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Analysis of Seasonal Pattern and Variation of Rice Prices in Tanzania

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Authors' contributions

This work was carried out in collaboration between both authors. Author MYJ designed the study, wrote the protocol and performed the survey and tabular analysis of the study. Author YY supervised meticulously the whole work. Author MYJ wrote the first draft of the manuscript and managed the literature. Both authors read and approved the final manuscript.

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ABSTRACT

The objective of this paper was to study Tanzania's rice sector, regarding the seasonal behavior of wholesale rice prices in the Mbeya Region. It's considered that price is the most crucial variable in the farmer's decision making. The classical multiplicative model was employed in the analysis of monthly time-series data from 2004 to 2018 to verify if there were changes in the seasonal variation pattern. The data were obtained from the Ministry of Industry, Trade, and Marketing in Tanzania. According to the results, rice prices seem to have followed a consistent and logical pattern around their annual average, in spite of increased uncertainty and variability in the overall Tanzania grains markets. The months of November to May were the best month for selling rice as the seasonal variation indexes were highest, above 100%; thus, farmers would gain more by storing rice during the harvest period for future sales. On the consumer side, the best month for purchasing rice was from June to October, which is harvest season. Knowledge of these rice price patterns and the risk levels of specific months can be useful to producers and purchasers as they develop their annual marketing plans.

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1. INTRODUCTION

Rice is the most important cereal in the world and is the staple food for mitigating hunger on the planet Briceño and Álvarez [1]. According to FAO [2], Tanzania is the second-largest producer of rice in Southern Africa after Madagascar, with an estimated annual production of 2.3 million tones. In Tanzania, rice cultivation is the primary food source, forming part of the essential diet for rural and urban families [3], which is produced in small, medium, and large properties. Rice production ranks second after maize in terms of grains, with per capita consumption of 25 kg per year, accounting for around 9 percent of the nation's calorie intake [4]. Tanzania produces various varieties of rice, depending on the region and agro-climatic conditions. About 25% of the national rice production comes from two regions: Mbeya and Morogoro [4].

The products of the agri-food sector have a major feature; the volatility of prices [5,6]. Price variation has been one of the major concerns for those responsible for economic policy in recent years because of its influence on the dynamics of economic activity, inflation, and balance of payments [7]. According to Hoffmann [8], the mastery of seasonal variation in agricultural prices is vital for directing the decisions of farm producers and traders, as well as for articulating government agricultural policies. Seasonal price variability may also translate into food security. When different coping mechanisms are not available or inadequate to cope with variations in food prices, households might no longer be able to smoothen their consumption throughout the year, resulting in welfare loss.

In general, prices for agricultural products are highly unstable compared to non-agricultural products. This price instability is directly linked to the biological nature of agricultural production (which suffers from climate instability or pests), also implying the difference between planned production and production obtained. Seasonal variations also influence monthly price changes, as some crops can only be harvested once or twice a year, and for some of them, the possibility of storage is impractical. The gaps between the decision to produce and the harvest due to the adaptation of some crops are another factor that changes the price relationship. Geographical dispersion between crops also influences price because it makes production control, gathering, and forecasting difficult. On the other hand, agricultural production has a very complex adaptation to market needs; this is because consumption remains virtually continuous throughout the year or grows at steady rates between the years, driven by population growth and rising per capita income, while production is unstable and seasonal [9,10]. These factors make it difficult to adjust between production and market nuances, which forces producers to be more careful with price fluctuations. Several authors point to volatile behavior, both in production and in the price of agrifood products, causing producer inconsistency [11,12,13].

Given the above, this study aims to understand the price pattern and variation in the context of planning and decision making to market rice in the wholesale markets, through the analysis of a historical price series, in the period from 2004 to 2018. This analysis somewhat reflects the price variation at the national level.

