DE GRUYTER OPEN

DOI 10.1515/sbe-2017-0010

INVESTIGATING A RANDOM WALK IN AIR CARGO EXPORTS OF FRESH AGRICULTURAL PRODUCTS: EVIDENCE FROM A DEVELOPING COUNTRY

MAWANGA Freddie Festo
Makerere University Business School, Kampala, Uganda

Abstract:
Since the 1990s exports of fresh agricultural products by air from Uganda have been increasing and making a significant contribution to her International trade. Products include mostly fish, flowers, papain, and vanilla constituting over 95% of all air exports. Farming of the items is mainly by small scale farmers who depend on the natural climate of the country. Consequently, monthly yields are also climate dependent making individual export volumes unpredictable. In spite of these uncertainties, this study was intended to investigate possible existence of a model in the trends. Monthly data were collected from Uganda Civil Aviation Authority from 2009 to 2012. Analysis was by using ARIMA Approach with the help of Eviews 8.Visually the data exhibited irregular patterns and without a trend or seasonality. First order differencing stationarised the data and the residuals had a random non-significant noise suggesting a Random Walk Model expressed as ARIMA (0, 1, 0) and a negative drift. The model shows a link between current and one lag export volumes and the negative drift is a convergence of successive differences in export volumes. These findings have policy implications in expansion and forecasting of the exports potential of applicability of Random Walk Theory in practice.

Key words: *ARIMA, Fresh Agricultural Exports, Random Walk, Drift*

1. Introduction

In many developing countries, production of agricultural products is by indigenous people. Farming depends therefore on the natural climate of the country leading to diverse production quality and volume challenges. One farming sector by small scale farmers in these countries is production of fresh agricultural products. Its increase over the years is a result of their value on the International trade (Kasarda, Appold & Mori, 2006). Uganda is one of the developing countries that exports fresh agricultural products since the 1990s through Entebbe International Airport. Exports include mainly fish, flowers, papain and vanilla. According to Civil Aviation Authority of

Uganda Annual Statistics Book of (2012) the fresh agricultural exports amounted to 23,475 tones in that year and this was95% of all air cargo exports, while (UBOS, 2012 Statistical Abstracts) reported that these exports constituted over 7% of all export revenue earned by the country. Each product has its own farming life cycle and export conditions. For example volumes of fish from the natural waters increase during the wet seasons or when most nights in any month are dark, although fish farming is being encourage. Vanilla is grown under natural conditions and has one main harvesting season in a year, while flowers are grown mainly under controlled environment by medium and large scale investors. Papain is grown by local community famers and has two main harvest seasons in the year. According to Civil Aviation Authority of Uganda Annual Statistics Book of (2012), air cargo exports of fresh agricultural products from Uganda included; 37% to Middle East, 35% to Europe, 9%to South Africa, 9% to South Sudan, 5%to Kenya. However, the monthly export volumes are irregular. This volatility could be contributing to lack of interest in investigating possible models in the series and policy formulation despite the growing importance fresh agricultural exports on the International trade have in the country.

Motivation

Exports of air cargo fresh agricultural products are a substantial contributor to Uganda's International trade. Despite the products having growing value internationally, the export trends have remained irregular and thus attracted little research. A quantitative analysis of these trends could be used to confirm statistically a Random Walk model in the series. This study investigated this knowledge gap as an extension of the works of (Basak, West &Narang, 2013) that export of perishable or sensitive products for any country has a big contribution to international trade; and (Belaire-Franch & Opong, 2005) that irregular series can be modelled using a Random Walk Theory and also understand any possible policy implications of the trends.

