure 6: *Correlogram of Residual Sales in Gigawatt Hours*

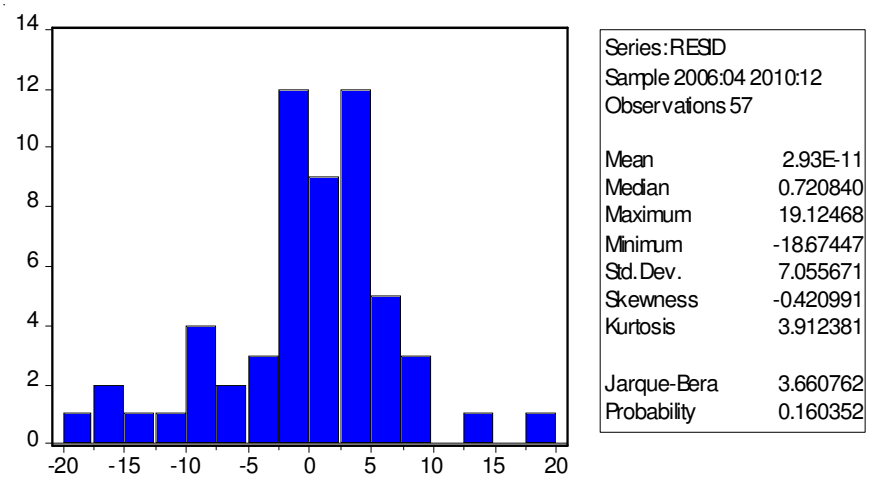


Another diagnostic test was the residual test-histogram-normality test of the model, whose output is shown in Figure 7, based on the hypothesis that:

H_0: p-value =0 (the residual distribution is not normal)

The critical Jarque-Bera value using Chi-square at 2 degrees of freedom at 95% confidence level is 5.99, while the computed value was 3.661 with a p-value of 0.16, confirming that the residuals follow a generally normal distribution, though skewed to the left and a kurtosis, as shown in Figure 7.

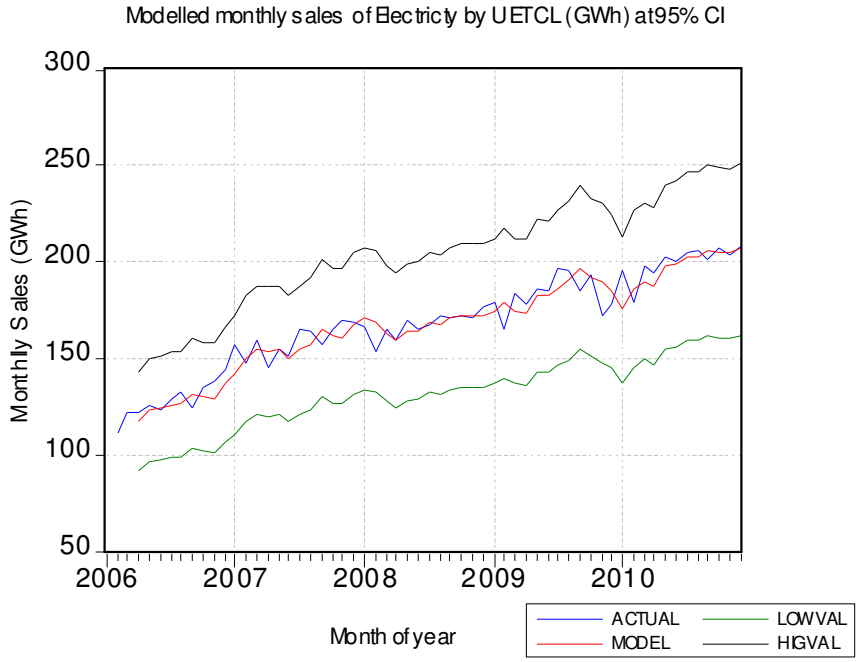
Figure 7: *Residual Test Histogram Normality Test of Monthly Sales by Uganda Electricity Transmission Company Limited in Gigawatt Hours*



The critical value at 95% confidence interval is 1.96 and using the standard errors of the parameters their margins of error were 0.7217 for the constant and 0.2089 for the variable y_t. The estimated model sales with their upper

and lower confidence limits and the actual monthly sales were plotted, as shown in Figure 8, thus confirming that the model was good.

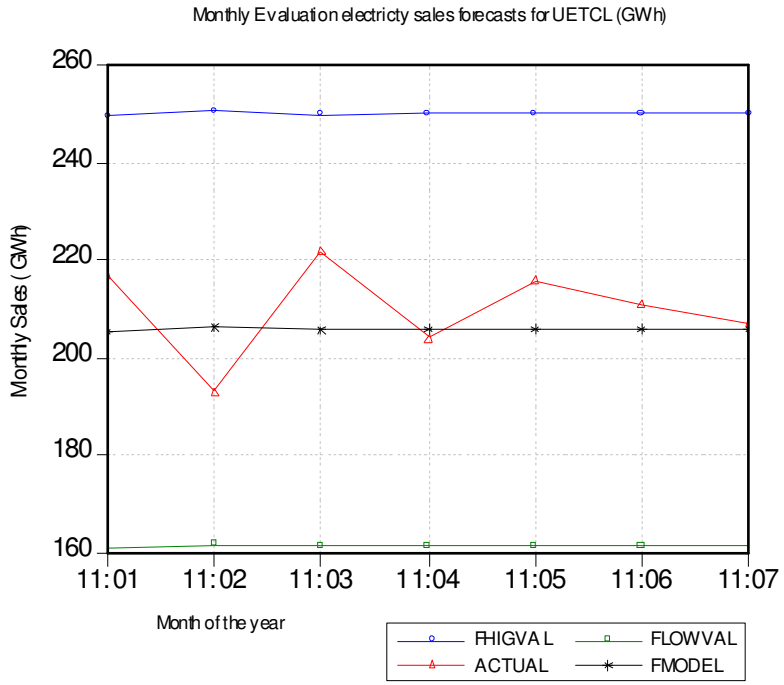
Figure 8: *Modelled Monthly Sales by Uganda Electricity Transmission Company Limited in Gigawatt Hours at 95 Percent Confidence Level*



When evaluating the estimate model, the first portion of the data is for testing and modelling it, while the second portion is for evaluating the estimate. Evaluation data is used to measure the real-time performance of the model as a way of producing confidence-building forecasts rather than actual forecasting. However, one drawback to this approach is the absence of a scientific technique for determining the best point at which to split the data. In this study, forecasts for the model estimate and upper and lower

confidence limits were calculated for the period January 2011 to July 2011, thereafter plotted with the actual monthly sales for that period as shown in Figure 9.

Figure 9: *Monthly Evaluation Electricity Sales Forecast for Uganda Electricity Transmission Company Limited in Gigawatt Hours*



According to Figure 9, the dataset of the actual monthly sales was within the upper and lower evaluation forecast limits of the estimated model. With this confirmation and assuming other factors influencing monthly sales of electricity by UETC are the same, the model could be used to forecast monthly sales beyond July 2011.

Conclusion

The ARIMA model gives a good fit estimate of the varying monthly electricity sales by UETC using Eviews, which was identified as ARIMA(1,1,0), whereby the next month's forecast values can be predicted using the current and previous values substituted in the equation $Y_e = 0.9675 + Y_{(t-1)} - 0.6004Y_{(t-1)} + 0.6004Y_{(t-2).}$ when compared to the simple regression model estimate. This is a simple and yet powerful tool for providing a quantitative analysis of sales, which could provide qualitative information for planning, explaining, describing, intervening in, forecasting and allocating the resources of this service.

The ARIMA model utilises lag values on the assumption that other factors in the business remain the same, which is not always the case. Utilisation of the model would therefore require the addition of qualitative information in order to make more realistic forecasts. Furthermore, the sale of electricity by UETC is influenced by unique factors within Uganda, which means that the estimated model "as is" is not adaptable to any another bulk electricity transmission company and certainly when UETC increases its sales, by 250 Gigawatt Hours, from the new Bujagali power generation station the model estimate will need to be reviewed to remain relevant.

This study focused on identifying a forecasting model estimate using ARIMA and time series of monthly sales only. Another study using a causal approach to forecasting monthly electricity sales could be investigated also.

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The Effects of Vertical Collaboration and Buyer-Supplier Compliance on Contract Performance in Uganda's Public Procuring and Disposing Entities (Pde's): The Case of The National Water and Sewerage Corporation

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Abstract

The purpose of this study was to explore the effects of vertical collaboration and buyer-supplier compliance on contract performance. This research was prompted by reports of increased poor contract performance characterized by the poor quality of services provided, incomplete and sub-standard work, and the failure to deliver on agreed schedules, increased user complaints and contract violations in Uganda's Public Procuring and Disposing Entities (PPDE's). Anecdotal evidence attributes poor contract performance to the lack of a clearly designed formal contractual governance mechanism, inadequate information sharing, poor decision synchronisation and the lack of incentive alignment. Despite numerous classical studies reported in different domains involving vertical collaboration, buyer-supplier compliance and contract performance, no existing empirical study has examined the effects of vertical collaboration and buyer-supplier compliance on contract performance. This study therefore aims to answer the following research questions: (1) what is the level of vertical collaboration, buyer-supplier compliance and contract performance at the National Water and Sewerage Corporation (NWSC)? (2) Does

vertical collaboration and buyer-supplier compliance influence contract performance? Using cross-sectional and quantitative survey data drawn from NWSC, the findings reveal that vertical collaboration and buyer-supplier compliance are significant predictors of contract performance. The results of this study have managerial and theoretical implications that are also presented in this article.

Keywords: *Vertical collaboration, buyer-supplier compliance, contract performance*

Introduction

Organizations the world over experience prolonged contract development and negotiation cycles, improper contract approvals, limited contract visibility and control, contract violations and the inability to enforce buyer-supplier compliance with contract terms (Avery, 2004). In particular, procurement contracts are among the many types of contracts that are frequently affected. A procurement contract is any legally binding agreement entered into on behalf of the organization for the acquisition of goods or services (Public Procurement and Disposal of Assets[PPDA] Act (2003)). The contract may range from a very formal and structured contractual document to a verbal commitment. Similarly, contract management entails the terms and conditions that are set prior to the contract and that must be met during contract execution (Ntayi, Rooks, Eyaa & Qian (2010a). Contracts normally go through a number of rigorous statements and negotiations before, during and after contract execution. These statements rarely reflect the desired outcome of the contract and therefore expose the contracting parties to undesirable risks (Ahimbisibwe, Muhwezi & Nangoli, 2012b). Therefore, buying organisations are also encouraged to build collaborative and long-term relationships with their suppliers to avoid poor

contract performance (Ahimbisibwe & Nangoli, 2012). Indeed, effective contract performance can hardly occur without the partner's cooperation (Ting et al, 2007).

In Uganda, most contracts exceed the targeted cost and have never been completed and yet the government of Uganda cannot invoke any of the clauses in these contracts to enforce them, and so it remains the loser (Ahimbisibwe, Muhwezi, & Eyaa, 2012a). Anecdotal evidence reveals the existence of poor quality services, incomplete and sub-standard work, the failure to deliver on agreed schedules, an increased number of user complaints and a high level of contract violations in Uganda's Public Procuring and Disposing Entities (PPDE's) (Ahimbisibwe, Nangoli & Tusiime, 2012c). Similarly, the PPDA annual report (2011) reveals that the services are basically not provided on time, specifications are not matched and internal users are always complaining of late deliveries. This indeed indicates that there is an urgent problem that needs to be addressed, which if remains unaddressed the government will continue to lose a lot of taxpayers' money in contracts and the standard of living will continue to diminish due to poor contract performance.

Mugisha, Berg & Katashaya (2004) describe a number of performance enhancement programmes that have been initiated and implemented in the National Water and Sewerage Corporation (NWSC) since 1998. Among these include a 100-day programme (February–May 1999) and the service and revenue enhancement programme (August 1999–August 2000). To improve performance further, the NWSC headquarters later on entered into area performance contracts with its subsidiary utilities to increase managerial autonomy, introduce performance incentives and hold them more accountable. Most of these contracts with NWSC were for one year and were renewed for three consecutive years (2000-2003). These

projects were intended to ensure a stable water supply but, to the dismay of NWSC, the plant production capacity of 10.6 million cubic metres per day has not been achieved, which could have resulted from poor contract management.

Similarly, Mugisha et al (2004) noted that in Uganda there are over 57 delegated area management contracts between NWSC and private operators aimed at improving the water supply. This has been evidenced through several works contracts that have been undertaken by the NWSC, resulting in a number of variations, which have delayed contract completion, leading to the failure of buyer-supplier compliance. Consequently, since these contracts have a direct impact on business operations, they have greatly affected financial performance in terms of delayed sales and customer service delivery, thus leading to loss of revenue and reduced profit margins, among others. The challenge that remains is how to effectively improve contract performance through vertical collaboration and buyer-supplier compliance at NWSC to enable improved service delivery.

Despite numerous classical studies that are reported in different domains involving vertical collaboration, buyer-supplier compliance and contract performance, no existing empirical study has examined the effects of vertical collaboration and buyer-supplier compliance on contract performance. Ahimbisibwe (2008) examined outsourcing contracts, trust, opportunistic behaviour and service delivery in public procuring and disposing entities. Similarly, Ahimbisibwe et al. (2012b) elucidated the relationship between outsourced contracts, buyer-supplier trust, opportunistic behaviour and supplier performance in Ugandan PPDE's. Ahimbisibwe & Nangoli (2012) also empirically investigated Uganda's public sector procurement by examining the moderating effect of buyer-supplier trust on the relationship between outsourced formal contracts and supplier delivery performance.

None of these studies specifically addresses the effects of vertical collaboration and buyer-supplier compliance on contract performance, leaving it as an area that is understudied and requiring attention.

This study therefore focuses specifically on filling this research gap by examining contract performance using the antecedents of vertical collaboration and buyer-supplier compliance in order to provide a new viewpoint from which we can gain an understanding of contract performance in Uganda's public sector. In so doing, a contribution to the existing contract performance literature is made by providing a framework for gaining an understanding of the unknown relationship between vertical collaboration and buyer-supplier compliance that affect contract performance. This study therefore aims at answering the following research questions: (1) what is the level of vertical collaboration, buyer-supplier compliance and contract performance at the NWSC? (2) Does vertical collaboration and buyer-supplier compliance influence contract performance?

The remainder of this article is organised as follows. The next section covers theory and reviews literature to develop hypotheses for testing the research model. The subsequent two chapters cover methodology and data analysis. The article concludes by discussing the findings, implications, limitations and directions for future research.

Theoretical Foundation

Many scholars have advanced several theories to describe and justify the concept of contracting (Gottschalk & Solli-Saether, 2005). The core competencies theory suggests that activities should be performed, either in house or by suppliers, depending on what is core or non-core (Hancox & Hackney, 2000). This implies that activities which require non-core

competencies should be contracted out to best-in-the-world suppliers (Gottschalk & Solli-Saether, 2005). Similarly, according to the resource-based theory of the firm, contracting out is a strategic decision, which can be used to fill gaps in a firm's resources and capabilities (Grover, Teng & Cheon, 1998). The underlying logic here is that organisations are different and must develop self-motivated competences to adjust to varying environments. This is supported by the transactional cost theory (Williamson, 1979), which argues that transaction costs arise because completing contracts is often impossible and incomplete contracts give rise to subsequent renegotiations when the balance of power between the transacting parties shifts. Hence, all functions should be contracted out where benefits like revenue and reduced costs for the company exceed the transaction costs.

In contrast, the proponents of the contractual theory, such as Luo (2002), argue that a contract provides a legally bound institutional framework, in which each party's rights, duties and responsibilities are codified, and the goals, policies and strategies underlying the arrangement are specified. Therefore, every contract has the purpose of facilitating exchange and preventing opportunism. Supplier opportunism is "self-interest seeking with guile" (Williamson, 1979). Ntayi et al (2010b) further describe guile as "lying, stealing, cheating and calculated efforts to mislead, distort, disguise, obfuscate or otherwise confuse." Neo-classical economic theory posits that firms enter into contracts to attain cost advantages from the assumed economies of scale and scope possessed by vendors (Ang & Straub, 1998).

Likewise, Lambe, Spekman and Hunt (2002) reveal that, according to the partnership and alliance theory, partnerships can reduce the risk of inadequate contractual provision, which may be comforting for clients about

to enter into a contract for a complex and high-cost activity such as installing IT. Finally the relational exchange theory, which is based on relational norms, suggests that the key to determining how efficiently contract governance is carried out lies in the relational norms between the parties (Artz & Brush, 2000).

In summary, some theories give reasons why organisations should engage in contracting (theory of core competencies, resource-based theory, transaction cost theory, neo-classical economic theory and theory of firm boundaries) while others indicate the challenges that may be associated with outsourced contracts (contractual theory, partnership and alliance theory, relational exchange theory, social exchange theory, agency theory and stakeholder theory) (Gottschalk & Solli-Saether, 2005).

Table 1 gives a summary of the theoretical foundations of contracting and their significance in explaining the concept of contracting with supporting references.

Table 1: *Theoretical Underpinnings of Contracting*

Theory and key authors	**Implication and relevancy in explaining the concept of contracting**
Theory of core Competencies (Hancox & Hackney, 2000)	Activities should be performed either in house or by suppliers depending on what is core or non-core
Resource-based Theory (Grover, Teng & Cheon, 1998)	Contracting is a strategic decision, which can be used to fill gaps in the firm's resources and capabilities
Transaction cost theory (Williamson, 1979)	All functions should be contracted out where benefits like revenue and reduced costs for the company exceed the transaction costs.
Contractual theory (Luo, 2002)	Contract provides a legally bound institutional framework in which each party's rights, duties, and responsibilities are codified, and the goals, policies and strategies underlying the arrangement are specified.

Theory and key authors	**Implication and relevancy in explaining the concept of contracting**
Neoclassical economic theory (Ang & Straub, 1998)	Firms contract out to attain cost advantages from assumed economies of scale and scope possessed by vendors.
Partnership and alliance theory (Lambe, Spekman & Hunt, 2002)	Partnerships and Alliances reduce the risk of inadequate contractual provision and comforts clients who contract out complex and high-cost activities.
Relational exchange theory (Artz & Brush, 2000)	The key to determining how efficiently contract governance is carried out lies in the relational norms between the parties.
Social exchange theory (Das & Teng, 2002)	Contracting is regarded as an on-going reciprocal process in which actions are contingent on rewarding reactions from others.
Agency theory (Hancox & Hackney, 2000)	Contracting is viewed as an agency relationship that arises whenever one or more individuals, called principals, hire one or more other individuals, called agents, to perform some service and then delegate decision-making authority to the agents.
Theory of firm Boundaries (Lonsdale & Cox, 2000)	Contracting is viewed as one of the ways by which the boundary of the firm can be adjusted to meet market demand.
Stakeholder theory (Gottschalk & Solli-Saether, 2005)	Stakeholder groups have significant differences in terms of expectations and goals in regard to contracting and so satisfying these interests based on the principles of moral management determines the success of contracting.