2. MATERIALS AND METHODS

The study used secondary data on the monthly rice prices paid to producers for the marketing of 100 kg sack in the Mbeya region from January 2004 to December 2018, available from the Ministry of Industry and Trade, Tanzania. Information on the consumer price index was collected from the Tanzania National Bureau of Statistics (NBS).

2.1 Data Availability Statement

"The data that support the findings of this study can be accessed through the Ministry of Industry and Trade, Tanzania at http://www.mit.go.tz, and Tanzania National Bureau of Statistics at https://www.nbs.go.tz."

In order to analyze the behavior of rice price in the stated period, we used the classical centered time series model, divided into four patterns: Trend (T), which is the long-term behavior of the series, which may be caused by demographic growth, gradual change in consumption habits, or any other aspect that affects the long-term variable of interest; Cyclic variations or cycles (C), which are fluctuations in the price values lasting more than one year and repeating with certain periodicity; Seasonal variations or seasonality (S), which are fluctuations in price values lasting less than one year due to climatic or economic variations, etc.; and lastly Irregular variations (I), which are unexplained fluctuations, such as natural disasters, terrorist attacks, etc. [8], (Spiegel, 2001).

Decomposing a time series into patterns is very useful as it allows us to identify which components are acting in that particular set. There are two modes of decomposition of a time series: the additive model and the multiplicative model. In the additive model, the value of the series is Y = T + C + S + I if data are recorded annually, and Y = T + C in the absence of seasonality and irregular variations. While, in the multiplicative model, the value of the series Y = T × C × S × I if data are recorded annually and Y = T × C in the absence of seasonality and irregular variations [8].

Calling the dependent variable Y and T, C, S and I as independent variables, the general time series model is presented by equation (1).

$$Y = f(T, C, S, I) \tag{1}$$

Note that in the additive model, the independent variables have the same unit of the dependent variable, and in the multiplicative model, the product of the independent variable units produces the same unit of the dependent variable. The model to be adopted depends on the data series and the intrinsic characteristics of the problem. If the variations are regular, the additive model is used, otherwise the multiplicative model [8].

2.2 Trend

Trend determination assists in assessing the behavior of a time series and its use in forecasting. The trend can be removed from the time series to facilitate visualization of the other components and to identify the typical range of values the variable can assume when there is no increasing or decreasing behavior over time.

Equations (2) and (3) explains trend removal in the additive and multiplicative models, respectively.

Additive model:

$$Y - T = S + C + I \tag{2}$$

Multiplicative model:

$$Y/_T = S \times C \times I \tag{3}$$

In the additive model, with the removal of the trend, the values of the series fluctuate around zero. If equal to zero, the trend is not affected by seasonal, cyclical, and irregular factors. If greater than zero, indicates the trend increase, and if less than zero, the trend decreases. Alternatively, in the multiplicative model, with the removal of the trend, the values fluctuate around 1. If equal to 1, the seasonal, cyclical, and irregular factors do not affect the trend. If they are different from 1, but with error from 1 to 5%, the trend will not be affected by seasonal, cyclical, or irregular factors either, and if the error around 1 is greater than 5%, the trend will be affected by these factors.

The trend can be obtained through regression models or moving averages. In regression, the mathematical model most used to try to explain the effect of treatments on the response variable is the polynomial model. The adjusted polynomial (regression equation) is of the form of equation (4).

$$T_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \ldots \ldots \ldots + \beta_n t^n \tag{4}$$

Where β_n, are the parameters to be determined and $n = 1,2,3, \ldots n$ is the degree of the model polynomial. In the case of the experiments, the variable t, or independent variable, is a nonrandom variable that corresponds to the treatments and the variable T, or dependent variable, which is the response variable (random variable).