2. Literature Review

Fresh Agricultural Production and Export

Globally the types of fresh agricultural products produced vary from one country to another because of different factors. In most developing countries production is mainly by small scale farmers although they face varying challenges. For example, (UNCTAD, 2008) reveal that production of fresh fish in Sub-Sahara does not have prior realistic market opportunities globally and locally, has no clear government and private sector roles, and farmers are not equipped with the required competencies to compete globally. They conclude that there is need for a deliberate effort by governments and the private sector to set up appropriate strategies that can make the small scale farmers contribute effectively in the trade. Another study by (Chandra1 & Kar, 2006) reveals that although India is a leading fruit producer worldwide, the exports face challenges related to production practices, post harvest technologies, supply chain challenges, market access, non-tariff restrictions; and unfavourable governmental policies. That is why Sáenz, Cruz & Lam (2009) recommends that effective logistics in fresh agricultural production should include integrated planning and implementation processes; and efficient information management throughout the entire supply chain so that the products are available to consumers rapidly, economically and reliably.

According to UNCTAD (2008) export of fresh agricultural products has a segmented market worldwide although in Sub-Saharan Africa countries it is affected mainly by quality requirements, low exports volumes, countries not being strategically placed or lack of infrastructural and logistical facilities. Wu (2011) gives one example of export challenge as a requirement to book containers in advance, while (Kasarda et al, 2006) found the cost of ocean container freight and delays due to interruptions in flow of information between organizations as a challenge. While exporting fresh-agricultural products face different challenges, (De Mel, Jayaratne & Premaratne, 2011) found that their volumes have been increasing because of increase in passenger volumes**.** In this business, export information is very important, because (Allen, 1994) asserts that it benefits farmers and agribusiness industries to provide routine publications; and for governments to formulate policies.

ARIMA Modeling

Modeling provides substantial contributions to understanding the dynamics of activities such as time series in which data is assumed to consist of a systematic pattern of a long term trend, seasonality and random noise. According to Box-Jenkins(1976), ARIMA modeling of time series assumes a time dependent variable Y (Y_1, Y_2,..,Y_n), ordered according to a time variable t(1, 2, .., n) and when the series do not have a seasonality component the equation for the series is:

$$Y_t = C + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + ...+ \phi_p Y_{t-p} + \varepsilon_t - \beta_1 \varepsilon_{t-1} - \beta_2 \varepsilon_{t-2} - ... - \varepsilon_{t-q}$$

Where ϕ_i (i = 1….p), β_i(i= 1, …….. q) are parameters to be estimated and $\beta_1 \varepsilon_{t-1}$ ... are error terms.

The equation is summarised as ARIMA (p, d, q) where p is Autoregressive order, d is order of Differencing, and q is order of Moving Average when the series are stationarised. Practical values of p, d, and q are 0, 1 or 2, thus providing a diverse set of possible models in any data. The Box-Jenkins Approach suggests four phases of analysing data. The first stage is identification of the model in which the parameters of ARIMA(p, d, q) are suggested using Correlograms and Augmented Dickey Full (ADF) tests when stationarity is attained. However. it may be necessary to transform the data to satisfy the conditions of the first phase. Common transformations include using the natural logarithms; square roots or reciprocals of the data when the original data exhibits increasing variance. Estimation phase involves using outputs of different estimate equations of the model to find which one has the highest R^2 and lowest SSE and BIC as a most suitable model. In the third phase the most suitable model undergoes Diagnostic test to find out whether its residuals are a noise and follow a normality distribution. Finally, the model is evaluated before its applicability in forecasting.

Random Walk Models

Random Walk in time series occurs when the noise component dominates a pattern revealing an irregular growth, thus excluding a likelihood of modeling the data using the level of the series (Y_t) at each period directly. Poole (1967) was one of the first researchers to investigate the Random Walk Theory focusing on volatility of stock market rates and up to now most studies applying this theory focus on this activity. Modeling of such series is considering the difference between successive data values expressed as ($Y_t – Y_{t-1}$). Halkos & Kevork (2005) aver that many economic time series seem to have random walk components and define a random walk as the cumulative sum of random disturbances. When the mean of the random disturbances is 0, as is often the case, the random walk will show no overall trend but when the mean is non-zero, its value is called a drift and its sign will show the direction of the long term trend in the series. The mean of the trend determines a bias called a stochastic trend rather than deterministic trend though the series has both components. The theory of Random Walk is expressed therefore as:

$$X_1 = ϴX_0 + α_1, \text{ but } X_2 = ϴX_1 + α_2, \quad \text{and } X_3 = ϴX_2 + α_3$$

and it is generalised as: $Xt = \sum \alpha t$

where X_t is the current value and $α_t$ is a random variable with mean zero and this represents a recursive trend of dependence. If a model has a drift, μ the equation is:

$$X_1 = ϴX_0 + α_1 + μ \text{ but } X_2 = ϴX_1 + α_2 + μ \text{ and } X_3 = ϴX_2 + α_3 + μ$$