Literature Review

Essentially, a contract is a formal written agreement that is legally binding on two or more competent parties, which creates obligations, whereby one party becomes bound to another to do or omit to do certain acts that are the subject of that contract (Ntayi et al., 2010a). This implies that contracts provide the framework for economic exchange, outlining the nature and terms of the relationship, what is to be provided and the rights and obligations of parties to the contract. This can occur through ex ante

mechanisms that bind the parties together, such as requiring parties to undertake transaction-specific investments or credible commitments to the relationship (Williamson, 1983). Alternatively, ex post mechanisms may be incorporated, which provide parties with rights and sanctions over others in the event of non-performance or other pre-specified situations. Goo et al (2006) revealed that service contracts mainly involve service level agreements. They defined a service level agreement as a formal written agreement developed jointly between a service recipient and service provider that specifies a product or service to be provided at a certain level so as to meet business objectives. Service level agreements specify responsibilities, strengthen communication, reduce conflict and build trust in an exchange relationship. In addition to the above, Goo et al (2006) identified the contractual elements as foundation, change management and governance characteristics.

Foundation characteristics are contractual elements that collectively explain the common beliefs of organisations, which intend to build a spirit of agreement among those entities involved in the contract (Ntayi et al., 2010b). Elements under foundation characteristics include service level objectives, pricing schedules, ownership and other contractual clauses, (Lusch & Brown, 1996).

Change management characteristics are contractual features that deal with how various situations that might occur in the future would be handled, such as price inflation clauses in the industrial purchasing contracts and express warranties that address product failure (Macneil, 1980). These contract features deal with the ground rules and procedures for future contingencies, which would lead to a desired outcome if followed. Contractual elements under change management include future demand management plan, anticipated change and innovation and feedback plan.

It should be noted that in relational exchange a person cannot anticipate all the contingencies and make complete plans and so these contracts have many tacit assumptions, which could range from general to specific ones.

Governance characteristics are contractual features, which provide administrative procedures for implementing parties' roles and obligations in a contract. They explain how the relationship should be managed through a clear statement ***concerning measurements, conflict arbitration, penalties, rewards and the channel of communication that is agreed on.*** These contractual safeguards involve provisions and administrative procedures aimed at preventing and resolving disputes and distributing costs and benefits under future contingencies (Williamson, 1979). The major contractual elements under governance characteristics include communication plan, measurement charter, conflict arbitration plan and enforcement plan**.**

Vertical Collaboration and Contract Performance

Successful collaboration must involve delivering services that meet requirements. The commercial arrangement must be acceptable to both parties, offering value for money for the customer and adequate profits for the provider. The relationship between the parties will determine how they regard each other and the way in which their relationship operates is vital to ensuring the contract is successful Jensen et al (2005). Lamothe et al (2008) suggest that managing the relationship comprises a discrete set of responsibilities and activities that for larger contracts may be assigned to a nominated individual, such as the relationship manager, or to a team. Even if the responsibility for managing the relationship is to be met by the same individual or team responsible for managing service delivery, it is important to ensure that the specific tasks of relationship management are carried out. The approach to managing the relationship will vary, depending on the

type of contract. There is no one style that is appropriate for every contract or for every provider. For some non-strategic contracts a more tactical approach may be suitable. For long-term strategic contracts the emphasis on building a relationship will be much greater. In fact the requirement for the original procurement may have been for a relationship enabling certain outcomes to be realised, rather than for a specified set of services to be provided. Contractual arrangements may commit the organisation to one provider or a small number of providers to a greater or lesser degree and for some time, and inevitably this involves a degree of dependency (Lamothe et al., 2007). This is because the costs involved in changing provider are likely to be high and in any case contractual realities may make it highly unattractive. It is in the organisation's own interests to make the relationship work.

The three key factors for successful collaboration are mutual trust and understanding, openness and excellent communication and a joint approach to managing delivery. There must be mutual trust between the customer and provider if the relationship is to work, as well as an open relationship so that people feel they are able to share problems, plans, concerns and so on, since it is often cited as a benefit or an aspiration for partnership approaches (Morgan & Hunt, 1994). Information sharing is key to developing an open relationship, since good communication always contributes to the management of a relationship. Many cases of mistrust or concern over poor performance in a service relationship result from the failure to communicate at senior management level or from each party's failure to understand the business goals or intentions of the other (Smith, Rathgeb & Lipsky, 1993). Many procurement projects are marked by an almost overriding concern not to expose their thinking, position or concerns to providers for fear that providers will exploit such information for their own ends and to the detriment of 'our' interests (opportunistic tendencies)

(Van & David, 2003). Encouraging the sharing of information can involve a significant change in practice; however, there should be a realistic balance between openness and reserving negotiating positions. After the contract has been awarded, the relationship can be developed, partly by engendering a culture of information sharing, whereby the objectives should be made explicit and discussed openly. From the foregoing we hypothesize that:

H1: *The higher the degree of vertical collaboration the better the level of contract performance.*

Buyer-Supplier Compliance and Contract Performance

Under pressure to do more with less resources, organisations have moved from direct service provision to providing services by contract. Proponents argue that contracting can reduce costs and improve flexibility and customer satisfaction (Brown and Potoski 2003). Critics point to a growing number of failed contracts, arguing there are numerous pitfalls associated with contracting. It has often been argued that management of the contracting process from procurement to renewal is essential if organisations are to realize the gains of contracting (Wise, 1997). Any test of performance must account for disparities in contract management capacity across the contracting units. Organisations today receive goods and services from a variety of vendors working under contract, including for-profit and non-profit ones and government agencies from other jurisdictions. There are many accounts of successful contracting and advocates of such alternative service delivery arrangements promote competitive contracting with the promise of efficiency, cost savings and improved effectiveness.

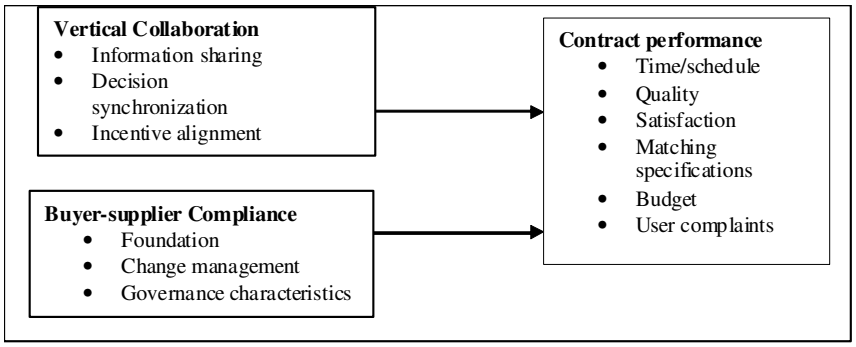
At the same time, the academic literature and popular press are fraught with accounts of contracting disasters, where governments' fingers have been badly burnt by unscrupulous vendors. Citing a growing number of

incomplete, failed and corrupt contract arrangements, critics argue that contracting creates numerous procurement problems, sacrifices service quality for efficiency and cost savings, often does not result in improved efficiency and cost savings, and ultimately "hollows" the state (Deleon and Denhardt, 2000; Milward, 1996; Milward, Provan, and Else, 1994). Contracting is not a "one-size-fits-all" proposition. The success or failure of any alternative service delivery arrangement is likely to depend on how well organizations are able to manage the entire process, from assessing the feasibility of contracting for particular services through implementing contract arrangements to monitoring and evaluating service outcomes and vendor performance activities that require organisations to have strong management capacity. From the foregoing we hypothesize that:

H2: *The higher the degree of buyer-supplier compliance the better the level of contract performance.*

The following conceptual framework in Figure 1 examines the effects of vertical collaboration and buyer-supplier compliance on contract performance.

Figure 1: *Conceptual framework for contract performance in PPDE's*



Research Design

This study used the cross-sectional research design, which combined both qualitative and quantitative approaches. The quantitative approach focused on descriptive and inferential statistics, while the qualitative one focused on explaining the statements of the respondents.

Sample Size and Data Collection

The study population consisted of 200 staff of the NWSC from Kampala District, Uganda. Using disproportionate stratified sampling, the respondents were selected from different categories so as to minimize bias and ensure that only those employees involved in contract management were examined. For each branch office, at least one member of staff was selected from top management, the procurement, user, transport and stores departments and the contracts committee. These individuals were considered to be more knowledgeable about the subject matter of this study because of their participation in awarding, signing, renegotiating, monitoring and terminating contracts.

Table 2: *Sample Size*

Staff Category	Population	Sample
Top Management	20	3
Procurement professional	30	9
User department	100	11
Contracts committee	5	5
Transport	20	2
Stores	25	5
Total	200	35

Primary data was collected from respondents using a self-administered questionnaire, which gave anonymity, leading to more valid responses,

and allowed respondents to fill them in at their own convenience. The questionnaire was designed according to the objectives and study variables, and responses to the questions were based on a five-point Likert scale, ranging from 5 – strongly agree to 1 - strongly disagree. The data was compiled, sorted, classified, entered into the computer and analysed using the Statistical Package for Social Sciences (SPSS). Zero-order correlation and multiple regression analyses were conducted to investigate the relationship between the variables and the extent to which the independent variables explained contract performance in Ugandan PPDEs.

Survey Design

The self-administered survey was initially designed based on the findings from the comprehensive literature review involving vertical collaboration, buyer-supplier compliance and contract performance. The initial draft of the survey was then pilot tested using management lecturers from Makerere University Business School Kampala, a major postgraduate research centre in Uganda, as respondents. The pilot survey was also tested using individuals from 5 NWSC branch offices. Based on these pilot tests and comments from respondents concerning the clarity of the questions contained in the survey, measurement items were improved as required and any changes were consistent with the guidelines set forth by Dillman (1991). The questions were brief and to the point, addressing only one issue at a time. In addition, each construct, as outlined in the conceptual framework proposed by this study, was measured by at least five questions or items that were created on the basis of established theory. The questions were designed to capture the perceptions that individuals from the NWSC (top management staff, procurement, user, transport and stores departments and contracts committee) had with regard to the contracts they are expected to manage on an ongoing basis.

Measurement of Constructs

In this study, vertical collaboration was defined as a system of teamwork, whereby employees within vertical hierarchical levels work together to accomplish a task or complete a contract or project. For example, top level management and key procurement officers work with line managers and the user department to determine the real costs associated with production or contracting out a product. Vertical collaboration was therefore measured based on information sharing, decision synchronization and incentive alignment (Kweku-Muat & Sullivan, 2003). Contract performance was measured, based on the work of Dummond (1991), which focuses on lead-time, satisfaction, matching specifications and user complaints. Buyer-supplier compliance measurement items were directly adopted from Goo et al (2006) to measure the extent to which provisions of the contract (foundation, change management and governance characteristics) are addressed to evaluate the level of compliance with the contract.

Data Reliability and Validity

The reliability of the research instrument was ascertained by performing Cronbach's alpha coefficient test (Cronbach, 1951). This test examined the internal consistency of the scales used to measure the research variables and the results are illustrated in Table 3 below.

Table 3: *Cronbach's Reliability Coefficients*

Variable	Cronbach Alpha Coefficient
Vertical Collaboration	.7325
Buyer-Supplier Compliance	.8527
Contract Performance	.7102

Source: Primary Data

From Table 3 above, all the Cronbach alpha coefficients are above 0.6, which is an acceptable standard for research (Nunnully, 1978). This test also proved that the questionnaire used in the study was reliable.

Common Method Bias

In self-reporting, consistency, acquiescence, social desirability, affectivity and transient moods lead to common method variance, which is of concern in survey research when sampling perceptual data (Podsakoff, Mackenzie, Lee, & Podsakoff, 2003). Common method bias was examined in two ways. Firstly, we sought to overcome the problem of self-report data by designing a questionnaire that avoided implying that one response is better than another by paying attention to wording and avoiding socially accepted responses. Consistent with Podsakoff et al. (2003), we improved item scales by avoiding vague concepts, providing examples where necessary, we kept questions simple, specific and concise, avoided double-barrelled questions, reduced questions relating to more than one possibility into more simple questions and avoided complicated syntax. Secondly, common method variance was assessed using Harman's one factor test (Podsakoff et al., 2003). No single factor emerged or one general factor accounted for most of the variance, implying that no substantial common method variance was present. Similarly, on close examination of the output from unrotated factor solution, discriminant validity was also present.

RESULTS AND ANALYSIS

Demographic Characteristics of the Sample

The demographic characteristics include gender, age group, highest level of education and position held in the entity.

Table 4: *Age Group of Respondents by Gender*[1]

Age Group of respondents	Gender of Respondent		Total
	Male	Female	
20 - 30 years	3 (16.7)	6 (35.3)	9 (25.7)
31 - 40 years	7 (38.9)	7)41.2)	14 (40.0)
41 - 50 years	6 (33.3)	4 (23.5)	10 (28.6)
51 - 60 years	2 (11.1)		2 (5.7)
Total	18 (51.4)	17 (48.6)	35 (100.0)

Source: Primary Data

The majority of the respondents were aged 31 to 40, representing 40.0 percent, followed by those aged 41 to 50, comprising 28.6 percent, and then by those aged 20 to 30, representing 25.7 percent. Lastly, the respondents aged 51 to 60 comprised 5.7 percent. The results further indicate that male respondents were in the majority, comprising 51.4 percent, with females comprising 48.6 percent.

Table 5: *Level of Education by Position Held in the Entity*

Position held in the entity	Level of Education		Total
	Secondary	University	
Management		3 (9.4)	3 (8.6)
Procurement professional		9 (28.1)	9 (25.7)
User department	3 (100.0)	8 (25.0)	11 (31.4)
Contracts committee		5 (15.6)	5 (14.3)
Transport		2 (6.3)	2 (5.7)
Stores		5 (15.6)	5 (14.3)
Total	3 (8.6)	32 (91.4)	35 (100.0)

Source: Primary Data

The results in Table 5 demonstrate that the majority of respondents had completed university education, comprising 91.4 percent, and 8.6 percent had received secondary education. Table 5 also shows that most

[1] Number in brackets are percentages and this is done for the whole article

respondent (31.4%) were from the user department, followed by procurement professionals (25.7%), respondents on the contracts committee and those from the stores department, comprising 14.3 percent. Respondents from management comprised 8.6 percent and those from the transport department comprised 5.7 percent.

Level of Vertical Collaboration

The study findings on the level of vertical collaboration in the organization under study are given in Table 6 below.

Table 6: *Level of Vertical Collaboration*

Survey questions	N	Minimum	Maximum	Mean	Std. Deviation
The suppliers inform us about which products are on the market	35	3	5	4.69	.53
The suppliers inform us about change of price of the different products	35	3	5	4.60	.55
The suppliers openly share confidential information on on-hand inventory levels	35	3	5	4.57	.56
We share point-of-sale data with suppliers in the supply chain	35	3	5	4.37	.65
There is an aggregate demand forecast for the products likely to be supplied	35	3	5	4.57	.61
There is joint planning with suppliers most of the time	35	3	5	4.60	.65
There is consultation and agreement with suppliers on the pricing policy	35	3	5	4.60	.55
A joint decision is made with suppliers on inventory requirements	35	3	5	4.63	.55
There is joint resolution with the manufacturer on demand forecasts	35	3	5	4.57	.56
There is joint resolution with the manufacturer on order processing time	35	3	5	4.74	.51
There are subsides in the form of lower retail prices from the suppliers	35	3	5	4.46	.61
There are shared savings on reduced inventory costs	35	1	5	3.49	1.01
The suppliers are willing to share with us	35	1	5	3.31	1.02
We have made an inventory with the suppliers	35	1	5	3.54	1.04

Source: primary Data

The findings in Table 6 indicate that the respondents strongly agree that the suppliers inform them about which products are on the market (Mean = 4.69, strongly agree), inform them about a change in the price of different products (Mean = 4.60, strongly agree) and the suppliers openly share confidential information on on-hand inventory levels (Mean = 4.57, strongly agree). The results further show that the respondents strongly agree that there is an aggregate demand forecast for the products likely to be supplied (Mean = 4.57, strongly agree), there is joint planning with suppliers most of the time (Mean = 4.60, strongly agree), there is consultation and agreement with suppliers on the pricing policy (Mean = 4.60) and a joint decision is made with the suppliers on inventory requirements (Mean = 4.63, strongly agree).

The results on vertical collaboration between suppliers and the organisation's staff also show that the respondents further strongly agree that there is joint resolution with the manufacturers on demand forecasts (Mean = 4.57, strongly agree), there is joint resolution with the manufacturers on order processing time (Mean = 4.74, strongly agree) and that there are subsides in the form of lower retail prices from the suppliers (Mean = 4.46, strongly agree). The findings also show that respondents agree that they share point-of-sale data with suppliers in the supply chain (Mean = 4.37, agree), there are shared savings on reduced inventory costs (Mean = 3.49, agree) and that they have made an inventory with the suppliers (Mean = 3.54). The results also show that respondents are not sure if the suppliers are willing to share with them (Mean = 3.31, not sure).

Level of Buyer-Supplier Compliance

The descriptive results on the level of buyer-supplier compliance in the entity under study are given in Table 7 below.

Table 7: *Buyer-Supplier Compliance*

Survey questions	N	Minimum	Maximum	Mean	Std. Deviation
Our contracts contain a statement concerning process ownership roles and responsibilities	35	3	5	4.46	.56
Our contracts contain a list of processes that are required to manage the agreements between us and suppliers	35	3	5	4.57	.65
Our contracts contain a list of processes directly affected by the service included in the agreements	35	3	5	4.43	.65
Our contracts contain a statement of the key business measurements required	35	3	5	4.40	.65
Contracts contain established service quality targets	35	3	5	4.57	.56
Contracts contain a general description of the services required, major categories of the services and specific service elements	35	3	5	4.69	.58
Contracts contain processes for scheduling, costing and modifying agreements with new demand	35	3	5	4.40	.65
We include processes used to obtain end-user feedback on the provider's delivery of services to meet new demand	35	3	5	4.43	.65
The contract indicates the processes we should use to prioritize changes and modify the volume, type or level of service to match evolving user requirements	35	3	5	4.40	.65
The contract specifies relevant technology, business and industry drivers for change	35	3	5	4.26	.70
The contract specifies roles, responsibilities and decision making procedures for each category of change	35	3	5	4.40	.55
We include clear definitions of the key categories of change e.g. changes in volume	35	3	5	4.57	.56
Contracts stipulate the innovation process including implementation and prioritization	35	3	5	4.37	.55
Contracts indicate process for business improvement and technology advancement e.g. technology upgrades	35	3	5	4.34	.68
Contracts include innovation incentives/rewards	35	2	5	4.31	.80
Contracts include statement of how changes will be implemented based on measurement results	35	3	5	4.49	.56
Our contracts provide for efficient feedback on the identified drawbacks	35	3	5	4.60	.60
Contracts indicate prioritization methodology for current tasks and feedback	35	4	5	4.63	.49
Contracts contain a statement of the communication policy	35	3	5	4.46	.56
Contracts show the organization's reporting structure	35	3	5	4.60	.60
Contracts show identified communication initiatives/imitative owners and recipients for various initiatives	35	3	5	4.40	.55

Survey questions	N	Minimum	Maximum	Mean	Std. Deviation
Our contracts contain a statement of measurement methodology	35	3	5	4.40	.60
Our contracts contain a definition of what is to be measured, e.g. price, customer satisfaction	35	3	5	4.40	.55
Our contracts contain a definition of the processes to periodically measure the defined categories	35	3	5	4.34	.68
Our contracts contain a statement of the parameters for involving a third party in discussions between us and service providers	35	3	5	4.40	.69
Our contracts contain a schedule for regular interaction and a timetable for resolving issues between us and the providers	35	3	5	4.40	.69
Our contracts contain a statement of the practices and conduct rules required to preserve the independence	35	3	5	4.34	.59
Our contracts contain penalty definitions and a formula	35	3	5	4.40	.65
Our contracts contain conditions under which termination may occur	35	3	5	4.63	.55
Contracts contain a statement of existing responsibilities	35	3	5	4.54	.56

Source: Primary Data

The results in Table 7 above show that respondents generally agree that there is buyer-supplier compliance as all the means on the different questions regarding buyer-supplier compliance are above 4, implying they either agree or strongly agree.