The determination of trend (T) by moving averages is done according to Zilli and Barcelos (2006), by calculating the arithmetic mean of the first k periods of the series, placing the result in period t, precisely in the center of the k periods. If k is odd, that is, $k = 2\lambda + 1$ terms, where λ is a positive integer less than t, the moving average M_t corresponding to Y_t is given by equation (5).

$$M_t = (y_{t-\lambda} + y_{t-\lambda+1} + \ldots \ldots + y_t + \ldots \ldots + y_{t+\lambda-1} + y_{t+\lambda})/k \tag{5}$$

Where k = number of periods, M_t = moving average at time t (period) and, y_t = value of series at the time (period) t. The higher the number of periods in the series, grouped by moving averages, the more "smooth" the trend line becomes, and the fewer the number of periods, the more the trend will follow the original data. For this reason, when a series has many irregularities it is common to "smooth it out" using moving averages.

2.3 Seasonality

Seasonal variations in a time series are short-term fluctuations, which always occur within the year, and which are systematically repeated year after year. There are several methods for obtaining seasonal variations, as well as the lower and upper limits of variation in the period, called lower and upper confidence limits, respectively. According to Arias et al. (2009), among the most used methods, stands out the seasonal variation index (SVI), defined by equation (6).

$$SVI = {}^{Y_t}/_{CMA} \quad (6)$$

Where $SVI =$ Seasonal Variation Index; $Y_t =$ monthly arithmetic means in each period and; $CMA =$ general average of the series values in the period. According to Arias et al. (2009), the calculations for the lower and upper confidence limits in the period t are obtained through equation (7).

$$LCL \geq {}^{L}/_{CMA} \text{ and } HCL \leq {}^{H}/_{CMA} \quad (7)$$

Whereby: $LCL =$ lower confidence limit, $HCL =$ upper confidence limit, $L =$ lowest monthly series value each year, and $H =$ highest monthly series value each year.

As there were no irregular phenomena that could alter rice production during the historical series of the surveyed data, the parameter linked to the irregular variation I was eliminated from the model (I = 0). Thus, seasonal variation S was eliminated by choosing 12 months in the calculation of the moving average and irregular variation I, leaving only the trend T and the cyclic variation C.

To be able to forecast rice sack prices at certain times both inside and outside the period considered (2004 to 2018), the polynomial adjustment equation of the moving average values was determined, as well as the respective adjustment coefficient R^2, for establishing the model explanation.

3. RESULTS AND DISCUSSION

The historical price series of 100 kg sack of rice, marketed at wholesale markets in Mbeya region from 2004 to 2018, after correcting for inflation according to the Consumer Price Index (CPI) of the Tanzania Bureau of Statistics, referred to December 2018 (MIT, 2019; NBS, 2019) are presented in Table 1.

3.1 Seasonal Variation Index

Using equations (6) and (7), we calculated the seasonal variation index (SVI), the lower confidence limit (LCL), and the upper confidence limit (HCL) respectively. From Table 2, it is evident that the months with the highest SVI, above 100%, were from November to May, when the average price of rice was higher than expected. From April, the trend was for the price of rice to drop and reaches below 100% in June, continuing this behavior until August, but with an upward trend from September, reaching above 100% from November to May. The reason for this trend is that December to May is a growing period; this implies that the supply of rice is low as only rice which was stored is supplied, leading to higher prices during the period.

Disregarding the lower and higher risks, when the SVI is above 100%, the marketing of rice is favorable to the producer and unfavorable to the buyer, and the opposite occurs when the SVI is below the 100% level. Fig. 1 depicts the behavior for seasonal variation indexes of the price for 100 kg bag of rice in the study area, as well as the lower and upper confidence limits, respectively.

From Fig. 1, it can be concluded that from November to May the producer is likely to sell his product at a high price (SVI above 100%), but at the risk of selling it at a meager price between April and September, (LCL curve away from SVI curve). Note that December, January, March, April, and May are the months when the producer is most likely (at risk) for the most significant economic gains when the HCL curve is farthest from SVI. Coincidentally, there is some risk of loss in the marketing of rice by producers in February, April, May, and November, as the distances from SVI to LCL, are vast, representing risks of selling rice at prices well below those historically practiced.