Generalized as: $Xt = \mu t + \sum \alpha t$

Lindgren & Rue (2008) suggest that when a Random Walk Model has significant positive autocorrelation in the residuals at lag 1, its suitability should be compared with a model of ARIMA (1,1,0), and if it is negative and significant the comparison should be with a model of ARIMA(0,1,1) rather than forcing other popular models as discouraged by (Box & Jenkins, 1976). Using this literature the following Hypothesis is made.

H_o: Monthly volumes of fresh agricultural products exports from Uganda are independent suggesting a Random Walk model.

3. Materials and Methods

There are two main goals of time series analysis; identifying the nature of the phenomenon represented by the sequence of observations and forecasting the series. In this study, the Box-Jenkins ARIMA model was used to achieve these two goals.

Monthly data were collected from UBOS Annual Abstracts for the period January 2009 up to December 2012. The collected data is shown in Table 1.

Table 1: Monthly Fresh Agricultural Exports (Tones)

	Year			
Month	**2009**	**2010**	**2011**	**2012**
January	2,656	2,279	1,894	2,216
February	2,092	1,855	1,889	2,151
March	2,294	1,776	1,863	2,378
April	1,797	1,067	1,857	2,212
May	1,886	1,361	2,060	2,450
June	2,086	1,565	2,129	2,590
July	1,866	1,794	2,202	2,701
August	1,721	1,861	2,095	2,458
September	2,035	1,692	2,124	2,596
October	2,247	2,183	2,160	2,580
November	1,864	2,120	1,971	2,693
December	1,644	1,982	2,191	2,479

According to the Box-Jenkins Approach, the data were divided into two parts; the Training data (2009:01 to 2012:06) and Evaluation data (2012:07 to 2012:12) for analysis purpose in the analysis (Weiss & Provost, 2003).. Analysis was with the help of Eviews 8 Package because of its ease of use and interpretation of outputs for time series data. Box & Jenkins (1976) processes were applied in modeling by considering outputs of the line graphs. The line graphs though irregular did not justify transformation of the data since the pattern had no increasing variance. Correlograms and ADF tests were used to determine stationarity through successive differencing. Estimation of the model was based on (Box & Jenkins, 1976) suggestion of analysing the characteristics of the first order lag of the ACF in the correlograms. Diagnostic tests were carried out on the residuals to confirm its suitability before measuring its forecasting performance. Lastly out of sample forecasting and forecasting for 2013:01 were computed using the estimation equation.

4. Findings

A line graph of the Training data is shown in Figure 1 revealing an irregular pattern without seasonality and directional trend. A shock exists in 2010:04 to 2010:06. Furthermore, exports in April are less than those of the preceding and succeeding months while January exports are more than February export volumes in all years.