Level of Contract Performance

The study findings on the level of contract performance are given in Table 8 below.

Table 8: *Contract Performance*

Survey questions	N	Mini-mum	Maxi-mum	Mean	Std. Devi-ation
Suppliers deliver as per the specification	35	2	5	4.03	.86
We do not doubt the quality of our suppliers	35	2	5	4.26	.74
The suppliers are free from defects	35	3	5	4.09	.74
Our suppliers are reliable	35	2	5	3.91	.85
Suppliers have been consistent in delivering	35	2	5	3.97	.45
Suppliers have led to cost savings in this entity	35	2	5	3.86	.77
The cost of our suppliers' service in this entity is lower than that of previous service providers	35	1	5	3.37	.91
Suppliers have initiated new efficient methods of service provision	35	2	5	3.91	.74
Suppliers have introduced modern technology in their operations	35	2	5	3.71	.89
Suppliers have initiated better services	35	3	5	4.06	.48
Our suppliers meet our expectations	35	3	5	4.03	.51
Overall I am happy with our suppliers	35	3	5	4.14	.55
I feel we should continue with our suppliers	35	3	5	4.14	.55
Suppliers provide the service we expect	35	3	5	3.94	.54
Suppliers genuinely attend to our needs	35	3	5	4.11	.53
Considering everything, I am satisfied with our suppliers	35	2	5	3.89	.47
We were right to use these suppliers	35	3	5	4.06	.42
Suppliers perform their tasks promptly	35	2	5	4.00	.59
Whenever we need more goods, our providers deliver on time	35	2	5	3.89	.68
I do not complain of delay in service delivery by suppliers	35	1	4	2.20	.99
Our suppliers cooperate in problem solving	35	3	5	4.14	.60
We share critical information with our suppliers	35	2	5	2.94	.94
Our service providers are friendly and readily available when needed	35	3	5	4.00	.42
I feel we should continue the relationship with our suppliers	35	4	5	4.23	.43

Source: Primary Data

The findings in Table 8 above show that the respondents agreed that suppliers deliver as per the specification (Mean = 4.03, agree), they do not doubt the quality of their suppliers (Mean = 4.26, agree), the suppliers are free from defects (Mean = 4.09, agree), their suppliers are reliable (Mean = 3.91, agree), have been consistent in delivering (Mean = 3.97, agree) and have led to cost savings in their entity (Mean = 3.86, agree). The results further show that the respondents agreed that their suppliers have initiated new efficient methods of service provision (Mean = 3.91, agree), introduced modern technology in their operations (Mean = 3.71, agree), initiated better services (Mean = 4.06, agree) and meet their expectations (Mean = 4.03, agree). They also agree that, overall, they are happy with their suppliers (Mean = 4.14, agree), they feel they should continue with them (Mean = 4.14, agree), they provide the service expected (Mean = 3.94, agree) and genuinely attend to their needs (Mean = 4.11, agree).

The finding in Table 8 on buyer-supplier compliance also indicate that the respondents agreed that, considering everything, they are satisfied with their suppliers (Mean = 3.89, agree), they were right to use these suppliers (Mean = 4.06, agree), their suppliers perform their tasks promptly (Mean = 4.00, agree) and whenever they need more goods, their providers deliver on time (Mean = 3.89, agree). The respondents also agreed that their suppliers cooperate in solving problems (Mean = 4.14, agree), their service providers are friendly and readily available when needed (Mean = 4.00, agree) and they feel they should continue the relationship with their suppliers (Mean = 4.23, agree). The results reveal that the respondents were unsure if the cost of their suppliers' service in their entity is lower than that of previous service providers (Mean = 3.37, not sure) and whether they share critical information with their suppliers and they disagreed that they do not complain of a delay in service delivery by suppliers (Mean = 2.20, disagree).

Correlation Analysis and Regression Analysis

The results indicated a significant positive relationship between all the predictor values and contract performance, supporting both HI and H2. The results, in Table 4.6, indicate a significant positive relationship between vertical collaboration and contract performance (r = .320, p< .005), hence supporting H1: *The higher the degree of vertical collaboration the better the level of contract performance*. This implies that when there is a high degree of vertical collaboration in an entity, there is the likelihood of an improvement in contract performance. The correlation results also show that there is a moderate significant positive relationship between buyer-supplier compliance and contract performance (r = .340, p<.005), supporting H2: The higher the degree of buyer-supplier compliance the better the level of contract performance. Similarly, this implies that when buyer-supplier compliance in an entity increases there is the likelihood of increased improvement in contract performance.

Table 9 shows the zero order correlation between vertical collaboration, buyer-supplier compliance and contract performance.

Table 9: *Zero Order Correlation*

	1	2	3	4	5	6	7	8	9
Information sharing-1	1.000								
Decision synchronization-2	.381**	1.000							
Incentive alignment-3	.293*	.262*	1.000						
Vertical Collaboration-4	.261*	.340*	.223*	1.000					
Foundation characteristics-5	.326*	.253*	.380**	.275*	1.000				
Change management-6	.258*	.224*	.219**	.405**	.305**	1.000			
Governance characteristics-7	.301*	.396**	.206*	.321*	.230*	.228*	1.000		
Buyer-supplier compliance-8	.330**	.434**	.422**	.478**	.357**	.330*	.372**	1.000	
Contract performance-9	.340**	.303*	.330*	.320*	.230*	.205*	.301**	.340*	1.000
*Note: * ** Correlation is significant at the 0.05 and 0.01 level (2-tailed) respectively.*									

Regression Analysis

Consistent with the results above, the regression model shown in Table 10 reveals that vertical collaboration and buyer-supplier compliance are significant predictors of contract performance and account for 18.77% of the variance in contract performance (Adjusted R Square = .1877). Surprisingly, these findings further reveal that buyer-supplier compliance is a better predictor of contract performance than vertical collaboration (Beta = .292, Sig. <.005) that was initially assumed. The variance inflation factor was less than 4 and the tolerance ratio was above 0.1, indicating that multi-collinearity in this study was not a problem (Garson, 2010) and as such interpretation of the beta weights and R-squares was reliable.

The findings from regression analysis are summarised in Table 10.

Table 10: *Regression Model Summary of Coefficients*

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
Model		*B*	*Std. Error*	*Beta*			*Tolerance*	*VIF*
	(Constant)	.960	.181		5292	.000		
	Vertical collaboration	.190.	.063	.220	4313	.005	.472	2.065
	Buyer-supplier compliance	272	.056	.292	3420	.005	.545	1.452
	Dependent Variable: Contract Performance							
	R Square	0.199						
	Adjusted R Square	0.187		Sig.	0000			

Discussion of Findings

The purpose of this study was to explore the effects of vertical collaboration and buyer-supplier compliance on contract performance. The findings indicate that there is a significant positive relationship between vertical collaboration and contract performance in NWSC. These findings reflect those of Ahimbisibwe et al. (2012), who found that one way to ensure effective contract management is through information interaction and communication, which are important components of vertical collaboration. This is further supported by Ahimbisibwe and Nangoli's (2012) findings indicating that the lack of interaction and communication or the refusal of buyers and suppliers to share information has prevented the development of a stable and long-term relationship, which is so essential. This calls for continued good communication to take place to ensure effective contract performance.

The findings also showed that there is a significant positive relationship between buyer-supplier compliance and contract performance in the NWSC. These findings mirror those of Mugisha et al (2004), who emphasize that performance-based contracts are a way of ensuring effective contract performance through sound commercial service agreements or contracts. Outcome levels are determined by mutual party agreements with an emphasis on shared benefits being received by both parties. They further argue that minimum performance levels are determined by technically related dimensions, such as quality, quantity, availability, legislative maintainability, capacity, comfort, appearance and safety. This argument is further in line with Ntayi et al's (2010b) research, which established that performance-based contracts ensure that payment is made only for services that meet the required levels of service and place emphasis on the purpose of the service to be provided rather than the manner in which it is provided. Consequently it is vital for companies to plan the creation of the contract effectively if they are to maximize the benefits and minimize the risks.

These findings also mirror those of Ahimbisibwe et al 92012c), who found that most problems within the supply chain are due to poorly designed or weak contracts and the key is to make sure the company's goals and objectives are clear and are discussed during the negotiation process so that a working relationship can be established. With a tight contract, a company free from a conflict of interest has a structure for the relationship at hand and ultimately the risk of failure for both partners is minimized. These findings also reflect Sadler's (2002) findings by arguing that predetermined performance standards should focus on achieving a minimum standard with an emphasis on maximizing profits, while defining details of quality, quantity, timing and method of delivery of the corresponding inputs and outputs required by both parties to support the contractual process. Components of information quality, such as response time, accuracy of data, reliability and quality of support services, should all be defined according to the activity being contracted.

Conclusion and Recommendations

Effective vertical collaborations can ultimately lead to better contract performance since the buyer and supplier can share information effectively and feel they are getting what they ultimately deserve, thereby improving contract performance. Proper management of buyer-supplier compliance ultimately leads to better contract performance, resulting in better service delivery. As such, it is important to ensure that institutions actually strengthen the relationship with their suppliers so that buyer-supplier compliance is improved. Effective vertical collaboration and buyer-supplier compliance ultimately lead to better contract performance in PPDEs.

Recommendations

In the light of the findings, discussions and conclusion, the following recommendations are made. Public entities are advised to have a policy and put in place measures to guide them in the setting up of vertical

collaboration so as to improve contract performance. Since buyer-supplier compliance is important in helping an institution become more competitive and deliver better services, resulting in contract performance, these public institutions should ensure that they cultivate and enhance buyer-supplier compliance so as to improve contract performance.

Limitations of the Study

Although this study provides interesting findings, there are limitations worth noting. Methodologically, this study adopted the cross-sectional research design, which was unable to critically analyze the behaviour of the variables under study and so this has implications for the conclusion of the study. The measurement tools used were adopted from previous studies and so any limitations embedded in them would have affected this study. The study used closed questions in the survey to collect data and this had the weakness of limiting the amount of data collected. It is likely that relevant data may not have been captured because of this. The use of a questionnaire in which all the data was collected in the same measurement context using a common rater and in a common item context could have led to common methods bias. Future studies should try to obtain measurements of the independent and dependent variables from different sources and at different times. The purpose of this study was to explore and examine possible correlations but not causality (though correlation is necessary for linear causation in the absence of any third and countervailing causative variable and can indicate possible causes or areas for further investigation; in other words, correlation gives a hint). This research identified and explained some correlations between these variables and they should be used as a basis for additional work to look further into confirmatory studies and causality.

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Flexibility in the Supply Chain as a Means of Achieving Delivery Reliability: The Case of Perishables Supply Chain from Ghana to the International Market

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Abstract

This study analyses the extent to which the presence of flexibility in the supply chain can act as a mitigating factor in achieving reliable delivery to the international market, particularly of perishable products (i.e. fruit), which are time critical in nature. This study employs the qualitative research methodology, whereby a case study involving the supply chain for the export of perishables from Ghana to the international market was conducted. The evidence from the findings shows that, among other factors, poor transport infrastructure, delays in ship/plane arrivals, high fuel prices, financial obstacles, power imbalance between the supply chain actors, bureaucratic documentation processes and natural calamities hinder the attainment of flexibility in the supply chain. This in turn means that the supply chain for the export of perishables from Ghana to the international market cannot cope with changes in demand, leading to greater delivery unreliability. The study recommends that actors should work together in the supply chain to overcome these risks/problems in order to achieve flexibility in the supply chain, which could result in reliable delivery to the international market. The study informs policy makers and implementers, academicians and practitioners.

Keywords: *Supply chain flexibility, supply chain risk, power and dependence, transportation*

Introduction

The declining performance of main traditional export commodities, dominated to a large extent by cocoa since the 1980's (Danielou and Ravry, 2005), compelled Ghana to look for alternatives to diversify the export base because the economy could no longer be sustained solely by these commodities. This led to perishables being elevated to traditional export products. Horticultural exports have grown dramatically over the past decade, experiencing a growth rate of 7% (UNCTAD, 2007), and has the potential to grow further.

In addition, the growth in the export of perishable food items can also be attributed to Ghana's trade liberalization policies, which made it possible to expand trade with the international world in the past decade. Takane (2004) observed that the increase in perishable exports is attributed to Ghana's adoption of the Structural Adjustment Programme and other policy changes aimed at trade liberalization, which in turn have increased the participation of the private sector in horticultural activities.

Moreover, there is growing demand for fresh fruit and vegetables by European consumers, especially during the winter. Due to improved technology, such as irrigation schemes and modern farming techniques, Ghana has been able to take advantage of their growing demand. This is because the use of modern technology has improved farming activities and doubled production output beyond the demands of the local market, turning Ghana into being a food-surplus country (Tetteh, 2006).

Based on the above view, it is evident that the agricultural sector, through the production of perishables, has the potential to continue contributing a large share of the country's GDP, hence having a positive impact on poverty reduction. For Ghana to benefit more and enjoy sustainable development

from this business, given the opportunities available in the international market for these products, it should be clear to all concerned that increased business with the international world calls for a critical look at creating value from a well-performing perishables' supply chain, as suggested by Danielou and Ravry (2005). Moreover, future growth in the export of perishable products will depend on Ghana's capacity to improve its product portfolio and the quality of its products. Furthermore, Ghana as a country must realise that in the global economy the dynamics of competition are not based on geography but rather on competitive strategies, as claimed by (Rehber and Turhan, 2002). In the light of this, the study agrees with (Buatsi, 2002) that Ghana's development strategy for perishable products must strive to differentiate its products and compete not only on the basis of price but also on the reliability of the supply chain and the assurance of quality.

Problem Statement

Given the growing global demand for perishables like pineapple, banana, yam and mango (UNCTAD, 2008), it is evident that more perishables could be exported from Ghana, which could significantly contribute to the country's GDP and poverty reduction. On the other hand, the international market for perishables is getting crowded and competition is becoming fierce as more African countries, like Cote d'Ivoire and Kenya, are taking advantage of the increasing demand for these products. This is an opportunity for them to also diversify their agriculture into producing perishables as a means of improving the livelihoods of their small farmers and create new employment opportunities. Therefore, for Ghana to be able to effectively satisfy international demand and effectively compete in the international market, delivery reliability (in terms of the quality and quantity of the produce, consistent supply, appropriate delivery speed, time and required frequency) needs to be put in place. This will ensure the

delivery of high quality products, so that their short shelf life is prolonged and the reliability of their supply increased, which have now become the key drivers of value creation (Danielou and Ravry, 2005).

One of the most significant changes in the paradigm of modern business management is that individual businesses no longer compete as solely autonomous entities, but rather as supply chains (Lambert, Cooper and Pagh, 1998). Despite the favourable climatic conditions and geographical location of Ghana, compared with competitors like South America for supplying perishables that meet the demand of the global market, Ghanian exporters are losing ground to competitors because of their reliance on their positive cost differentials, particularly in terms of freight. However, the global market is now undergoing a revolution based on quality enhancement and traceability, which calls for inter-network competition. Previous studies (Pedersen, 2001; Buatsi, 2002; Takane, 2004; Tetteh, 2006; and UNCTAD 2008) have been able to highlight and explain this challenge to businesses exporting perishables from Ghana to the international market, but very little has been studied in connection with supply chain management. Most of the studies talk about this challenge in relation to exporters or the government, which are just a specific link in the perishables supply chain rather than the supply chain as a whole. This study contends that, ultimately, the success of exporters of Ghanaian perishables in the international market will totally depend on business process excellence and the management's ability to manage relationships with other members of the supply chain, like farmers, transport agencies and the government. The future of Ghana's perishable products depends on the ability of its supply chain to adapt to a changing landscape (flexibility), whereby innovation and performance will increasingly affect its capacity to compete and be reliable in the world market. In the light of this, this study analyses how flexibility in the supply chain for perishables acts as a mitigating factor in achieving delivery reliability in the international market.

Literature Review

The main focus of this section is to review previous research studies in various scholarly journals, books and theses, among others. For the purpose of this study, literature concerning supply chain flexibility (both internal and external), supply chain risks, and power and dependency are reviewed.

Supply Chain Flexibility

In the past few years there has been a sudden interest in supply chain flexibility. Although there have been some studies on flexibility, most researchers agree that there is still more to be explored. Koste and Malhotra (1999) argued that performance should be assessed based on the absence or presence of flexibility in the supply chain. They explained that each supply chain focuses on a certain dimension of flexibility, depending on the competitive priorities of the supply chain. Flexibility is perceived with respect to chain actors' ability to be prompt and the degree to which they can adjust to speed, destination and volumes (Lummus, Duclos and Vokurka, 2003). Thus flexibility becomes the means through which the supply chain is able to withstand and counteract disruption risks (Rao and Wadhwa, 2002). In this light, supply chain flexibility should be examined from an integrative, customer-oriented perspective (Lummus, Duclos and Vokurka, 2003). Fisher (1997) pointed out that the nature of a product's demand should determine how to devise an effective supply chain strategy. Thus for perishables with a very short life cycle, it is necessary to have a flexible supply chain, which will be market responsive. In our view, the critical nature of perishables necessitates the adoption of Stevenson and Spring's (2007) suggestion of viewing flexibility beyond individual members, to viewing flexibility from the supply chain perspective as a whole.

Internal Flexibility (for individual actors)

Known as manufacturing flexibility, Ndubisi; Jantan; Hing; and Ayub, (2005); Lummus, Duclos and Vokurka (2003) describe internal flexibility as reflecting an organisation's ability to effectively adapt and/or respond to changes or cope with environmental uncertainties that add value in the customer's eyes. According to them, internal flexibility concentrates on flexibility within a single firm, which is recognised as a component of marketing and R&D strategies and one element of business strategy, with certain dimensions impacting the growth and financial performance of a firm.

On the other hand, a firm's flexibility is based on the internal resources (i.e. flexible technology, labour and infrastructure) that can be used to achieve different types of internal flexibility (Reichhart and Holweg, 2007). For the perishables supply chain, we consider volume, (Ndubisi et al 2005, Reichhart and Holweg, 2007), labour, routing, delivery and market flexibilities (Lummus et al 2003) to be important elements, which require close coordination between actors to prevent out-of-stock conditions for produce that may suddenly be in great demand.