From the buyer's point of view, the best period for buying rice is from June to October, when the SVI curve is below the 100% level. February is also a good month for the buyer to make his purchase of rice, although he is paying the price slightly above the 100% level for the bag of rice, the risk of paying a very high price is small because historically rice has not reached a very high price in this month (HCL curve close to the SVI curve).

Table 1. Real prices of the 100 kg bag of rice marketed in the Mbeya region, from January 2004 to December 2018 (in 1000 Tsh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	139.28	147.74	158.33	172.67	153.49	137.22	133.53	138.64	134.73	142.49	147.96	153.93
2005	154.32	156.97	153.78	156.79	148.79	137.58	130.83	121.95	123.51	127.49	129.88	145.33
2006	153.50	169.09	174.73	209.42	224.69	174.74	178.31	171.03	182.92	182.53	188.51	186.27
2007	182.42	170.76	158.84	158.97	158.37	159.66	149.97	144.90	155.03	163.58	172.25	173.47
2008	174.93	150.90	216.38	208.56	203.40	156.65	171.52	172.44	175.90	196.05	208.07	222.75
2009	216.14	226.62	215.03	202.34	197.33	167.49	206.31	187.86	182.46	192.59	193.53	202.51
2010	200.19	192.85	189.17	172.56	161.62	146.87	141.34	143.72	142.04	153.06	161.56	169.07
2011	170.94	180.63	190.91	197.49	178.91	169.44	175.33	174.66	178.65	229.19	267.74	253.93
2012	267.67	289.94	291.72	303.37	255.12	253.45	263.67	263.87	250.27	257.71	273.29	289.74
2013	301.63	255.74	235.92	163.54	166.17	169.19	165.33	139.40	129.80	132.68	140.61	137.67
2014	141.59	139.85	156.59	167.92	168.65	148.56	143.33	130.65	126.63	141.84	155.49	162.31
2015	151.26	163.66	167.18	178.31	163.16	160.78	154.34	155.89	161.42	170.42	171.20	182.57
2016	181.94	180.63	189.17	179.75	168.87	148.59	147.49	151.59	149.09	153.01	151.33	150.29
2017	155.97	169.59	181.85	183.56	184.62	175.70	180.55	163.33	188.53	188.96	192.00	194.89
2018	190.27	190.25	190.36	199.72	194.17	186.58	190.54	188.70	186.72	181.50	144.76	140.42

Table 2. Seasonal variation index of the 100 kg bag of rice in the Mbeya region

Months	Seasonal variation Index	Confidence limits (100%)	
		Lower confidence interval	Higher confidence interval
January	104.67	94.98	127.38
February	104.62	86.01	113.19
March	107.83	94.82	121.93
April	106.94	78.97	121.48
May	102.85	84.64	126.85
June	93.89	83.73	101.26
July	94.13	86.56	103.92
August	90.67	83.20	96.63
September	91.50	81.69	101.97
October	97.12	87.63	101.63
November	101.50	86.11	113.99
December	104.29	92.86	118.55