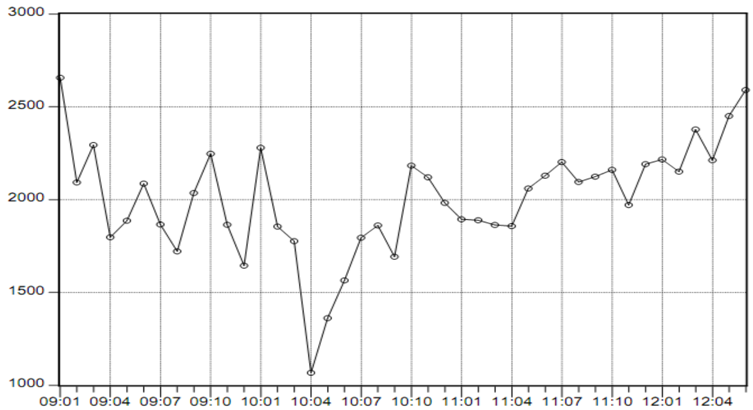
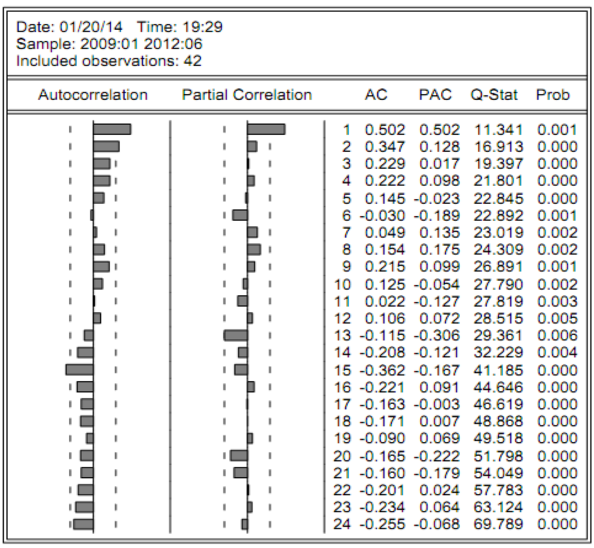


Figure 1: Monthly Trends in Training Data

A correlogram was plotted using 24 lags as shown in Figure 2 and the ACF reveals a serial correlation while the PACF cuts off after the first lag



Date: 01/20/14 Time: 19:29
Sample: 2009:01 2012:06
Included observations: 42

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.502	0.502	11.341	0.001
		2	0.347	0.128	16.913	0.000
		3	0.229	0.017	19.397	0.000
		4	0.222	0.098	21.801	0.000
		5	0.145	-0.023	22.845	0.000
		6	-0.030	-0.189	22.892	0.001
		7	0.049	0.135	23.019	0.002
		8	0.154	0.175	24.309	0.002
		9	0.215	0.099	26.891	0.001
		10	0.125	-0.054	27.790	0.002
		11	0.022	-0.127	27.819	0.003
		12	0.106	0.072	28.515	0.005
		13	-0.115	-0.306	29.361	0.006
		14	-0.208	-0.121	32.229	0.004
		15	-0.362	-0.167	41.185	0.000
		16	-0.221	0.091	44.646	0.000
		17	-0.163	-0.003	46.619	0.000
		18	-0.171	0.007	48.868	0.000
		19	-0.090	0.069	49.518	0.000
		20	-0.165	-0.222	51.798	0.000
		21	-0.160	-0.179	54.049	0.000
		22	-0.201	0.024	57.783	0.000
		23	-0.234	0.064	63.124	0.000
		24	-0.255	-0.068	69.789	0.000

Figure 2: Correlogram of Monthly Data Trends

A correlogram of the series was plotted using 24 lags as shown in Figure 2 and the ACF reveals a serial correlation while the PACF cuts off after the first lag

The correlogram suggests an initial ARIMA (1, 0, 0) model which was tested for stationarity with ADF Statistic using the Hypothesis

H_o: p = 1 (the series is non-stationary)

The Hypothesis was not rejected because the series yielded a value -2.053039 (greater than the critical value of -3.6019 at 1% level of significance). The series was differenced and the line graph suggests stationarity as shown in Figure 3.