To increase flexibility, every company should periodically redesign its supply chain based on its objectives and changes in the business environment (Garber and Sarkar, 2007). In addition, Fassoula (2006) suggests that firms must reinvent themselves in a way that can allow them to continuously adapt to different market requirements and compete successfully. Garber and Sarkar (2007) advised that firms should create more flexible supplier relationships to ensure a change in production capacity in case a new product sells faster or slower than expected. For instance, capacity increases to accommodate peak-season build-ups.

External Flexibility (for the entire supply chain)

It is difficult for a company to survive in isolation from its business partners in the network of the value chain, which encompasses the entire production activities of a product life cycle (Lee, 2004). Proposed by Lummus, Duclos and Vokurka (2003), external flexibility is the flexibility of the entire supply chain resulting from the flexible components at each of its nodes and their interrelationships. This proposition has been supported by Reichhart and Holweg (2007), stating that flexibility will differ at different nodes in the system, which, when taken together, contribute to the entire supply chain's responsiveness to achieve competitive advantage, such as speed of delivery.

To conclude this sub-section, it is evident from the above review that most of the studies on flexibility have been done in relation to manufacturing industries abroad. No study has been done in Africa to date to link flexibility in the supply chain, market reliability and perishable agricultural products. This study therefore fills this theoretical gap.

Supply Chain Risks

Even the most sophisticated supply chain cannot be said to be risk-proof nor adequately prepared to handle unexpected risks and disruptions when they occur. The critical nature of perishables, coupled with the numerous insurmountable challenges of developing countries, demand that risks and disruptions are taken into consideration when viewing the flow of perishables. The nature of the product makes it impossible for chain members to have the same kind of freedom other supply chains may have (Sandvik, 2008). There are many definitions of risk, depending on their specific application and their context (Husdal, 2008). Manuj and Mentzer (2008, 135) define risk as 'a chance of danger, damage, loss, injury or any other undesired consequences'. The sources of supply chain risks are

many, as different links in a supply chain are exposed to different types of risks (Faisal, Banwet and Shankar, 2006). Understanding risk sources, as argued by various researchers, helps actors to determine the various types of supply chain risks that organisations and entire supply networks are exposed to.

Supply chain risks can be seen as internal, e.g. the lack of formal procedures or the failure or breakdown of operations, or external to the supply chain, e.g. disruption of supplies to the focal firm or economic shifts (Husdal, 2008). Most researchers argue that it is good to gain an understanding of the various types of supply chain risks because most of them are overlapping and do not exist in isolation (Manuj and Mentzer, 2008) and in addition they affect differently the strategic decision making and performance (Ritchie and Brindley, 2007) of the channel member as well as the entire supply chain.

Risk Management

Since all risks cannot be avoided (Manuj and Mentzer, 2008), it is important to plan ahead for when harmful risks are likely to occur. Risk management strategies include information sharing, collaborative relationships and trust, joint training and development programmes, joint proactive assessment and planning exercises (Faisal, Banwet and Shankar, 2006; Ritchie and Brindley, 2007; Miller, 1992; Saad and Kleindorfer, 2005; Cucchilla and Gastaldi, 2005); developing risk management awareness, knowledge and skills (Ritchie and Brindley, 2007; Faisal, Banwet and Shankar, 2006); as well as aligning incentives and proper revenue sharing arrangement so that the value and benefits generated are maximized and shared fairly (Faisal, Banwet and Shankar, 2006; Saad and Kleindorfer, 2005).

Not all risks affect all supply chains (Manuj and Mentzer 2008), but with

the transportation of perishables certain types of risks are more likely to be prominent. Some of the risks can be product rejection, power cuts, information flow disruptions, breakdown of trust, natural disasters, strikes and government policies, among others. We also try to explore the extent to which flexibility can mitigate some of these risks and disruptions.

It is very important for supply chain members to be aware of the various internal and external risks facing the entire supply chain and plan ahead for dealing with them. This is because risks in the supply chain have a negative impact on flexibility in the supply chain. Given the critical nature of perishables, when the supply chain actors are faced with too many risks (e.g. few and poor roads, unreliable weather, strikes and lack of cooperation between supply chain actors), this leads to an inflexible supply chain, which in turn results in unreliability in terms of quality, quantity, time, speed, customer service, etc.

Power and Dependency

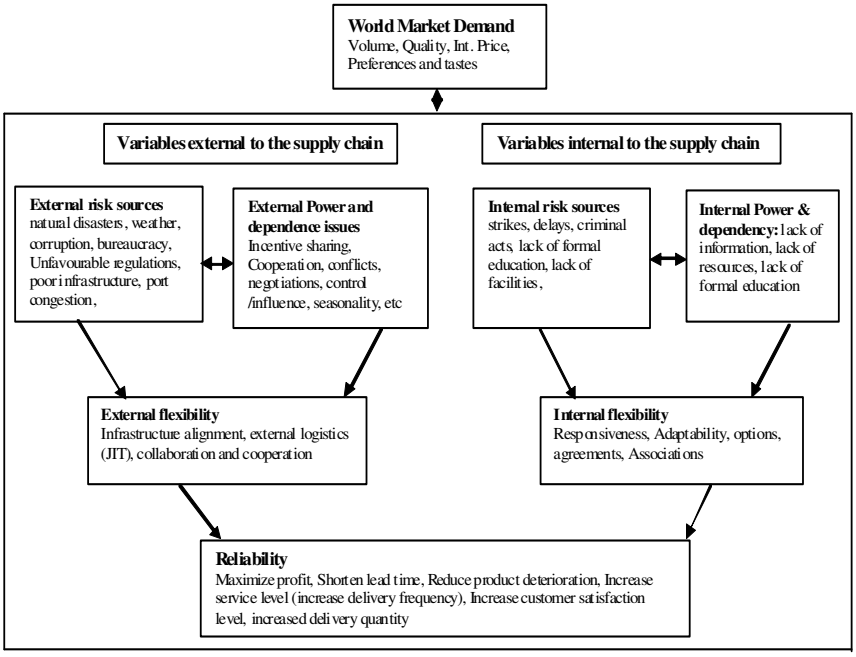
Power and dependency are generally considered important concepts in gaining an understanding of the buyer-seller relationship (Caniels and Gelderman, 2007). In this regard, Maloni and Benton (2000) postulated that the significant and expansive effects of power and dependence on inter-firm relationships have direct implications for the supply chain. A high level of interdependence is an indicator of a strong, cooperative long-term relationship characterized by mutual trust and commitment (Kumar, Scheer and Steenkamp, 1995). Close and lasting cooperation between supplier and buyer will lead to an improvement in quality, delivery reliability, lead times and reduced costs (Caniels and Gelderman, 2007). Kumar, Scheer and Steenkamp (1995) and Maloni and Benton (2000) found empirical evidence that a strong buyer-seller relationship leads to high-level performance of the entire supply chain. This could be in the form of a high level of commitment, cooperation, trust and conflict resolution.

Caniels and Gelderman (2005) argued that the buyer-seller relationship that is characterised by asymmetric interdependence leads to unproductive partnerships so that, in the long term, the position of the weaker party will be eroded too much and the partnership will be destroyed. However, various researchers have proposed several ways in which the consequences associated with asymmetric interdependence can be mitigated. Diamantopoulos (1987) believed that the firm enjoying a power advantage may choose to share control with the less powerful firm in a more or less equitable manner to foster a democratic relationship. Heide and John (1992), supported by Joshi (1998), proposed that for a strong buyer facing a large number of small suppliers relational norms can serve as a governance mechanism against opportunistic behaviour, especially when transaction-specific assets are involved. Modifying Emerson's (1962) ideas, Kumar, Scheer and Steenkamp (1995) suggested that relatively dependent firms should work to increase their partner's dependence by increasing their value to the partners or by reducing the partner's alternatives. However, according to Heide and John (1988), firms in a symmetric relationship should not relax but instead should continuously take the necessary initiatives to maintain that balanced relationship.

Power is the major means available to achieve coordination and cooperation among channel members (Berthon et al, 2003). Therefore, it is very important to examine the power and dependence positions of buyers and sellers (Caniels and Gelderman, 2005) to be able to establish various favourable supply chain strategies. For the purpose of this study, it is therefore necessary to assess the power-dependency relationship between partners in the perishables supply chain (farmers, transport companies, exporters), in order to find out how power distribution in this supply chain influences its flexibility. Power imbalance issues like mistrust, conflict and lack of commitment among supply chain actors could be a source of supply chain risks and therefore affect flexibility and market reliability negatively.

Conceptual Model

Figure 1: *Flexibility in Interacting Factors Leading to Achievement of Reliability in Perishables Supply Chain*



(Adapted from Bråthen (2001)'s model for demand for transport infrastructure services)

From the literature review, the best strategy for gaining an understanding of the supply chain is to start by determining the nature of the product in question. Market delivery reliability is a prerequisite for responding to the world market's demand for perishables, which are characterised by a short life cycle with fairly predictable demand and seasonal production. On the other hand, market reliability of the supply chain is determined by how flexible the supply chain is in responding quickly to any changes in the market given the critical time factor of perishables, which calls for a shorter

lead time from the area of production to the area of consumption to prevent their deterioration. Therefore, based on this view, supply chain flexibility is the main focus of this study as the major determinant of reliability. This is because it plays a facilitative role in the coordination process by helping firms manage the high level of environmental and operational uncertainty inherent in international operations.

Figure 1 however shows that there are some critical factors that need to be taken into consideration to enhance flexibility, such as risks and power distribution in the supply chain. Too many risks could result in a high level of inflexibility in the supply chain, which in turn hinders reliable delivery to the market of that supply chain and vice versa. Furthermore when proper distribution of power among supply chain actors is not achieved some members will not act favourably towards achieving the entire supply chain's objectives. This will also in turn lead to inflexibility in the supply chain as these actors will tend not to adjust their operations in favour of powerful members, resulting in unreliability of the perishables supply chain because it is unable to deliver products to the market at the right time, speed and frequency, in the right quantity and of the right quality.

We argue that this model is positive since it tries to address the causes and effects of the challenges that could face the logistics of the perishables supply chain given its critical nature and short life cycle. The model further assesses how flexibility will mitigate the challenges and how it will improve the overall performance of individual actors as well as the entire supply chain. We agree with most researchers that more work needs to be done concerning supply chain flexibility and so with the aid of the findings from the field we examined extensively flexibility issues within this perishables supply chain in subsequent sections.

Methodology

The focus of the study was on sampling four perishable export products considered to be among the highest performing in the non-traditional export sector in Ghana. The study employed the qualitative research design given the nature of the research question so that both a survey and single case-embedded research strategy suggested by Yin (2003) was followed by means of interviews and questionnaires. We selected the units through purposive sampling of the actors (farmers, exporters and government agencies) we considered to be the most prominent in the supply chain. To eliminate the shortcomings (deviation from the core study) associated with the embedded case study design, the supply chain as a whole was assessed by considering other units (banks, transporting agencies, insurance) as well. Consideration of major sub-units and all other units in this perishables supply chain gave us a broader picture of and insights into the case study.

Data Collection and Analysis

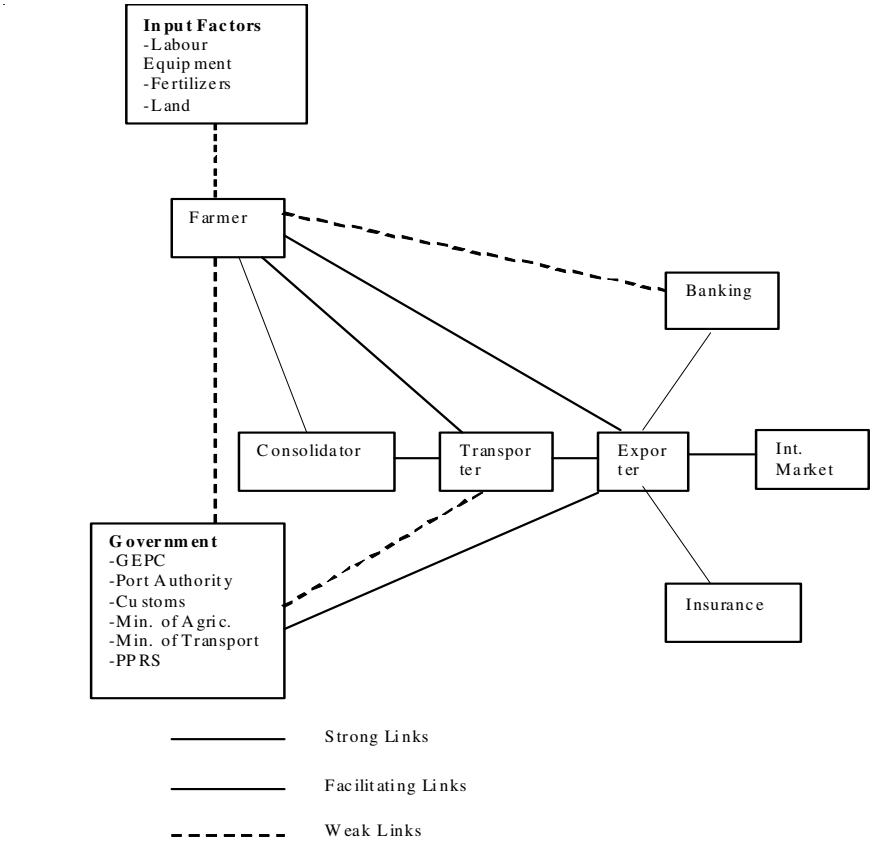
In ensure access to a wide range of information, both primary and secondary data was collected. Secondary data includes previous studies and documented sources such as scholarly journals, theses, books, documents and reports from the World Bank, Ministry of Food and Agriculture in Ghana, United Nations and the National Bureau of Statistics, among others. Primary sources include information collected from the field through direct observation by visiting farms, major ports and the offices of exporting firms. Questionnaires, consisting of both structured and unstructured questions, were administered to ten firms, which are actively engaged in exporting perishables. With the aid of interview guides, group interviews were conducted in the local language with three different groups of farmers of perishables (pineapple, banana and mango) on their farms or at an agreed location. Each interview group consisted of between six and twelve farmers. Finally, there was a detailed discussion with the Research Director of the Ghana Export Promotion Council (GEPC) through the use of an interview guide.

The study was able to collect a lot of in-depth information from the field

and the data was analysed through the use of Computer-Assisted Qualitative Data Analysis Software (CAQDAS) i.e. NVivo. This was employed by the researchers to search for, organise, label and annotate the textual and visual data collected, which in turn enabled them to organise it into various categories, themes and patterns.

Findings

Figure 2: *Hypothetical Structure of Perishables Supply Chain*



(Source: Authors' construct based on the findings and literature review)

Based on the literature review and findings from the field, we conceptualised the structure of the perishables supply chain as shown in Figure 2 above. In this structure, we consider the exporter to be the focal firm (refer to 6.1.2).

According to the findings from the case study and literature review, there are strong links between supply chain actors, which could be portrayed by collaboration or vertical integration. These are crucial links that demand the active involvement of actors at such nodes. The facilitating links that enhance the performance of the supply chain signify a low level of interaction between supply chain actors. These weak links depict minimal or no interaction between supply chain actors, as in the case between farmer and banks.

Farmers' Position and Function

In the perishables supply chain, farmers are the main suppliers of export products (i.e., yam, pineapple, mango and banana). Farmers are classified into three different categories, namely small, medium and large-scale farmers. These categories have an influence on the responsibilities undertaken by the farmer in this supply chain. Generally farmers are not responsible for the physical movement of the product from the farms, except when a large-scale farmer is involved (for example, Golden Exotics Limited), who will usually enter into a long-term contract with the transporting company to move the produce from the farm directly to the port. However, when the road to the farm is impassable by truck, the small to medium-scale farmer has to hire labour to head-load the produce (human porterage) or use three-wheeled push carts to take it to the roadside for the trucking company to pick up or to take to the consolidator's shed for packaging.

A large-scale farmer, who is financially able to carry out exporting activities, will usually integrate farming and exporting and therefore use the information

from the international market in his daily farming operations. Thus, small and medium-scale farmers need to collaborate with commercial exporters so as to get that information. Large-scale banana farms produce 50,000 tons per season on average; however there is no data on the volume produced by small and medium-scale farmers. A small-scale mango farmer however produces 220-250 tons per season.

Exporters' Position and Function

In this supply chain of perishables, exporters serve as the major link between farmers in Ghana and customers in the international market. The exporter represents a large number of small and medium-scale farmers, who due to their low literacy level depend on the exporter to move their goods and provide the necessary information concerning the international market, such as quality, preferences and price, among others. The end-user in the international market also needs a representative (usually the exporter) in the country of production to ensure the smooth flow of the produce.

Exporters are also classified into small, medium and large-scale categories. These classifications together with the use of a consolidator usually define the responsibilities of the exporter. Large-scale exporters, who transport large volumes of cargo to the international market (for example firm 2 in table 1), most often collaborate with the consolidators of services, such as packaging, labelling and storing the produce. This enables exporters to concentrate on customs and documentation as well as international transport arrangements. These arrangements are made by the exporter because they assume ownership of the cargo at the farm and because they know their financial status and the kind of transport they can afford. They normally enter into a long-term contract with one or two transporting operators to transport produce from the farm to the port. Small and medium-scale operators usually carry out consolidating activities either at the farm or at

their sheds, due to the fact that the volume that they transport is much less than that of the large exporter. They use short-term or on-the-spot contracts with the transporting company to move the produce from the farms/sheds to the port.

Government's Position and Function

The GEPC, which is a government body, only deals directly with exporters, either individual exporters or associations. It acts as a link between exporters and the central government by intervening in issues to give satisfaction to both parties. For instance, they oppose government policies which they think will have a negative impact on exporters and vice versa. Until the late 1990s there was no funding from the government for non-traditional exporters but currently they can access funds from the government as a result of GEPC's successful discussions with the Ministry of Agriculture to motivate these exporters.

Furthermore, the government offers training programmes to farmers whereby extension officers visit the farms to educate farmers on modern farming methods and the proper application of weedkiller and pesticides. The government controls the chemicals used in farming activities through the Environmental Protection Agency. This is done through unannounced visits to the farms to inspect what and how chemicals are applied.

Intermediaries' Position and Function

Transporting Agencies

Most exporters do not have their own trucks or vans to cart the produce from the farms to the ports and so they engage the services of private transport operators**.** This arrangement varies from on-the-spot hiring to

long-term contracts. The exporter assumes ownership of the goods on the farm. However, the transport company is responsible for the goods while being transported from the farm to the port.

There is no cooperation between small and medium-scale farmers with regard to transporters, because rarely do these farmers make transport arrangements. However, large-scale farmers, who undertake exporting activities themselves, have vertical integration for transportation.

Insurance Companies

Only about 57% of the respondents (exporters) are insured against risks. The insurance covers marine accidents and theft. Insurance companies do not insure farm produce because they perceive it to be very risky. They are only willing to insure the farming equipment and other assets of farmers but not the farm or produce.