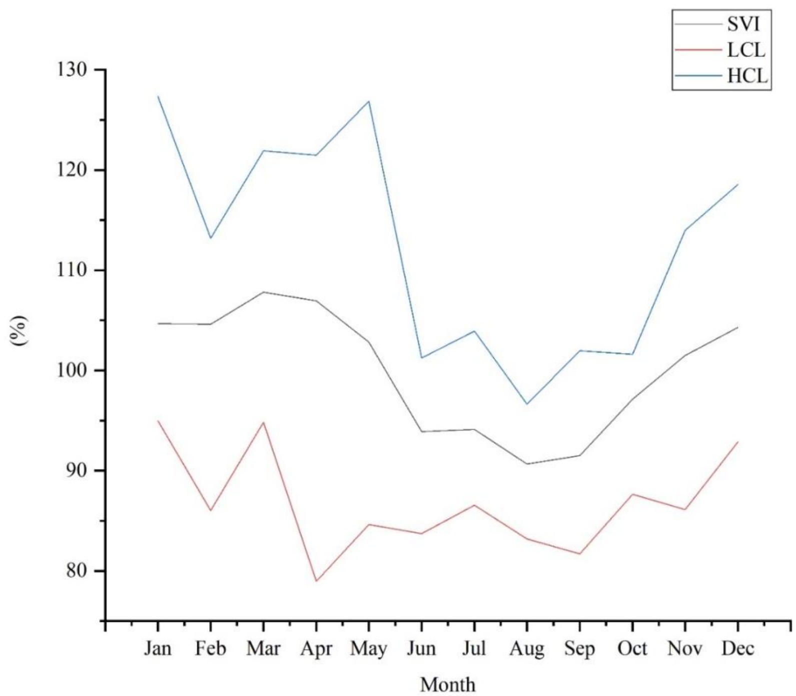

Fig. 1. Seasonal variation Index (SVI), lower and upper confidence limit (LCL and HCL), of the price for 100 kg bag of rice

3.2 Trend

The trend coefficients of all months showed a positive sign with a linear pattern, thus, indicating an increase in the prices of rice. This process may be due to demand growth for rice in rural and urban markets, which evolved faster than supply. Tanzania has one of the fastest-growing urban populations in East Africa, rising at 4.7 percent per year; the growing middle class prefers rice over other staples.

Initially, from Table 1, the 12 – period moving averages of the historical price series marketed in the study area was calculated, and Table 3 is obtained.

To analyze the behavior of moving averages (Table 3), the trend equation was determined through polynomial approximations, equation (4), whereby polynomial of grade 5 $T_t = 8E^{-09}X^5 - 2E^{-06}X^4 + 8E^{-05}X^3 + 0.0188X^2 - 0.377X + 54.006$), was found to be the best fits for the mean of price series paid to producers with R square of 0.7372.

From Fig. 3, it can be seen that from 2010 to 2013, there was a higher increase in the price level of the rice. This trend of a price increase during this period was due to food inflation, which rose to 19.3 percent in March 2012 [14]. From August 2013 onwards, the price of rice began to stabilize, driven by growth in domestic production and reduction in inflation.

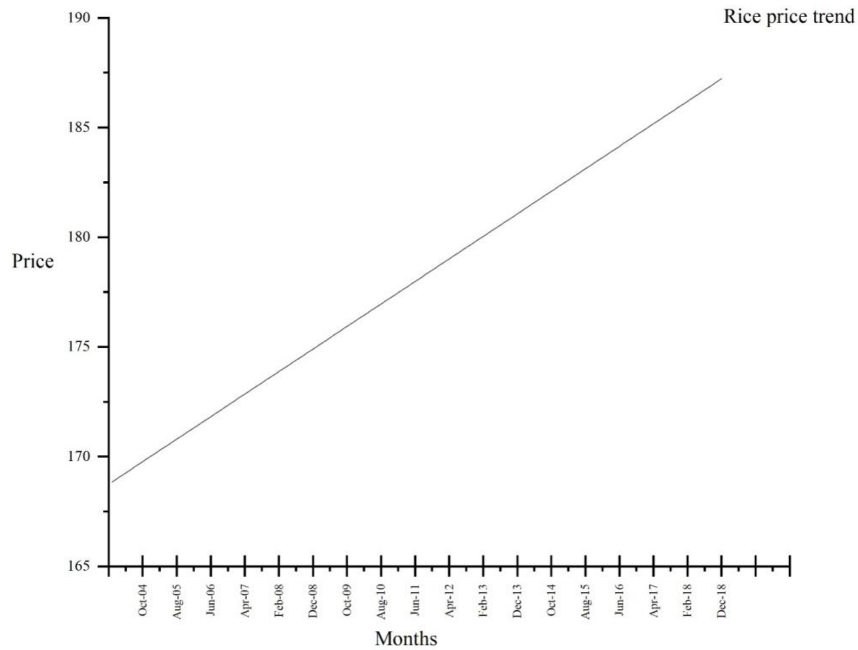

Fig. 2. Behavior of the wholesale price trend of 100 kg sack of rice in the Mbeya region