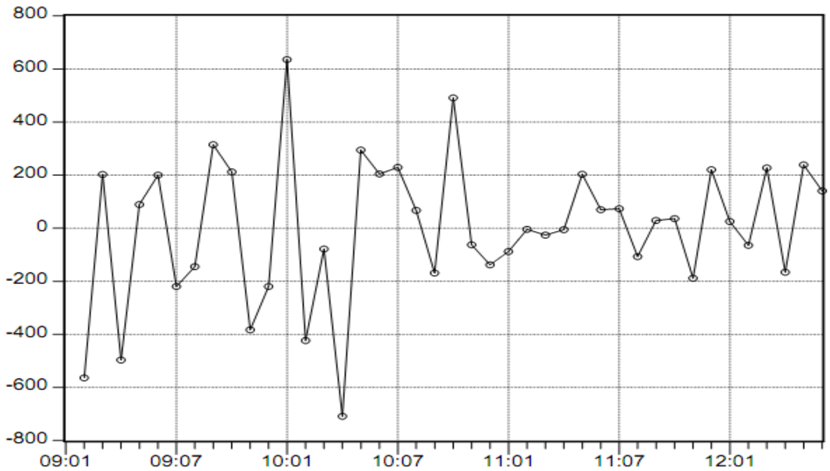
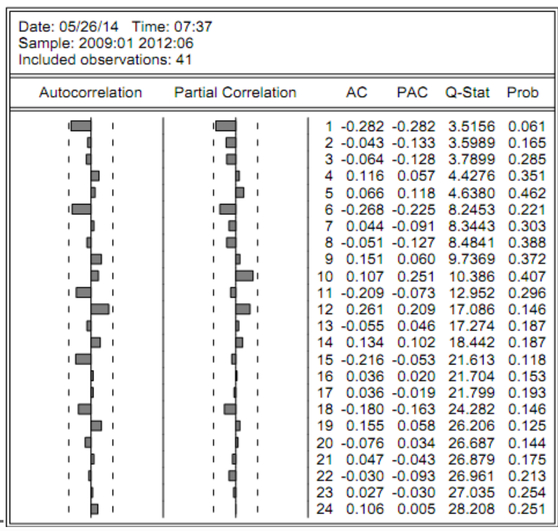


Figure 3: Monthly Trends of Differenced Data

A correlogram of the differenced series is shown in Figure 4 and reveals that the ACF and PACF values are not significant and are random suggesting a random walk model.

Figure 4: Correlogram of Differenced Monthly trends



Date: 05/26/14 Time: 07:37
Sample: 2009:01 2012:06
Included observations: 41

	AC	PAC	Q-Stat	Prob
1	-0.282	-0.282	3.5156	0.061
2	-0.043	-0.133	3.5989	0.165
3	-0.064	-0.128	3.7899	0.285
4	0.116	0.057	4.4276	0.351
5	0.066	0.118	4.6380	0.462
6	-0.268	-0.225	8.2453	0.221
7	0.044	-0.091	8.3443	0.303
8	-0.051	-0.127	8.4841	0.388
9	0.151	0.060	9.7369	0.372
10	0.107	0.251	10.386	0.407
11	-0.209	-0.073	12.952	0.296
12	0.261	0.209	17.086	0.146
13	-0.055	0.046	17.274	0.187
14	0.134	0.102	18.442	0.187
15	-0.216	-0.053	21.613	0.118
16	0.036	0.020	21.704	0.153
17	0.036	-0.019	21.799	0.193
18	-0.180	-0.163	24.282	0.146
19	0.155	0.058	26.206	0.125
20	-0.076	0.034	26.687	0.144
21	0.047	-0.043	26.879	0.175
22	-0.030	-0.093	26.961	0.213
23	0.027	-0.030	27.035	0.254
24	0.106	0.005	28.208	0.251

The ADF stationarity test was made using the Hypothesis:

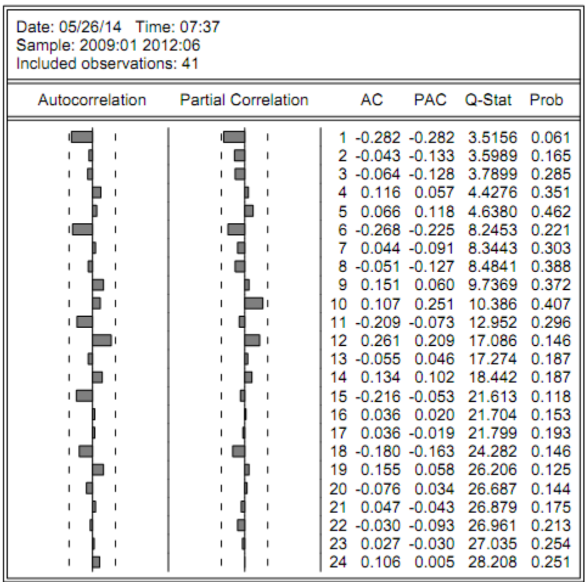
H_o: p = 1 (the series is non-stationary)

which was rejected because the ADF test statistic yielded an output of -5.554591(less than the critical value of -3.6019 at 1% level of significance suggesting that the model ARIMA(0,1,0) fits the data.