Table 1: *Summary of Exporting Activities (Based on the findings)*

	Firm 1	**Firm 2**	**Firm 3**	**Firm 4**	**Firm 5**	**Firm 6**	**Firm 7**
Product(s)	Pineapple	Pineapple Banana	Mango	Yam	Pineapple Banana	Yam	Banana
Int. Destination(s)	Netherlands USA	Germany, Belgium, USA	UK, Holland, Libya	UK, Holland	USA, UK, Holland, Germany	UK, Germany	Belgium, UK, Italy
Transport mode (Inland Phase)	Truck	Truck	Truck	Truck	Truck	Truck	Truck
Transport mode (International Phase)	Sea	- Sea - Air	- Sea - Air	Sea	- Sea - Air	Sea	- Sea - Air
Export Frequency	3 times a week	Daily	Twice a week	Twice a week	Twice a week	Once a week	3 times a week
Volume per season	N/A	960 tons (bananas) 320 tons (pineapples)	210 tons	N/A	200 tons (bananas) 300 tons (pineapples)	N/A	600 tons
Insurance	No	Yes	No	No	Yes	Yes	Yes
Access to bank loan	Yes	Yes	Yes	No	Yes	Yes	Yes

Banking System

Banks are involved in advancing personal loans to farmers and exporters, but most farmers cannot obtain a bank loan because the banks do not accept that farms have enough collateral. Only a few have access to loans by using their personal property, such as houses or land. The same applies to exporters.

Ports

There are no break-points in the inland phase of transportation. Therefore ports (Tema port and Kotoka International Airport) are the major and only break-points in this supply chain. At the port the cargo is placed in the storage facility before it is inspected and shipped to its final destination. Since ports operations and management are provided by the government, we considered port authorities as actors under the government instead of intermediaries, as shown in figure 2.

Internal Flexibility

This is looked at in relation to the actions and reactions of individual actors within the supply chain.

Product Flexibility

One of the most important elements of flexibility is the ability to adjust to speed. From table 2, we notice that most of the products are cultivated in regions not too far from the ports. This implies that product deterioration can be greatly reduced, because it takes only one hour when the road is good and three hours when road/traffic conditions are poor. Therefore, even though there are no cooling facilities on the trucks, product quality is not greatly affected. Also flexibility is enhanced by the fairly long post-harvest shelf life of products, which means they can get to the international market in good condition. This condition is further prolonged when

products are stored and transported at the right temperature. It is also worth mentioning that yam has a wider margin of flexibility than the other products under consideration. This is because yam can be stored in various traditional ways without refrigeratation. These include keeping the yam in barns or underground structures, putting them in ashes and covering them with soil with or without grass mulch. Also unlike bananas, pineapples or mangoes, which have to be harvested once they are ripe, yam tubers can be kept in the ground until there is demand for them without them deteriorating. In the light of this, yam has a wider degree of freedom under uncertainty so that delays in pick-ups and lack of storage facilities at the farm may not affect it as much as the other products under consideration.

Supply Flexibility

The whole process of producing or cultivating perishables is characterised by seasons, as shown in table 2. During the peak season farmers can supply any volume demanded, and for that reason can adjust quickly to the amount demanded by the exporter, which is induced by the demand from the international market. However during the lean season, supply flexibility is reduced as farmers are unable to meet the large volumes demanded individually. To cope with this situation they consolidate their cargo of pineapples and bananas in order to satisfy exporters' orders. The story is however different for mangoes, because there are only two seasons of production, after which there is no further supply of them even though there may be a demand for them throughout the year. Another inflexibility aspect of the supply of mangoes is that exporters place their order during the flowering stage, which means that the exporter cannot adjust his previous order irrespective of the demand from the international market. There is a high level of flexibility as regards yams because they are produced all year round and so are available to satisfy any exporter's order.

Flexibility in Demand for Storage Facilities

There are no storage facilities on or near the farms. This is because farmers feel that the distance from the farms to the ports is not far and few of them can afford to own these facilities. Flexibility is introduced when in order to cope with the situation farmers resort to harvesting only on pick-up days, thus using just-in-time techniques. We therefore believe that having a storage facility on or near the farms may not be as crucial as at the ports in the sense that when there are pick-up delays at the farms, farmers can easily sell their products to the local market. On the other hand, delays in ship/ plane arrivals or cancellation results in the extra cost for the exporter of taking the product back to the local market, which consequently reduces his profit margin. Flexibility regarding this situation at the port has been enhanced through the port authority's initiatives to rent out storage facilities to Sea Pineapple Exporters of Ghana (SPEG) and other Exporters' Associations. In addition, GEPC, which is a government body, liaises with some organisations and port authorities to put up extra cold storage facilities at the ports.

Flexibility at the Ports

The supply chain is faced with congestion at the ports, especially with regard to loading and documentation, mainly due to the activities of Plan Protection and Regulations Services (PPRS). This is a body which has the authority to thoroughly inspect all consignments going out of the country to prevent the export of drugs and to monitor the quality of goods. However this situation is being managed through introduction of the GCNet, which speeds up the scanning of consignments, thus minimizing delays. In addition, flexibility can be realized through GEPC's negotiations with PPRS to give priority to perishables in documentation processing. Furthermore, during periods of severe congestion, port authorities open an emergency gate for perishables only to enable smooth loading.

Table 2: *Flexibility with Regard to the Produce*

Produce	Region cultivated	Distance from the farm to the port (hrs)	Distance from the port to Int. Market (days=24hours)	Mode of Transport		Appr. Product post-harvest shelf life	Nature of the demand in int. Market	Number of production season per year
				Inland phase	Int. phase			
Pineapple	Central and Eastern	1 -3 hrs	Sea: 9-12 days Air: 1day	Road	Sea/air	1-3 weeks	Predictable, growing	Year-round, peak season (April-August)
Banana	Central and Eastern	1 – 3 hrs	Sea: 9-12 days Air: 1day	Road	Sea/air	10-18 days	Predictable, growing	Year-round, peak season (Jan-June)
Mango	Central and Eastern	1-3 hrs	Sea: 9-12 days Air: 1day	Road	Sea/air	10-14 days	Predictable, growing	2 peak seasons (June season and December season)
Yams	Northern	12-24 hrs	Sea: 9-12 days Air: 1day	Road	Sea	1-7 months	Predictable, growing	Year-round with varying peak seasons

NB: In a cool temperature the post-harvest shelf life of the product goes beyond what is depicted in the table.
(Source: Authors' construct based on the findings)

External Flexibility

This part looks at what is happening beyond the individual supply chain actor's environment.

Transport Infrastructure Flexibility

The provision of transport infrastructure (roads, airports and seaports) has remained the sole responsibility of the government, thereby exposing the supply chain to a limited number of transport modes (table 3), which has resulted in the number of modes available being restricted. Over-reliance on the roads means that there is inflexibility with respect to the choice of mode. However, deregulation of operations, management and pricing has introduced some flexibility with respect to the availability of trucks. Thus exporters have a wider choice of truck operators and so they are free to decide which operator to engage using the criteria given in table 3. This enables the exporter to focus on their core exporting activities. At the international phase, there is greater flexibility with regard to the choice of mode since the exporter has the freedom to decide whether to use air or sea or both depending on the demand conditions and criteria shown in table 3.

Road conditions may pose inflexibility in terms of traffic congestion, inaccessibility and accidents. However, the GEPC collaborates with the Ministry of Roads and Transport to construct feeder roads to areas where perishables are cultivated. Over the last four years, through cooperating with the Ministry of Agriculture under the Agricultural Diversification Project, it has been able to construct some feeder roads. Examples are the Aburi and Nsawam roads from the Eastern Region and some parts of the Central Region leading to Accra where the ports are located. The criteria for the selection of these areas are the short distance to the ports, the volume of

the produce from the region, the concentration of farming activities and the type of produce. In addition, part of the Millennium Challenge Account (MCA), funding from the USA government to develop the agricultural sector, is used to improve roads from the exporting farms to the ports. Through this funding, a dual carriage road is being constructed from the Mallam Junction through the Tetteh-Quarshie interchange, linking both air and sea ports. More flexibility has been introduced by the government, allowing trucks carrying perishables to travel after 6pm in order to facilitate the smooth flow of perishables so as to reduce product deterioration.

Storage facilities at the international phase of transportation is necessary to maintain the quality demanded by the international consumer. Even though it takes several days (sea) and hours (air), to reach international destinations, the presence of cooling systems (refer to tables 2 and 3) on the modes makes it possible to prolong the post-harvest shelf life of the products. Thus the presence of such cooling systems introduces flexibility into the supply chain.

Table 3: *Transport modes (Based on the findings)*

	Mode of Transport available	% Usage (based on response)	Reasons for use by ranking			Reason(s) of not using	Distance travelled (hours or days)	Cooling system presence
			1	2	3			
Inland phase	Railway	0%	-	-	-	Limited coverage	-	No
	Road	100%	Reliable	Easy access	Affordable cost	-	1-3 hours	About 30%
	Air	0%	-	-	-	Limited coverage	-	No
	Waterway	0%	-	-	-	Limited coverage	-	No
Int. phase	Sea	70%	Low cost	High capacity	Preferred by international market	-Slow	9-12 days	Yes
	Air	30%	Low risk of damage	Fast	Reliable	- High cost - Low capacity - Discouraged by the international market for environmental reasons	12- 16 hours	Yes

Capacity Flexibility

There are times when the exporter's order to the farmer cannot be fulfilled locally. This tends to introduce inflexibility in adjusting to the amount required by the end customer. However, large-scale farmers can adjust to this situation by topping up from subsidiaries in other countries. On some occasions flexibility is compromised when the space on the ship expected by an exporter is reduced upon the ship's arrival because it has loaded cargo from neighbouring countries it has been to. The low volume of cargo at the Ghana port does not make it attractive for shipping lines to call there. This in turn results in high freight costs being charged by the few that call, which is not proportional to the distance travelled. In the case of air, the capacity is dependent on the weight of the produce, the residual space and the number of passengers. Even though yams tend to be heavier than the other produce under consideration, they enjoy a fairly high degree of capacity flexibility. This is because, unlike other products whose weight cannot be reduced, yams' weight can be reduced by 10-12% in the first 3 months and 30-60% after 6 months through traditional ways of storage (Opara, 1999).

Quality Flexibility

Exporters share information with farmers about the quality demanded by the international market each time changes occur in the market. This information could be the amount and type of pesticides to be used, at what stage of the life cycle should pesticides and weedkillers be applied and the proper time to harvest the product, among others. This information helps farmers to adjust in order to provide the quality demanded by end-users in the international market. For instance, when they market shifted their preference from Cayenne to MD2 pineapples, exporters immediately shared this information with farmers.

Based on the above discussion, we can say that flexibility is present to some extent with regard to the internal and external elements, which have a positive influence on the performance of this supply chain.

Internal Supply Chain Risks

This part discusses the supply chain risks that originate from the action or inaction of chain members. These risks can be controlled by actors, either individually or through collaboration. Based on the findings, major risks faced by the internal perishables supply chain presented and discussed in tables 4, 5, and 6 below are power cuts, financial obstacles, damage and accidents, capacity problems, bureaucratic documentation procedures, delays in pick-ups and strikes.

Table 4: *Main risks the perishables supply chain has been exposed to in the past five years reported by GEPC*

Ranking	Nature of risk	Challenge to the supply chain	Government action(s)
1	Delays in ship/plane arrivals	Unreliable deliveries to the international market	Government has no control
2	Power cuts	Reduce product quality and post-harvest shelf life	Rationing
3	Damage	Reduces the quantity and quality of the produce demanded.	Left to exporters' management
4	Accidents	Reduce the quality of the produce demanded, late deliveries at the ports, and loss of part or the entire cargo to be delivered.	Education and training programmes reserving night driving to only perishables trucks
5	Storms	Loss of the produce at the farm resulting in lost sales and revenue, leaving the farmer financially weak.	Visited the farms affected, liaised with Min. of Agric. to come up with policies

Table 5: *Main Risks Reported by Exporters and Their Corresponding Mitigating Strategies*

Inland phase - Current risks			
Ranking	**Nature of risk**	**Challenge to the supply chain**	**Management strategy**
1	High fuel prices	Extra operating costs	Fuel to be subsidized by the Government
2	Financial obstacles	Inaccessibility and unavailability of funding and loan schemes limit exporters from expanding their operations.	Government loan schemes and reduction of export tax from 25% to 8%
3	Poor transport infrastructure	Extra costs in transporting the produce may influence product damage.	Constructing more roads and upgrading existing ones.
4	Capacity problems	Limit the volume to be transported to the port from the farm especially during peak seasons	Entering into on-the-spot and sometimes short-term contacts with the transporting company, relying on second-hand trucks to avoid incurring excessive costs.
5	Weather, i.e. too much or little rain, storms	Tends to be a source of power for some members over others, may reduce the volume and quality of cargo demanded, late or no deliveries.	Joint efforts are needed for the dependent actors to balance the power, seek insurance cover or obtain a loan from banks in groups. Government should work closely with private sector to improve the quality of the main and feeder roads.
Inland phase – Past risks			
1	Delays in transport arrangements	Effect on product quality, lost sales due to product deterioration.	Alternative transport arrangements or sell to local market
2	Strikes	Delays in various activities, e.g. harvesting for the supply chain, leads to extra costs	Hire temporary workers on a daily basis
3	Power cuts	Extra cost for fuel to operate the generator, effect on product quality.	Buy generators
4	Accidents	Reduce the quality of the produce, late delivery at the ports, and loss of part or the entire cargo to be delivered.	Government should be strict in implementing travel time and tonnage regulations
International phase - Current risks			
1	Bureaucratic documentation processes	Extra costs due to exporters' attempts to speed up the clearance process by bribing officials handling documentation.	Ghana Standard Board staff should be proactive, periodic training should be organised for officials responsible for perishables documentation
2	Delays in ship/plane arrival	Severe congestion at the port that does not favour produce quality as lead time increases.	It is important that there are adequate storage facilities at the port to preserve product quality.

Inland phase - Current risks			
Ranking	**Nature of risk**	**Challenge to the supply chain**	**Management strategy**
3	Capacity problems	Exporters are uncertain about the space left for them in the ship or plane, because of the low volume of cargo at Ghana ports.	Farmers and exporters should cooperate to increase the volume of cargo in order to attract shipping lines and airlines to the ports.
4	Power curtailments	Effects on product quality and extra costs for the generator fuel.	Buy generator
International phase-Past-exposed risks			
1	High fuel prices	Raise transport costs which in turn reduces exporters' profit margin	Pass the burden on to farmers by paying low price, opt to transport large volume of cargo using few trucks, ask government to subsidize fuel
2	Financial crisis	Impacts international consumer demand as it tends to reduce or limit their consumption level	Actors need to be proactive in responding to any changes in international market demand and supply the market accordingly.
3	Weather effects and seasonality of produce	Lead to irregularity of supply in terms of quality, quantity and delivery reliability	Actors have to secure insurance cover or get a loan from the bank either personally or in groups and take precautions with regard to planting and harvesting time.
4.	New entrants into the market	Reduce market share in the international market for the supply chain due to increased competition.	The supply chain as a whole should be responsive in responding to consumer demand in the international market

Table 6: *Main Risks Reported by Farmers and Their Corresponding Mitigating Strategies*

Ranking	**Nature of risk**	**Challenge to the supply chain**	**Management strategy**
1	Unpredictable rainfall	Can have an effect on the farm, the quality of the produce and the volume of the harvest.	Personal or group loans as well as insurance cover
2	Financial obstacles	Limit small-scale farmers from expanding their farming operations.	Personal or group loans from banks, government and interested donors
3	Lack of modern farming technology	Limits the farmers from increasing the volume and quality of the produce demanded by exporters	Government could subsidize modern farming equipment,
4	Delays in pick-ups.	Products deteriorate because they absorb heat which reduces their shelf life by 3 days	Sell to local market
5	Fire	Can lead to reduced harvest and ruin product quality	Fire education provided by extension officers

External Supply Chain Risks

This part discusses various supply chain risks that originate beyond the boundaries of the perishables supply chain (as presented in tables 4, 5, and 6). These risks cannot be controlled or avoided by supply chain actors; they can only adjust to these risks or put in place contingency plans. Based on the findings, major external perishables supply chain risks are delays in ships/planes, weather conditions, the high cost of fuel and the global financial crisis. The investigations revealed further that some risks are not only experienced on an individual level but are common to more than one level, irrespective of the position in the supply chain. For instance, financial obstacles, delays in pick-ups and weather conditions affect the farmer, transporter and exporter. In relation to the literature review, whenever the supply chain risk is high there is great inflexibility with regard to the supply chain's performance. Therefore the two affect each other negatively. It is our view that if the risks under discussion are properly managed or adequate contingency plans are put in place, supply chain flexibility will be greatly enhanced.

Power and Dependency

Table 7: *Sources of Power and Dependency in the Perishables Supply Chain*

Actor	Source(s) of power	Power over which actor	Sources(s) of dependence	Reliance on
Exporter	Information/resource (they are closer to GEPC and the international market consumer)	Farmer (they are in an asymmetric position as regards information)	Peak seasons (there is a large volume of cargo to be transported but the number of trucks is limited)	Transporter (fix higher transportation rate)
	Formal education and associations (give them advantage to negotiate various matters for the supply chain)	Farmer (small and medium-scale farmers have low level of education), Port authorities (work better in associations)		
	Access to funding (from bank and the government because they have collateral)	Farmer (small and medium-scale farmers have no/less access to funding)		

Actor	Source(s) of power	Power over which actor	Sources(s) of dependence	Reliance on
	Peak seasons (excess supply gives them higher negotiation power to fix price)	Farmer (may sell at any price fixed by the exporter to reduce the risk of product deterioration)		
	Incentive structure (unwritten, on-the-spot buying contracts are used to pass risks on to farmers)	Farmer (type of buying contracts used are not binding)		
Farmer	Lean season (supply is lower than demand)	Exporter (has to consolidate enough cargo demanded by international customers)	Condition of feeder roads	Government
			Lack of cooperation (leads to little negotiating power)	Exporter
	Large-scale farming operations (have integrated farming, exporting and transporting activities)	Exporter, Transporters	Less access to information	Exporter
			Low financial status (do not have collateral for bank loan)	Government, Banks
			Price structure (exporters pay more than local market)	Exporter
Transporter	Peak and rainy seasons (roads are in a bad condition and no alternative to road transport)	Exporter	Travel time and tonnage regulations	Government
	Poor feeder roads	Farmer		
Government	Policy formulation and enforcement	Farmer, Exporter, Transporter		

From the above presentation it can be said that cooperation to a large extent is favourable when dealing with problems. However, this is not always the case as different actors may be pursuing individual and group interests. This may lead to delays in decision making as there is a need to cater for the interests of different associations, and this does not augur well for a delicate supply chain like that of perishables. *The actions of actors in this supply chain exhibit an asymmetric relationship as each member tends to pursue different interests. As a result there is a greater level of dependence than interdependence. It is also our contention that if the supply chain actors were to cooperate and collaborate this would go a long way to closing the power gap. This in turn would help minimize most of the risks discussed above and therefore increase supply chain flexibility.*

SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis

The SWOT analysis is employed here to present a summary of our findings. It offers an in-depth insight into whether the attainment of reliability is feasible, by focusing on the elements in each matrix.

Table 8: *SWOT Analysis for the Perishables Supply Chain*

STRENGTHS	WEAKNESSES
- There is wide use of electronic means of communication e.g. Mobile phones, faxes, e-mail and GCNet. - There is ongoing research into strengthening the domestic supply chain through the World Bank. - Favourable geographical location of Ghana compared with competitors like South America. - Farmers are readily adapting to international market standards.	- Lack of modern farming and harvesting technology. - Credit and financial constraints and high interest rates. - Only few processing companies in the local market.

STRENGTHS	WEAKNESSES
- Large-scale farmers have an integrated logistical system (planting, harvesting, packing, transporting, storage) which ensures: - reliable delivery to ports - good produce quality - avoidance of transaction costs of middlemen. -Relatively low labour costs -Political stability favourable for further developments in the sector. - Most products are produced in regions relatively close to the ports.	- Business culture difference between Ghanaian suppliers and their European customers. - High level of uncertainty in shipping schedules as it depends on availability of residual space. - Lack of refrigeration facilities on farm premises and during inland transportation affect product quality. - Poor infrastructure (roads, storage) - High temperature. - High freight costs.

Managerial Implications

The managerial implication of the SWOT analysis from the government's point of view is that structures need to be put in place with the aim of making Ghana an attractive business environment. Issues to be considered here are policy formulation and implementation, regulations and the provision of physical infrastructure, which will aid the smooth flow of goods. By doing this, the government will be able to fulfil the needs and requirements of both shippers and shipping lines. This will consequently give Ghana a competitive edge over neighbouring ports.

An important managerial task for exporters is for them to avoid over-reliance on the government but for them to take action to reduce costs and increase profits. For instance, attracting ships to the ports is not only the responsibility of the government but also exporters having enough cargo to fill the ships that call at the ports.

Conclusion

From the above discussion on flexibility, risks and power, there is evidence of the presence of reliability in this supply chain to some extent. This is especially prominent in connection with reliability in terms of reducing product deterioration, shortening lead time and satisfying customers. However, to achieve greater reliability aspects like maximizing profits and increasing delivery frequency as depicted in the model need to be addressed. The means for dealing with these aspects are given in our recommendations in the next section.

Recommendations

For actors to reap the full benefits associated with this supply chain, it is important for all levels to be aware of their responsibilities in order for them to take the needed initiatives that will have a positive impact on the supply chain. An example could be adopting strategies for establishing and managing relationships and risks. Accordingly, it is critical that decision makers at all levels cautiously consider the issues raised and take steps that will result in continuous and long-term benefits for the supply chain as a whole.

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Determining the Extent of Financial Integration in East Africa Using Beta Convergence and Cointegration Analysis

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Abstract

This article investigates the extent of financial integration in East Africa over time by examining the degree of convergence in the stock markets. The paper further assesses the long-run equilibrium of returns among the East African stock markets. The study was motivated by the current move by the East African member states to establish a monetary union in the region. Knowing the position of the stage of financial integration could offer a way for overcoming impediments to the development of the envisaged monetary union. Data has been analysed using beta convergence and cointegration.

The findings of the study indicate that financial markets have some level of integration as evidenced by the beta coefficient of 0.61 and the absence of long-run equilibrium. Based on these findings we conclude that integration of the East African stock markets is far from being successful. A further study using rigorous econometric analysis is recommended in order to be able to control for other variables not considered in this paper, which affect the integration process. Alongside this, there is a need for a study on sigma convergence to determine the dispersion of investment returns.

Introduction

Capital market development is an important component of financial sector development and supplements the role of the banking system in economic development. In other words, capital markets are needed as an alternative source of financing, supplementing commercial banks, which dominate the East African Community's (EAC) financial sector and which lack competitiveness (Gaertner et al. (2011)). Specifically, capital markets assist with price discovery, liquidity provision, reduction in transactions costs and risk transfer. They reduce information costs through the generation and dissemination of information on firms, leading to efficient markets in which prices incorporate all the available information.

A large body of research has found evidence that capital market development contributes to economic growth, including in sub-Saharan African countries (Adjasi and Biekpe, (2006)). Developed capital markets promote growth by mobilizing domestic savings and investments and by efficiently allocating these resources to local companies. In addition, deep and liquid local capital markets can lessen the vulnerability of an economy to external shocks, by reducing currency and duration mismatches in raising funds. Financial development can reduce income inequality by increasing the income of the poor. Eichengreen and Luengnaruemitchai (2004) suggest that there exists a certain minimum-efficient size of bond markets, because large issuance and trading volumes are more economical. Capital markets in the EAC countries face the common challenges of low capitalization and liquidity, but to different degrees due to the low level of development in the markets. For this reason, the respective countries have been pursuing the development of capital markets through regional integration.

Regional integration is a process through which states enter into a regional agreement in order to enhance regional cooperation through regional

institutions and regulations. The objectives of the agreement could range from economic to political, although it has generally become a political economy initiative whereby commercial purposes are the means of achieving broader socio-political and security objectives. The agreement could be organized either at the supranational or intergovernmental decision-making level, or a combination of both.

The convergence of investment returns is a definition of financial integration in the sense that financial markets are integrated when the law of one price holds. This states that assets generating identical cash flows command the same returns, regardless of the domicile of the issuer and the asset holder. Given this definition, financial market integration can be measured by comparing the return on assets issued in different countries and generating identical cash flows.

When identical assets command different returns one would tend to conclude that financial markets are not integrated. For instance, this could be because legal barriers prevent capital from flowing freely between countries. Such barriers may reflect capital controls, tax codes, accounting and auditing differences, different bankruptcy laws and different quality of judicial enforcement, etc. However, some caution is warranted. Countries may share a common legal and regulatory framework, but identical assets may still command different returns. As well as legal barriers, there might be economic barriers; for instance there could be situations of asymmetric information that induce investors to evaluate differently assets that are otherwise identical.

We can therefore argue that the East African countries have been pushing for the integration of capital markets through a regional approach as a way of developing them. As such, this paper focuses on the stock markets,

because they are more organized than the bond market and there is observed consistency in trading resulting in the availability of data.

Research Problem

Financial markets are integrated when the law of one price holds. This means that investment returns and prices of similar assets within different countries in a given region converge to result in a common figure. Beta convergence acts as a good measure of determining the extent of financial integration and so is the law of one price. Existing literature in general indicates that there is evidence of increased beta convergence in the financial markets – stocks, bonds and treasury bills. The literature in this area is quite rich concerning Asia, which is a key emerging market, as well as the European Union (developed market). Further empirical evidence in the two markets points to faster integration/convergence in the money market than in the stock and bonds markets. However, narrowing it down to the case of the EAC countries, empirical findings have discussed macro-economic variables but none has focused on the stock market. There is no empirical evidence on the existence of beta convergence in the EAC stock markets. This study therefore seeks to bridge the gap by determining the degree of beta convergence and the existence of long-run equilibrium in the EAC countries' financial markets, specifically focusing on stock market returns.

Research Objectives and Questions

Given the above research problem, the objectives of the study were to examine the degree of integration in the East African stock markets, and to investigate the long-run equilibrium of returns in the East African stock markets.

Subsequent to the above research objectives our research questions were formulated as follows:

1. To what extent has integration of the East African stock markets been achieved in the last five years?
2. Is there a long-run relationship in the returns of the East African stock markets?

Literature Review

Definition of Financial Integration

Baele (2004) assumes that the market for a given set of financial instruments and/or services is fully integrated if all potential market participants have the same relevant characteristics, i.e.

1. They face a single set of rules when they decide to deal with those financial instruments and/or services.
2. They have equal access to the same set of financial instruments and/or services.
3. They are treated equally when they are active in the market.

The definition of financial market integration is closely linked to the law of one price. The law of one price states that if assets have identical risks and returns, then they should be priced identically regardless of where they are transacted. If the law of one price does not hold, then there is room for arbitrage opportunities. However, if the investment of capital is non-discriminatory, then any investors will be free to exploit any arbitrage opportunities, which will then cease to exist, thereby restoring the validity of the law of one price.

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Financial market integration is the process through which financial markets in an economy become more closely integrated with those in other economies or with those in the rest of the world. This implies an increase in capital flows and a tendency for prices and returns on traded financial assets in different countries to equalize. Therefore, financial market integration could proceed with enforcement of a formal international treaty.

Types of Financial Integration

Literature, (e.g. Oxelheim, (1990)) distinguishes between total, direct and indirect financial integration. Total financial integration embraces direct and indirect integration. Total or perfect integration means that expected real interest rates are the same in the markets concerned. Where total financial integration is not perfect, the reason may be imperfect direct and/or indirect financial integration.

Direct financial integration, which is also called capital market integration, is expressed in deviations from the law of one price for financial securities. Under perfect direct financial integration this law obtains, and an investor can expect the same return on investments from different markets (and a borrower the same loan costs), after the requisite adjustment has been made for risk. If the differential in expected risk-adjusted returns is greater

than zero but less than or the same as the transaction cost, we can say that markets are disintegrated although they may still be efficient.

Financial integration can also vary in strength from perfect integration to perfect disintegration or segmentation (Oxelheim, (1990)). When expected real interest rates are not the same in the markets in question (not perfect integration), then the markets are said to be segmented. Financial integration includes not only integration of financial markets or services but it can take other forms as well. These forms need not be interconnected nor are they advanced forms (stages) of the integration process. Liebscher (2006) shows that integration can take many forms and that aspects of integration include:

i. Monetary integration, either through currency unions (Europe, Western and Central Africa) or through dollarization, such as in Latin America and the Caribbean.
ii. Liberalization of the capital account.
iii. Subcontracting abroad of financial services or infrastructure, such as in the case of listing of securities on foreign stock exchanges.
iv. Foreign entry.
v. Regulatory convergence and harmonization.

Measuring Financial Integration

Various measures exist in the literature for assessing the level of financial integration. The methods used most are connected with growing investment opportunities.

Financial integration is often measured following the approach adopted by Baele et al. (2004). Baele considers three broad categories of financial integration measures as outlined below:

1. Price-based measures, which capture discrepancies in prices or returns on assets caused by the geographic origin of the assets. This category of measures is divided into two methods of measurement: yield-based and country effects.

2. News-based measures, which measure the information effects from other frictions or barriers. If the global news has relatively bigger importance than local news, the degree of systematic risk should be identical across assets in different countries.

3. Quantity-based measures, which quantify the effects of friction faced by the demand for and supply of investment opportunities.

Cointegration of Stock Markets

In an era of increasing globalization, the transmission of movements in international financial markets is an important issue for economic policy, especially in periods when markets are highly volatile. The determination of diversification strategies by an international investor also depends crucially on the nature and magnitude of the relationship that exists between different stock markets. Thus it is important for international investors to understand the relationship between the various markets in order to diversify risk and to derive high returns. A number of theories can be applied to carry out cointegration analysis, e.g. Wavelet theory and Fourier-Transform.

Empirical Review

A review of existing empirical literature shows that adequate empirical studies have been done, particularly on the European Union and Asia, because these were the first markets to embrace the concept of financial integration. Some literature is also available on South Africa, West Africa and a bit on East Africa, the region with the least developed financial markets

relative to the rest of the regions mentioned above. Below we highlight some of the empirical studies done in some of the regions mentioned above.

Most of the empirical work done in this field has focused on OECD countries and East Asia. Kaminsky and Schmukler (2002) studied the dynamic aspects of international financial integration and suggested that equity prices tend to be more internationally connected than interest rates. Moosa and Bhatti (1997) provide conclusive empirical evidence on the high level of integration between goods and the financial markets of Japan and six Asian countries by testing uncovered interest parity and ex ante purchasing power parity.

Bhoi and Dhal (1998) attempted to empirically evaluate the extent of integration of India's financial markets in the post-liberalization period. According to them, there exists a fair degree of convergence of interest rates in the short-term money, credit and gilt markets – but the capital market exhibits fairly isolated behaviour. Furthermore, they found that the integration of domestic and overseas financial markets is not robust.

According to Makin (1994), there is a consensus that uncovered interest parity fails to provide any information about the degree of financial integration. This is based on concerns regarding time-varying currency risk premia or irrational expectations about exchange movements. But UIP can be restated with a focus on the relationship between domestic and foreign interest rates, given expectations about movements in the exchange rate. In particular, if interest rates and exchange rates are non-stationary, then it would be interesting to see whether domestic and foreign interest rates have long-run co-movements.

There is debate over whether it is the lack of financial integration that is contributing to the lack of intra-regional trade or whether the causation is the other way round. Eichengreen and Park (2004) subscribe to the former view and Fukao et al. (2003) and Ronci (2004) to the latter. However, these authors use different data, with Eichengreen and Park focusing on banks, Fukao et al. on FDI and Ronci on short-term loans. Simple correlations of trade and financial flows among East Asia countries (China and Taiwan excluded through lack of data) undertaken by Cowen et al. (2006) for the period 2001-2004 suggest that correlations are positive but relatively small (compared with OECD countries). One-year lags or leads have little effect and so it is not possible to judge any causal impact. They conclude with the suggestion that East Asian financial and economic integration is likely to increase in the future, as it is lower than in regions where the barriers are lower, and the general trend is towards a reduction in barriers.

Cowen et al. (2006) place a lot of importance on the lack of vehicles for mobilizing savings in the Asian region. Their principal argument is in favour of pension funds and indeed of pension reform that makes people more concerned to establish pensions.

Cointegration studies investigating long-run relationships focus on the extent to which nascent stock markets in Asian countries are internationally integrated which, in turn, has important implications for the diversification potential of Asian stock markets (e.g. Chan et al. (1992); Hung and Cheung (1995); DeFusco et al. (1996); Masih and Masih (2001)). Studies estimating short-run dynamic causal linkages seek to better understand the propagation mechanism driving stock market fluctuations in different countries, especially with respect to market crashes (Masih and Masih, (1997), (1999); Ghosh et al. (1999); Sheng and Tu, (2000). These and other related studies (Chung and Liu, (1994); Arshanapalli et al. (1995);

Cheung, (1997); Janakiramanan and Lamba, (1998); Dekker et al. (2001)) employ vector autoregression techniques, including cointegration, granger causality, impulse response analysis and forecast error variance decomposition. In general, the empirical evidence presented in these studies is mixed with respect to both long-run relationships and short-run dynamic causal linkages.

Countries in Southern and Eastern Africa are working towards regionally integrated markets and trading platforms with central depositories and settlement systems that conform to internationally recognized Group of Thirty (G30) standards (Appiah and Pescetto, (1998)). In addition, a large proportion of countries in Sub-Saharan Africa have a long history of very low savings and deposit ratios (Kenny and Moss, (1998)), and incomplete credit markets with inefficient financial intermediation.

In assessing real convergence in the East African region, research has paid more attention to real GDP growth. In a bid to establish if the EAC is a viable monetary union, Buigut and Valev (2005) investigated the symmetric nature of demand and supply shocks belying real GDP growth in partner states from 1980-2001. Theory asserts that partner countries within a monetary union should have monetary policies similar to those of the monetary union as a whole and thus cannot apply monetary and exchange rate policies to respond to country-specific shocks (Mundell, (1961); McKinnon, (1963)). The results of this study showed that short-run shocks were not symmetrical, but lagged supply shocks associated with trade patterns. In addition, the speed of adjustment to shocks and the effect of variability on real output (real GDP) also appeared to be symmetrical, with the exception of Uganda. In particular, Uganda experienced large shocks and the rate of adjustment was very slow, which could prove costly for monetary union.

Although the findings of Beigut and Valey (2005) could not confirm a viable monetary union at the time, they pointed towards a potential monetary union if there was deeper trade integration, emphasizing the importance of a well-functioning common market. Opolot and Osoro (2009), who examined the synchronization of business cycles of real GDP from 1981 to 2007 across the region, found peculiar differences. While business cycle co-movements across the region were found to have improved since the 1990's, their number was still very low. Only Tanzania and Uganda had optimistic synchronizations within the region, casting more doubt on monetary union being possible at that time. Further assessments of catch-up growth have been conducted based on real per capita GDP. Sigma tests carried out by the IMF (2011a) indicate that, with the exception of Burundi, incomes across the region have grown closer over the last 15 years (1996-2010). All other countries' per capita incomes appear to be catching up with Kenya. Findings by Opolot and Lavunda (2009) further confirm this, but add Burundi to the group of 4. This resulting dissimilarity could be explained by differences in the data sample and might imply that in recent years all the other economies have grown much faster and their institutional structures and policies have become more similar compared to Burundi.

As regards the nominal variables, investigations have mostly focused on exchange rate behaviour. Buigut (2011) looked at both nominal and real exchange rates in the region using data from 1991 to 2009. He found partial convergence due to the fact that some countries exhibited slow convergence in the short run. He was unable to find a common trend in the long run for these EAC countries, urging caution in entering into a monetary union.

Largely, studies have found no evidence of the convergence of budget

deficits (including and excluding grants) in the region (IMF, (2011b); Opolot and Lavunda, (2009)). Analyses of the evolution of the criteria have instead shown increasing patterns of dispersion and divergence across states. Findings concerning inflation rates convergence appear to be mixed. While some found divergence across states (IMF, 2011b), others discovered convergence (Opolot and Lavunda (2009)). Even so, in the latter case, the effect was attributed more to the three original countries of Tanzania, Uganda and Kenya. When separated from the trio, Rwanda and Burundi appear to exhibit inflation divergence. However others, (e.g. Buguit (2011)) have found partial convergence. In general, there has been very little research on the convergence of current account deficits and national savings. However, Opolot and Lavunda (2009) showed interest in the variables. Their panel unit root tests showed convergence of the current accounts and national savings of the group of 5. However a more detailed examination reveals that the effects appear to be attributed to Kenya, Burundi and Rwanda in the case of current account deficits, while for national savings, convergence is mostly attributed to Kenya and Rwanda. These findings are quite surprising given that Rwanda and Burundi have just recently emerged out of civil strife, unlike Uganda or Tanzania. In addition, it should not be forgotten that the data used comes from the earliest period of the EAC as a bloc of five.

The review of the above literature, specifically on the East African region, indicates partial convergence of some countries that is largely attributable to the adoption of different/independent policies by them.

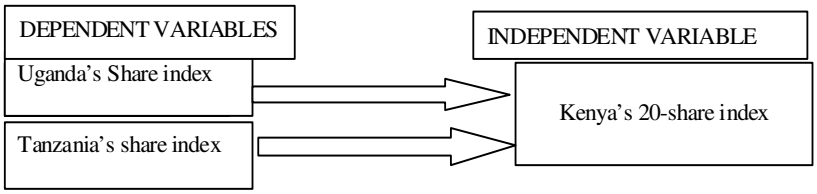
Research Gap

From the above literature there seems to be no empirical evidence of stock market convergence/integration and long-run equilibrium of stock market returns (measured using the respective stock indices) in East Africa, which

served as our motivation to examine the empirical evidence and add some knowledge to the existing literature based on our findings.