Estimation process was carried out by comparing the suggested model with ARIMA(0,1,1) because the first lag of the differenced data was negative and high (Box & Jenkins, 1976) but the former model was found to fit the data better because it had a higher value of R^2 and lower values of BIC and SSE. The estimation equation for the ARIMA(0,1,0) had a drift value of -1.67 and Durbin Watson value was 2.468307 showing a negative correlation between the series. Diagnosis of the model using a Jarque-Bera test for goodness of fit was carried out using the Null Hypothesis:

H_o: Residuals are normally distributed

Residuals of the histogram are shown in Figure 5 and the Jarque-Bera statistic value was 1.3 (less than the critical value of 5.9 at 5% level significance for 2 degrees and 41 observations) so the Null Hypothesis is not rejected and this was also confirmed further by the p-value = 0.5 (greater than the significant level of 0.05), thus the model was found good fit for data-was found good fit for data.



Date: 05/26/14 Time: 07:37
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		14	0.134	0.102	18.442	0.187
		15	-0.216	-0.053	21.613	0.118
		16	0.036	0.020	21.704	0.153
		17	0.036	-0.019	21.799	0.193
		18	-0.180	-0.163	24.282	0.146
		19	0.155	0.058	26.206	0.125
		20	-0.076	0.034	26.687	0.144
		21	0.047	-0.043	26.879	0.175
		22	-0.030	-0.093	26.961	0.213
		23	0.027	-0.030	27.035	0.254
		24	0.106	0.005	28.208	0.251

Figure 5: Distribution of Monthly residuals

Forecast performance of the model was computed and its MAPE value was 0.2% which was less than 2.03 (Pilatowska, 2011). A Random Walk forecast (Box & Jenkins, 1976) is represented by its immediate lag values expressed by the equation:

$$\dot{Y}_{t+1} = Y_t + \mu$$

Where $\dot{Y}_{t+1}$is a one period forecast, Y_t is current value and μ is the drift. Out of sample forecasting was used for confidence building using the evaluation data and a plot of the actual and forecast series is shown in Figure 6.

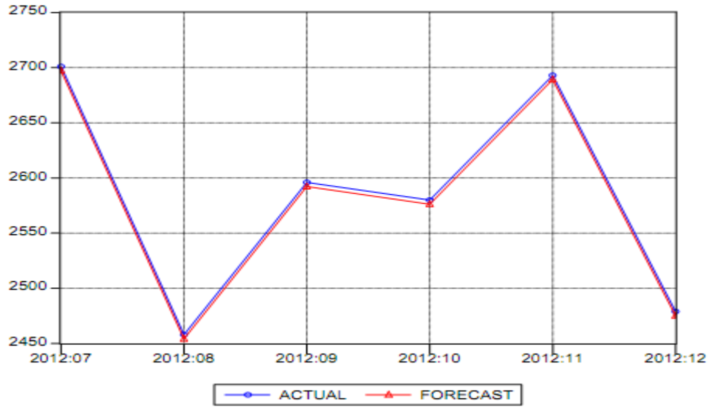

Figure 6: Monthly Trends of Evaluation Forecasting

According to the graph, out of sample forecast shows a "shadow" of the observed data lagging exactly one period of the actual data. Actual forecast of export volumes for January 2013 using the formula

$$\dot{Y}_{t+1} \quad = Y_t + \mu$$

The drift for the data series from 2009:01 to 2012:12 was -3.765957, so the equation becomes:

$$\dot{Y}_{2013:01} = Y_{2012:12} + -3.75597 = 2479 + -3.75597 = 2475$$

5. Discussion

Consistent with Basak et al (2013), the irregularity in exports of fresh agricultural products depends on factors like differences in their harvest periods, variations in production and export processes and quality variations. Irregularity in export volumes could be smoothened through aggressive programmes to equip the small scale farmers with requisite competences and support to produce the fresh agricultural products under more controlled and sustainable environments that meet export standards. The negative correlation revealed by the Durbin Watson value in the differenced series shows that a negative error in forecasting a given month leads to a positive error of forecasting in the following month thus fitting the stationarised trend. Existence of a drift shows that the series though random have a direction rather than tending to an assumed mean value. Since a drift is the average change of the differences and represents the acceleration between the monthly export volumes, its negative value indicates that as the time difference increases the exports volumes converge as explained by Lindgren & Rue (2008).

Vanilla requires sunshine, high rainfall and humidity, short dry seasons to stimulate flowering, has to be hand-pollinated early in the mornings within a day after flowering, has a cycle taking 8 – 9 months. As a result it makes vanilla production to depend so much on favourable weather which and proactive farming methods which are lacking. Sustainability of vanilla exports therefore, requires an integrated intervention approach. Modern farming of papain is being promoted to reduce irregularity in its production and its quality in meeting international standards. Its use globally is increasing in manufacturing different human items. So Uganda could exploit more opportunities of its export potential.

Traditionally fish harvesting in Uganda is from fresh natural waters (UNCTAD, 2008). However poor fishing methods have depleted the stocks of fish suitable for export, thus affecting export volumes. Even the eligible small scale fishermen do not have enough facilitation to sell their fish to the exporters which view is shared by (Briz et al, 2003). Efforts are made to promote fish farming among small scale farmers. Failure by the farmers to have the requisite management and technical competencies combined with challenges of climate and predicators makes production levels poor, low and irregular. Furthermore, infrastructural and logistical constraints make potential farmers and exporters fail to join the business. Considering export volumes of flowers. The item has seasonal trends although their production is controlled and more predictable because of help by Dutch Investors though their production is also affected by weather as asserted by UNCTAD (2008).

From this study, it is revealed that the overall export volumes of fresh agricultural products have irregularity and one of the ways to reduce this is collaborative efforts involving all stakeholders like farmers, investors, transporters, customers and government. The study also reveals that market for the products is still available as indicated by The Daily Monitor Newspaper of Monday January 27, 2014 page 3 that Government of Uganda has a plan to increase fish exports and other fresh agricultural exports because of the favourable climate all-year round, improvements in farming methods and improved air cargo transport.

6. Conclusion

Modeling time series can be complicated because it requires good understanding of the data and analytical skills particularly when using ARIMA techniques. Despite this challenge, in this study it has been proved that the irregular monthly export volumes of fresh agricultural products from Uganda can be modeled using the Random Walk Theory and expressed by ARIMA(0, 1, 0) model. This finding adds credence to the knowledge that most time series can be modelled thus enabling policy makers to exploit this potential and researchers to make more investigations in similar trends.

7. Implications

Air cargo exports avoid difficult or costly border crossings and reduce risks experienced in road and sea transports. With the increasing demand of organic farm products worldwide, government of Uganda can increase exports of fresh agricultural product using varying integrated strategies. One strategy could be setting up sustainable support programmes and regular interventions to farmers. The interventions could include financing, logistics, capacity building, advisory services, technological and communication infrastructure, advocacy and research. This can also be integrated with promotion of stakeholder involvement and encouragement of more aggregation of fresh agricultural product exports to exploit the increase in passenger flight connections globally.

8. Limitations and further Studies

The study is an initial attempt to model exports of fresh agricultural products from Uganda using ARIMA Approach. It is also known that these exports are affected by many causal factors that would enhance understanding and improvement of the business processes and formulation of policies. Furthermore, the study considered aggregated export volumes giving opportunities in analysing other trends like monetary trends and exports of individual fresh agricultural products.

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