Conceptual Framework

The concept of financial market integration discussed in this paper is analyzed by examining beta convergence and cointegration. Essentially, the focus is on the relationship between the 20-share index of the Kenyan market as the benchmark market (our independent variable) and both the Tanzanian and Ugandan stock markets as the dependent variables. Regression analysis of these three variables is used to determine the extent of the spread in stock market returns, in which case a spread of zero is interpreted to mean perfect integration, while the value of the beta coefficient points to a degree of convergence. The ultimate objective of the regression model is to establish whether there is a long-run equilibrium relationship between stock market returns (measured using the respective market indices) of the three key East African stock markets.
Diagrammatically;



From the above conceptual framework we derive the following postulates;

- **Postulate 1:** The East African stock markets have achieved financial integration of degree zero over the last five years.
- **Postulate 2:** There is no long-run relationship in the returns of the East African stock markets.

The two postulates, translated into our research questions, are answered by analyzing the data as shown in the data analysis section.

Data Analysis Models

The study employed the concept of beta convergence and cointegration analysis to analyze the data in line with the research objectives.

Beta Convergence

Beta (β) convergence is measured by the following regression with panel data:

$$\Delta Si,t = \alpha + \beta Si,t\text{-}1 + \Sigma_{l=1} ?_l \Delta Si,t\text{-}l + \varepsilon i,t$$

where *Si,t* denotes a spread of yields on a relevant portfolio investment between country *i* and a benchmark market at time *t*, and *l* represents lag. If financial markets are perfectly integrated, this spread should be zero as long as the securities traded have the same risks and maturity structures, following the law of one price ("mean reversion"). Therefore, a negative β coefficient indicates mean reversion taking place across the markets, and an absolute value of the coefficient represents the speed of convergence at which the spread is dissolved and investment returns on securities in country *i* converge with those in the benchmark market γl and measure lagging effects from ΔSi, in previous periods. A beta coefficient of 0 means there is no convergence taking place between investment returns and any value above 0 but below 0.5 would indicate weak/low convergence, while any value above 0.5 indicates strong convergence taking place between investment returns.

Cointegration Approach

In the literature, one of the methods used to examine the long-run

relationship between two variables is the cointegration approach. Serletis (1997) implemented this approach.

This issue of testing long-run relationships was developed by Johansen and Juselius (1990), who tested for the presence of multiple long-run relationships. In this study, we use this cointegration approach to examine the integration of returns in both the Kenyan/domestic market and other East African markets. One of the prerequisites for undertaking the cointegration framework is that the variables that are expected to have a long-run relationship should be non-stationary at their levels and should be stationary at the same order (or difference).

The long-run relationship that we are examining here can be expressed as

$$I = \alpha + \beta\, i^*$$

where 'I' and 'i*' are the returns in the East African markets of Tanzania and Uganda against the Kenyan market as the benchmark. As specified earlier, first we checked the stationarity properties of the variables and then tested whether they are cointegrated using the maximum likelihood technique outlined by Johansen and Juselius (1990).

The essence of the cointegration approach is to identify *r*, the number of cointegrating vectors. If *n* variables with unit roots have *r* cointegrating relationships, they have $n - r$ common stochastic trends. Thus if *r* equals $n - 1$, stock markets are perfectly integrated under one common long-run trend. Alternatively if *r* equals 0, all data series are independent (Kasa, (1992)). Johansen and Juselius (1990) derive two likelihood-ratio tests to infer *r*, known as the trace statistics and the maximum-eigenvalue statistics tests.

Research Data Used

The study used secondary data on market indices (as a measure of returns) on a monthly basis for the period January 2007 to August 2012. Secondary data was used because of its availability and reliability compared to primary data. The secondary data used was for the Kenya, Uganda and Tanzania stock markets. Rwanda and Burundi were excluded because of the unavailability of data. Essentially, the focus was on price-based measures of integration to determine the convergence of investment returns.

The main sources of data are the Handbooks of Statistics on the respective securities and stock exchanges published by the stock exchanges themselves. In the next section, we discuss the empirical results based on the multiple cointegration method.

Data Analysis and Findings

Given below is a presentation of the results and findings obtained from data analysis applying the multiple cointegration method to investigate the existence of a long-run relationship in the returns of the three East African markets.

Beta Convergence

The first three columns in Table 1 show the estimated beta coefficients using the panel data with ordinary least squares (OLS), fixed effects and random effects models. The beta coefficients, estimated at -0.61 in the panel regressions, are negative and significant. This is indicative of market convergence taking place. The fixed effects model implies that there is no significant difference in the beta coefficient across the countries. The two columns on the right of the table present the results of OLS regressions using individual spreads of Tanzania and Uganda from the benchmark

Kenyan market. The results are consistent with those from the panel data regressions except that the beta coefficient for Uganda is not statistically significant. In other words, the individual regressions suggest that integration between the Ugandan and Kenyan stock markets is stronger than that between the Tanzanian and Kenyan markets, although the fixed effects model indicates there is no significant difference in beta convergence between Uganda and Tanzania. A system of three variables with a cointegration relationship has been generated from the trivariate time series data, with y^1, y^2 and y^3 representing the three lagged differences.

Overall, beta convergence implies that mean reversion is taking place in the three stock markets.

Table 1: *Beta Convergence*

		Panel Regression		Individual Regression	
	OSL	Fixed Effects	Random Effects	Tanzania - Kenya	Uganda - Kenya
	-0.610	-0.610	-0.610	-0.520	-0.912
	(0.252)	(0.264)	(0.075)	(0.223)	(0.168)
y^1	-0.132	-0.123	-0.132	-0.063	0.052
	(0.243)	(0.244)	(.0.074)	(0.301)	(0.161)
y^2	-0.235	-0.235	-0.235	-0.254	0.182
	(0.201)	(0.202)	(0.086)	(0.238)	(0.149)
y^3	-0.001	0.000	-0.001	0.058	-0.007
	(0.159)	(0.150)	(0.068)	(0.184)	(.154)
Tanzania- Kenya		0.045			
		(1.326)			
Constant	0.519	0.512	0.519	0.462	0.718
	(0.603)	(0.693)	(0.071)	(1.069)	(0.568)

Cointegration Analysis

The steps undertaken were;

i. Verifying whether the data series are non-stationary, containing a unit root, and
ii. Selecting the number of lags used in the model.

For the first step, augmented Dickey-Fuller and Phillips-Perron tests were conducted on the stock price data.

The results indicated in table 2 below confirm that all data series are modelled as integrated of order one and appropriate for cointegration analysis. The same results are obtained whether or not the data are converted into US dollars.

Overall, given the absence of a cointegrating vector in the three stock markets, we conclude that there is no long-run relationship between the EAC stock markets. We tabulated critical values for the test statistic of up to three cointegration relationships; i.e. r = 0, 1, 2.

Besides the trace statistic, Johansen and Juselius [1990] suggested that the maximal eigenvalue statistic be defined as "2 ln (Q; r|r + 1) = "T ln(1 " ^λr+1,) for testing the existence of the r versus r + 1 cointegration relationship. Critical values for both test statistics and different specifications with respect to the inclusion of deterministic regressors are provided in the last three columns in table 2 below

Table 2: ***Cointegration Tests***

Number of Cointegrating Vectors	Trace Statistics			Maximum value statistics		
	Adjusted for Exchange Rates	Not Adjusted for Exchange Rates	5 percent Critical Value	Adjusted for Exchange Rates	Not adjusted for Exchange Rates	5 percent Critical Value
r=0	28.450	26.432	27.890	16.980	20.670	21.220
r=1	7.530	4.325	17.560	7.250	4.435	15.130
r=2	0.179	0.181	2.870	0.180	0.181	3.650

Conclusion

Based on the above results, we conclude that integration is still taking place but it is far from perfect, as indicated by the beta coefficient of -0.61. The absence of long-run equilibrium based on our findings is good grounds for us to conclude that integration of the East African stock markets is far from being successful. As we put forward this argument, we acknowledge that there is an element of integration (as discussed above). However, the issue of whether the markets are moving towards integration has not been addressed in this paper. We are of the view that further research on this is necessary, using sigma convergence.

Limitations of the Study

It should also be noted that the results may suffer from a spurious relationship: the estimated beta convergence may, to some extent, reflect each market's response to the external shock of the active participation of foreign investors in these markets, rather than convergence in the region. Secondly, due to the thinness of the markets in terms of the number of listed companies and the small size of transactions, it is feared that the data series does not fully reflect actual market performance.

Recommendations for Further Research

Given that the cointegration analysis indicates there is no long-run equilibrium among the EAC stock markets, the estimated convergence in the stock markets needs to be subjected to further scrutiny by carrying out a more rigorous analysis. We are of the view that more robust findings could be established if the data series was subjected to sigma convergence analysis. Such an analysis would address the issue of dispersion of the returns (not discussed in this paper). We propose that the coefficient of variation is used as an appropriate tool for this exercise as opposed to a linear time trend. In addition, more independent variables need to be considered, such as market activity as measured by volume of transactions per month, monthly turnover and market capitalization as a ratio of GDP (yearly). A hypothesis for each of the above parameters could be stated and tested at the five percent level of significance using a two-tailed Z-test, with the aim of establishing their significance in determining market performance. This method of data analysis would accordingly change from simple linear regression to multiple regression and multiple cointegration analysis.

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Use of Polynomial Fit to Predict Seasonal Rainfall in Nairobi, Kenya

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Abstarct

The study seeks to improve existing low frequency rainfall diagnosis and prediction in Nairobi.

Total monthly rainfall data for three stations in Nairobi, namely Dagoretti, Jomo Kenyatta International Airport (JKIA) and Wilson Airport, for the period 1957 to 2002, was considered for the study. The monthly rainfall data was fitted to several mathematical functions. These mathematical functions were grouped into five families based on their characteristic behaviour. These families were Exponential models, Growth models, yield density models, Processes producing sigmoidal or 'S'–shaped growth curves, and a miscellaneous family described to include the sinusoidal fit, Gaussian model, Hyperbolic fit, Heat-capacity model, Rational function, etc. The mathematical model which best simulated the March-May (MAM) and October-December (OND) seasonal rainfall at the three stations of analysis was chosen using the stepwise regression technique The value of R^2 for the best fit

was computed to show the percentage of rainfall information that is explained by the variation in the independent (time) variable.

From the results obtained, the stepwise regression technique selected the fourth degree polynomial as the best fit for analyzing the MAM and OND seasonal rainfall dataset. The oscillations of the MAM and OND rainfall followed a unique repetitive pattern, which was analogous to the solar cycle. Hence, the ten-year (10) solar cycle was employed to get the fourth degree polynomial variables. The error sum of squares (SSE) [which was used to assess the deviation of predicted rainfall values from the observed values] was computed for 5, 10 and 11-year periods, where it was also evident that the ten-year period had the least error compared with the 5 and 11-year periods. Hence from the study, it was found that the 4th degree polynomial function can be used to predict rainfall over Nairobi, with acceptable error values. This accurate rainfall forecast will assist in the planning and management of all climate-sensitive socio-economic activities.

Keywords: *Stepwise regression, rainfall variability, polynomial function, solar cycle*

Introduction

There are ongoing efforts to better understand the coherent multidecadal fluctuations in the global climate system resulting from interactions between the various components of the climate system itself, such as the oceans, land and atmosphere. It is generally assumed that the slowly varying sea surface temperatures (SSTs) are the dominant source of this variability (e.g., Kawamura *et al*. 1995a,b; Livezey and Smith, 1999; Mo *et al*. 2001; Hoerling *et al*. 2001), which has prompted several extended climate simulations using general circulation models (GCMs), forced by the observed near-global SSTs (Graham, 1994; Lau and Nath, 1994). Chelliah

and Bell (2004) studied the coherent decadal fluctuations in tropical convection and surface temperatures over the central Pacific, the West African monsoon region, the Amazon basin and the Indian Ocean, which are shown to constitute the dominant decadal-scale mode of variability in the tropics.

The East African region is characterized by a complex topography, which includes large lakes, the Rift Valley, flat plains and a snow-capped mountain on the Equator. Almost all facets of societal and economic activities in the region are critically dependent on variability of the seasonal rainfall, which occurs during boreal Spring (Long Rains, March-May) and Autumn (Short Rains, October-December). However, societies are often unprepared to adjust quickly to dramatic deviations from normal rainfall regimes. Extremes in weather may result in loss of life and damage to property, including large-scale destruction of existing infrastructure. These negative impacts have been detrimental to the economy.

The forecasting of severe weather and extreme climate events is one of the major challenges facing meteorological services worldwide and more so in the tropics (Christine *et al.* (1998)). However, researchers have made enormous efforts in addressing the issue of accurately predicting rainfall. Amongst some of the techniques that have been employed to predict rainfall in East Africa are the use of numerical and statistical methods. Mathematical functions, especially polynomial regressions, have also been used to characterize weather elements, including rainfall, in different parts of the world. For instance, Christine *et al.* (1998) used polynomial regression to derive a simple model for each monthly climate variable to relate climate to position and elevation on the Digital Elevation Model (DEM) in Ireland. Accurate assessments with subsets of each climate dataset showed that polynomial regression can predict the average monthly climate in Ireland

with mean absolute errors of 5 to 15 mm for monthly precipitation, 0.2 to 0.5°C for monthly averaged maximum and minimum temperatures, and 6 to 15 min for monthly averaged sunshine hours.

Camberlin and Philippon (2001) presented a forecast of the March-May 2001 rainy season in East Africa, using complementary statistical techniques: the Multiple Linear Regression and the Linear Discriminant Analysis. Their prediction scheme involved the use of SST indexes and atmospheric predictors. The March to May period corresponds to the main rainy season in Equatorial East Africa (the so-called "long rains"). Although this rainy season exhibits less inter-annual variability than that of that of October-December (the "short rains"), it is the main agricultural period in East Africa, and droughts severely affect the entire economy (e.g., in 2000 in Kenya). However, these inter-annual variations are much less known about than those of the "short rains". In particular, the teleconnections with SST anomalies (both regional and global) are much weaker (Ogallo et al. 1988; Rowell et al. 1994; Mutai and Ward, 2000), and this precludes the definition of acute seasonal rainfall prediction models based on that sole variable.

Rainfall in East Africa is of an oscillatory character in time and, as shown by Ogallo (1977), the result of the spectral analysis indicated that there were some oscillations in the annual rainfall series. Potts (1971), and Rodhe and Virji (1996) showed that oscillatory peaks of 2-2.5, 3.5 and 5.6 years, in addition to other peaks associated with EL Nino (Ropelewski and Halpert, 1987) exist in East Africa's rainfall. However, it has never been clear as to when these oscillations in the rainfall occurred.

In investigating Kenya's rainfall variability and its relationship to other climatic elements, it has become imperative to analyze the irregularly distributed rainfall events in time. To meet this requirement, this study used the stepwise

regression technique, as it seeks to improve existing rainfall monitoring and prediction in Nairobi.

Data and Methods

Data on total monthly rainfall obtained from the Kenya Meteorological Department (KMD) was used in the study. The data was for three stations in Nairobi city, namely Dagoretti (10 18'S, 360 45'E), JKIA (10 19'S, 360 55'E) and Wilson (10 19'S, 360 49'E), which are in the same homogeneous climatic zone. The data considered for the study was for the period 1955 to 2005.

Data Quality Control and Estimation of Missing Records

Data quality control is important in order to detect any discontinuities in the data that may have occurred from non-natural influences like changes in observational schedules and methods, instrumental and other human processes (WMO, 1966). Heterogeneity means that records are not objectively comparable over long periods of time and between different stations.

It is therefore important to ascertain the homogeneity of any meteorological data before using it in any study. The single mass curve was used to check on the homogeneity of the rainfall data. The mass curve was obtained by plotting cumulative records of rainfall against time. Basically, from the plot of a single mass curve, a straight line indicates a homogenous record, whereas heterogeneity can be indicated by significant deviations from the straight line in some of the plots.

The missing rainfall records were less than 10% of the total data. The different methods of estimating missing data (WMO, 1962) include the

arithmetic mean method, the isopleths method, the Thiessen polygon method, the isohyetal method, the finite differencing method, and the correlation and regression method. In this study the correlation method was used to estimate the missing records.

Choosing the Best Fit Model

Monthly rainfall data for the three stations (i.e Dagoretti, JKIA and Wilson) was fitted to several mathematical functions. These mathematical functions were grouped into five families based on their characteristic behaviour as given by Muthama (2002). These families include exponential models, which have exponential or logarithmic functions involved, growth models characterized by a monotonic growth from some fixed value to an asymptote, the yield density models, which have the 'asymptotic' and 'parabolic' yield density relations, processes producing sigmoidal or 'S'–shaped growth curves, and a miscellaneous family described to include the sinusoidal fit, Gaussian model, hyperbolic fit, heat-capacity model, rational function, etc. The mathematical model which best simulated March-May (MAM) and October-December (OND) rainfall at the three stations of analysis was chosen.

Through the use of the stepwise regression technique, the fourth degree polynomial was selected as the best fit for analyzing the dataset. This technique involves choosing the variables, i.e., terms to include in a multiple regression model. Forward stepwise regression starts with no model terms. At each step it adds the most statistically significant term (the one with the highest F statistic or lowest p-value) until there are none left. Backward stepwise regression starts with all the terms in the model and removes the least significant ones until all the remaining terms are statistically significant. It is also possible to start with a subset of all the terms and then add significant terms or remove insignificant ones.

The oscillations of the MAM and OND rainfall followed a uniquely repetitive pattern, which may be associated with the solar cycle. Recent observation shows a strengthening of tropical circulation associated with the decadal variability in the tropical mean radiative energy budget (Chen *et al*. 2002; Wielicki *et al*. 2002). Hence, a solar cycle of ten (10) years was employed to get the fourth degree polynomial variables. The fourth degree polynomial function is of the form;

$$Y = a+bx+cx^2+dx^3+ex^4 \quad (3)$$

where a, b, c, d and e are constants and x refers to the independent variable, also called the predictor, which is the time variable. Y is the dependent variable, also called the predictor, and the rainfall. The SSE was computed for 5, 10 and 11 year-periods. The sum of squared prediction errors (SSPE) is given by;

$$SSPE = \sum_{t=1}^{n} (y_t - \hat{y}_t)^2 \quad (4)$$

where $\hat{y}_t$ is the one-step predicted value and y_t is the observed/recorded value.

Results and Discussion

The results of the data quality control tests and 4th degree polynomial fit of the MAM and OND rainfall is depicted below.

Data Quality Control Results

Cumulative rainfall was plotted against time and the plot showed that the data for the three stations used in the study was homogeneous. The rainfall

records were therefore declared to be of good quality and hence suitable for climatological analysis. The single mass curves are shown in Figure 1. R-squared values (also called the coefficient of determination) have also been calculated by assuming a linear trendline. The R-squared value is a number from 0 to 1 that reveals how closely the estimated values for the trendline correspond to the actual data. A trendline is most reliable when its R-squared value is at or near 1. Figure 1 below shows the single mass curve for Dagoretti, and it is clear from the plot that the data record at this station was of good quality, as depicted in the almost straight line. The R2 value for the mass curve fit was very close to 1 and the linear trendline equation was of the form y=mx+b, 'm' being the slope and 'b' the intercept. Similar single mass curves were observed at JKIA and Wilson airport stations.

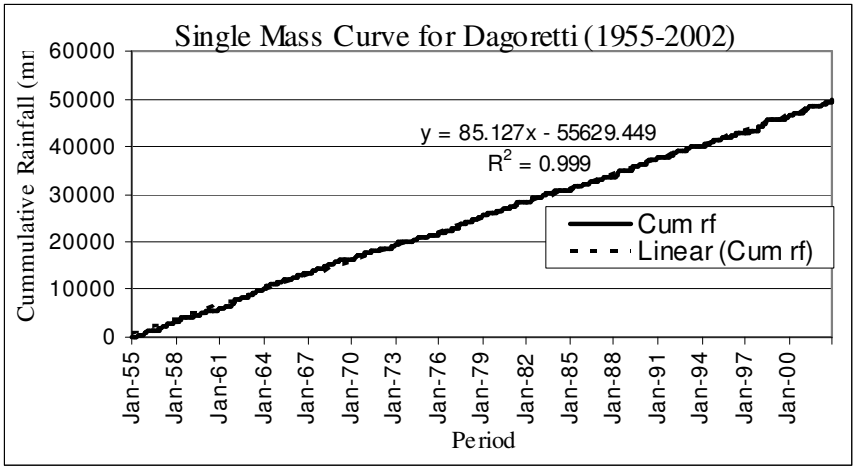


Figure 1: *Single Mass Curve for Dagoretti*

The Error Sum of Squares (SSE)

The SSE was used to assess the deviation of predicted rainfall values from the observed values. The computed SSE values for 10 years were lower than the SSE values for 5 or 11 years. Hence, the SSPE was lower for 10 years than for 5 and 11 years. Table 1 below summarizes the SSPE value results obtained for 10 and 11 years respectively.

Table 1: *SSPE Values for 10 and 11-Year Cycles*

10-Year Cycle			
Station	*Data period*	*SSPE for MAM*	*SSPE for OND*
Dagoretti	1957-2003	1139570.1	1371506
JKIA	1958-2002	703804.56	1111207
Wilson	1957-2002	1047649.8	1034849
11-Year Cycle			
Station	*Data period*	*SSPE for MAM*	*SSPE for OND*
Dagoretti	1957-2003	1199634.3	1426785
JKIA	1958-2002	764238.11	1164118
Wilson	1957-2002	1158147.2	1091048

It is evident from Table 1 above that the SSPE values for the 10-year cycle were lower than the SSPE values for the 11-year cycle.

Inter-Seasonal Rainfall Variability

Table 2 below illustrates the rainfall variability during the MAM and OND seasons in Nairobi.

As observed from Table 2 below, the amount of MAM rainfall had minimal variability over a decade (10 years) as compared to 5 and 11 years where the variability was more pronounced, as depicted in the range and standard deviation values. Information on the minimal variability in MAM rainfall over a ten-year period can be used for water planning and management in Nairobi.

The amount of OND rainfall had minimal variability in Nairobi for a 5-year period as compared to the 10 and 11-year periods. Hence it is recommended that water planning and management in Nairobi during the OND season should be for a period of 5 years.

Table 2: *MAM And OND Seasonal Rainfall Variability*

March-May Season						
	Dagoretti		*JKIA*		*Wilson*	
	Range	*Std dev*	*Range*	*Std dev*	*Range*	*Std dev*
Sum of 5 years	625.9	204.1	692.2	248.0	1485.5	528.6
Sum of 10 years	312.4	142.7	188.6	78.4	458.2	210.7
Sum of 11 years	362.8	161.1	714.1	354.5	805.0	371.3
October-December Season						
	Dagoretti		*JKIA*		*Wilson*	
	Range	*Std dev*	*Range*	*Std dev*	*Range*	*Std dev*
Sum of 5 years	1320.7	380.8	947.0	344.6	834.8	315.9
Sum of 10 years	1327.1	553.8	1156.6	560.6	1468.9	664.4
Sum of 11 years	1539.2	638.9	1303.8	600.2	1237.1	518.2

*Range here refers to the difference between maximum and minimum rainfall whereas Std dev is the standard deviation

Fourth Degree Polynomial Fit Results

Through the various curve-fitting analyses carried out, it was evident that the 4th degree polynomial function was the best fit for the three stations of analysis selected (i.e Dagoretti, JKIA and Wilson). The simulated MAM and OND rainfall using the 4th degree polynomial fit for the three stations of analysis is depicted in figures 2-7 below.

The 4th degree polynomial function used to get the simulated MAM rainfall at Dagoretti was of the form $Y = a+bx+cx^2+dx^3+ex^4$, where a =812.6, b= -223.5, c= 65.5, d= -8.6 and e= 0.385. From figure 2 below, the MAM rainfall at Dagoretti seems to have a significant decadal cycle. This 10-year cycle is analogous to the solar cycle. Although some of the peaks are not well captured, the overall rainfall trend is clearly illustrated.

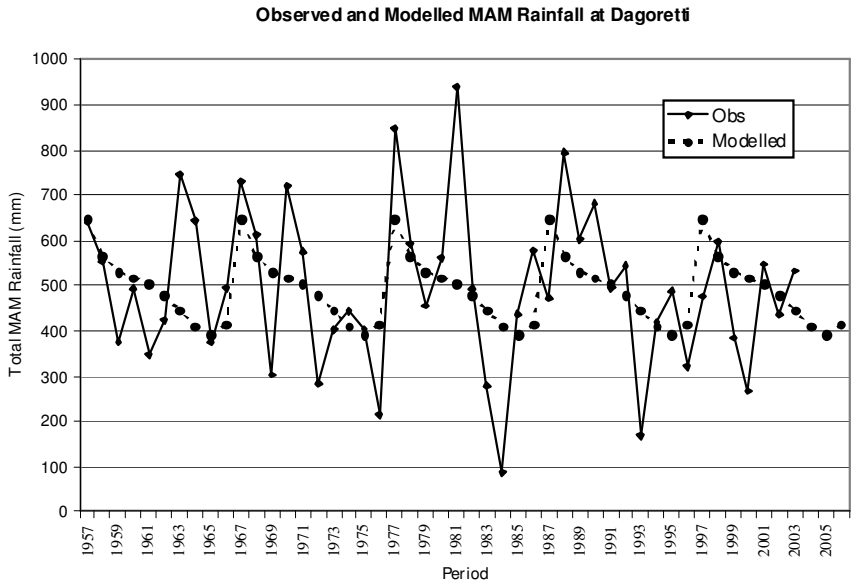


Figure 2: *Recorded and Simulated MAM Rainfall at Dagoretti*

The polynomial equation for the simulated OND rainfall at Dagoretti was of the form $Y = a+bx+cx^2+dx^3+ex^4$, where a=673.8, b=-433.1, c=151.1, d=-19.6 and e=0.836.

From figure 3 above, the 4th degree polynomial fit depicts the mean rainfall at Dagoretti. The predicted rainfall also seems to have a unique oscillation pattern of 10 years. A comparison of figures 2 and 3 shows that there is minimum variability in the MAM seasonal rainfall at Dagoretti as compared to the OND rainfall. This variability may be associated with the systems that influence the short (OND) and long (MAM) rains in Kenya, such as the inter-tropical convergence zone, easterly and westerly winds, monsoons and the presence of mountains. There is need to investigate this finding further.

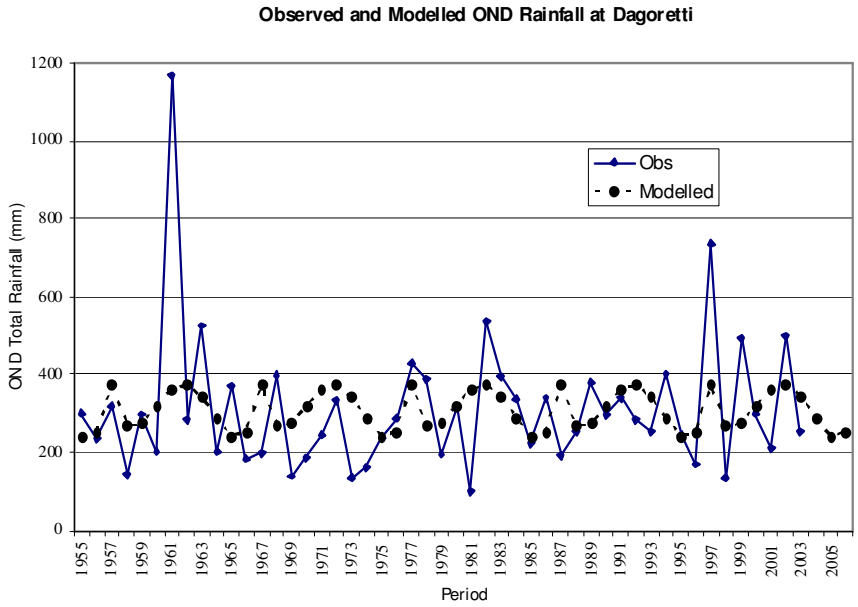


Figure 3: *Recorded and Simulated OND Rainfall at Dagoretti*

The polynomial equation for the simulated MAM rainfall at JKIA was of the form $Y = a+bx+cx^2+dx^3+ex^4$, where a= 654.4, b= -287.3, c= 89.1, d= -11.6 and e= 0.523.

From figure 4, a similar decadal cycle pattern as observed at Dagoretti for the same season was repeated. The rainfall peaks slowly declined over a period of 10 years.

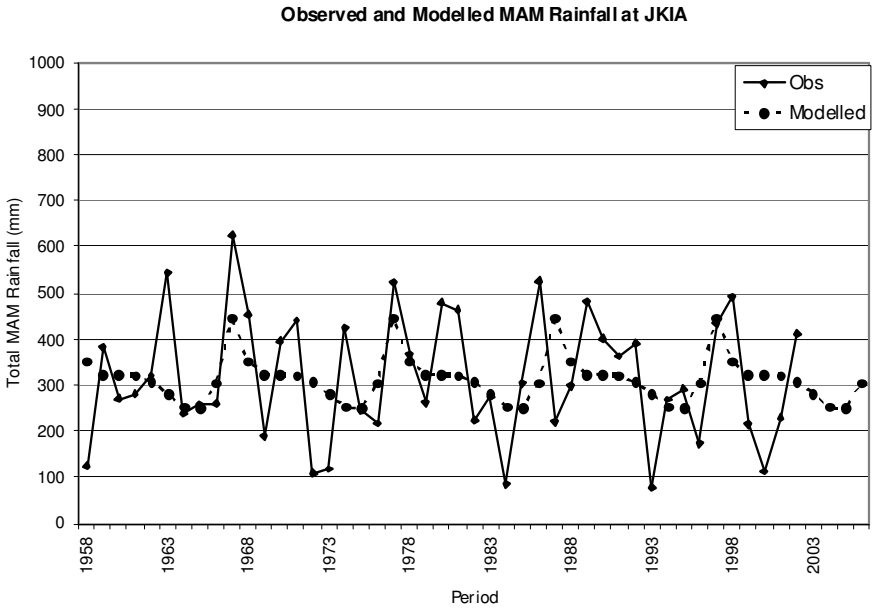


Figure 4: *Recorded and Simulated MAM Rainfall at JKIA*

The polynomial equation for the simulated OND rainfall at JKIA was of the form $Y= a+bx+cx^2+dx^3+ex^4$, where a=482.3, b= -238.6, c=82.2, d= -10.5, e=0.432. Figure 5 depicts mean rainfall at JKIA, which has the same decadal pattern as figure 3.

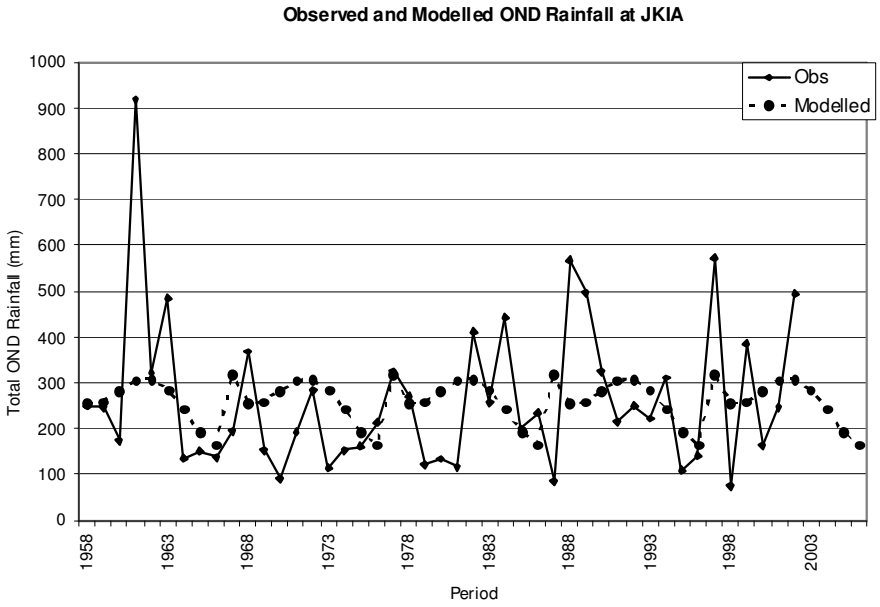


Figure 5: *Recorded and Simulated OND Rainfall at JKIA*

The polynomial equation for the simulated MAM rainfall at Wilson was $Y= a+bx+cx^2+dx^3+ex^4$, where a=843.3, b= -272.3, c=69.8, d= -8.6 and e=0.392. Figure 6 above has the same decadal pattern as figures 2 and 4 above. Using the 4^{th} degree polynomial fit, the prediction of the peak and general rainfall for the MAM season seems to be better simulated at Wilson than at Dagoretti and JKIA.

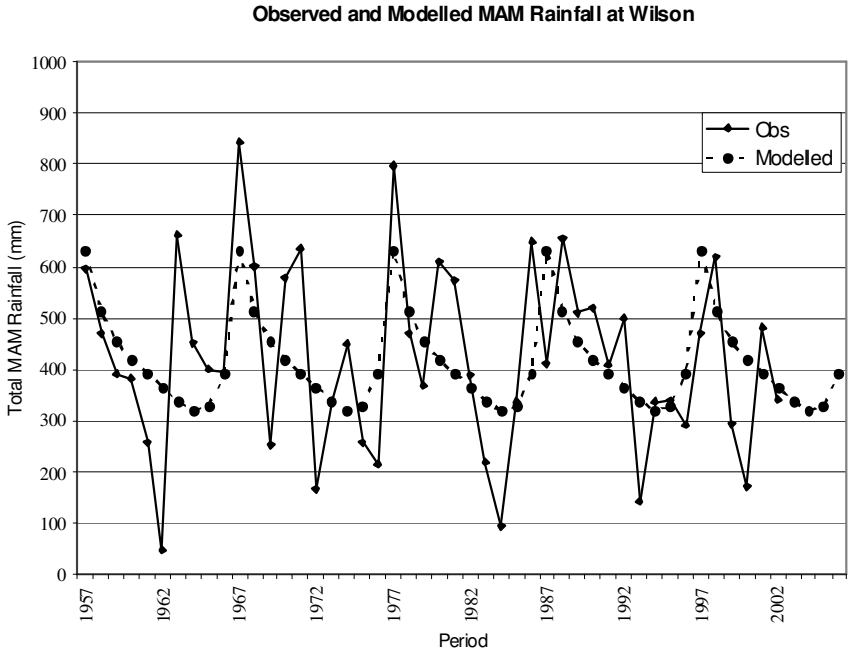


Figure 6: *Recorded and Simulated MAM Rainfall at Wilson*

The polynomial equation for OND rainfall at Wilson was $Y= a+bx+cx^2+dx^3+ex^4$, where a= 686.7, b= -520.7, c= 186.9, d= -24.5 and e= 1.051. Figure 7 has the same decadal pattern as figures 3 and 5 above. Even though figure 7 does not predict the peaks well, the general pattern of the mean seasonal rainfall has been captured.

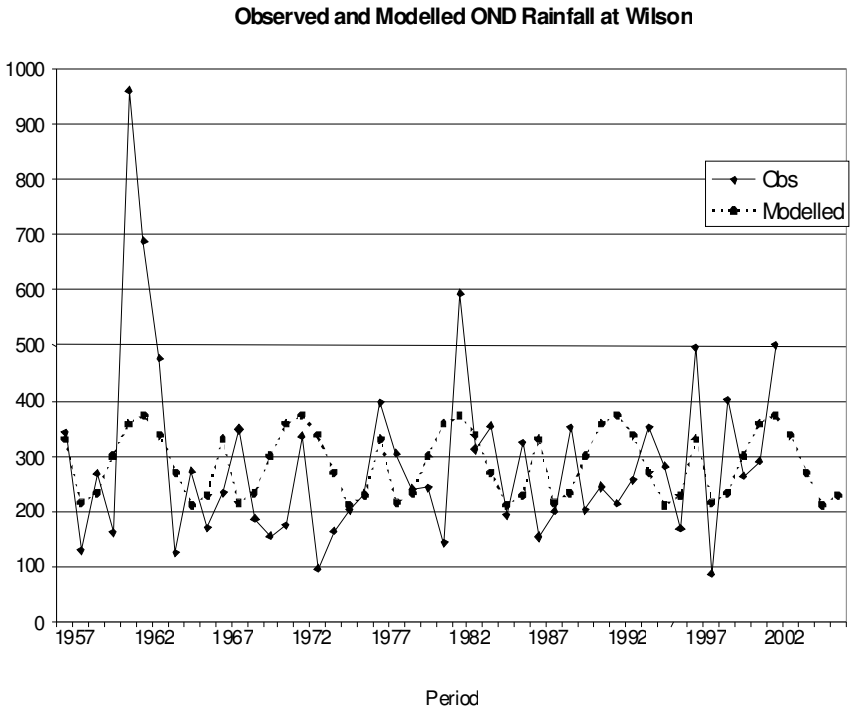


Figure 7: *Recorded and Simulated OND Rainfall at Wilson*

From the results obtained, the oscillations of the MAM and OND rainfall followed a unique repetitive pattern, which mimics the solar cycle. This suggests that the solar cycle of ten (10) years is useful for projecting long-term seasonal rainfall patterns at Nairobi. The SSE was computed for 5, 10 and 11 year-periods , where it was also evident that the ten-year period had the least error as compared to the 5 and 11 year-periods.

Conclusion

Amongst the numerous mathematical functions considered, the fourth degree polynomial was found to be the best fit for rainfall prediction purposes in Nairobi, for both the short rains (October-December) and the long rains (March-May). The ten-year period of rainfall used to generate the 4th degree polynomial function corresponded to the sunspots cycle of approximately 11.3 years. The ten-year period had the least SSPE, as compared to five and eleven-year cycles for both the long and short rains.

The amount of MAM rainfall had minimal variability over a ten-year period as compared to the 5 and 11-year periods. Unlike the MAM rainfall, the amount of OND rainfall had minimal variability over a 5-year period.

The 4th degree polynomial function was found to predict the peaks and the general pattern of MAM rainfall at Nairobi with minimal/acceptable error values. For OND, the 4th degree polynomial function simulated the general pattern of the mean values.

From the study it can be concluded that planning for water use and management in Nairobi during MAM should be for a ten-year period, since we have minimal variability during this period. For OND, it is recommended that the planning and management of water in Nairobi should be for a period of 5 years. This study recommends, therefore, that long-term rainfall prediction at Nairobi may attain reasonably good accuracy by using polynomial fit of the fourth order. This is a useful mechanism for planning.

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