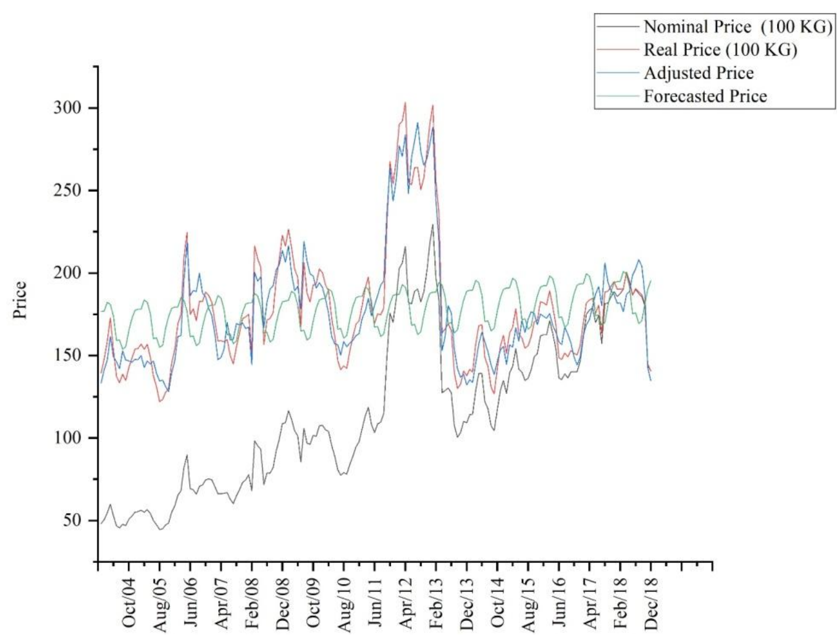

Fig. 3. Nominal prices, CPI corrected nominal prices, and 12 – period moving averages of the adjusted prices and the polynomial approximation of the 100 kg bag of rice marketed in the study area

Table 3. Moving averages of 100 kg sack of rice marketed in Mbeya region, from January 2004 to December 2018 (in 1000 Tsh)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						147.29	148.31	148.50	147.65	146.79	146.61
146.51	145.71	144.54	143.45	142.07	140.96	140.57	141.04	142.42	145.48	150.84	155.55
159.08	163.10	167.62	172.39	177.12	181.27	184.18	185.46	184.87	182.10	177.24	173.84
172.03	169.76	167.51	165.56	164.09	162.88	162.04	160.90	162.47	166.93	170.87	172.63
173.40	175.44	177.46	179.68	182.53	186.08	189.85	194.72	197.82	197.50	196.99	197.19
199.09	201.18	202.10	202.23	201.48	200.03	198.52	196.45	193.96	191.64	188.91	186.57
183.00	178.45	174.93	171.60	168.62	165.90	163.28	161.56	161.12	162.23	163.99	165.65
168.01	170.71	173.53	178.23	185.82	193.78	201.35	209.93	218.69	227.30	234.89	241.56
248.74	256.14	262.84	267.02	268.44	270.16	273.07	273.06	269.31	261.16	251.62	244.41
236.80	227.51	217.31	207.08	196.34	184.48	171.47	159.98	151.84	148.72	149.00	148.25
146.47	145.19	144.69	144.94	145.94	147.59	149.02	150.41	151.85	152.72	152.93	153.21
154.17	155.69	158.19	160.83	162.67	164.17	166.29	168.28	169.90	170.88	171.18	170.91
170.11	169.65	168.96	167.72	166.16	163.99	161.56	160.02	159.26	159.11	159.92	161.71
164.22	166.08	168.22	171.36	174.55	178.10	181.39	183.68	184.90	185.92	187.00	187.85
188.72	190.19	191.17	190.79	188.51	184.27						

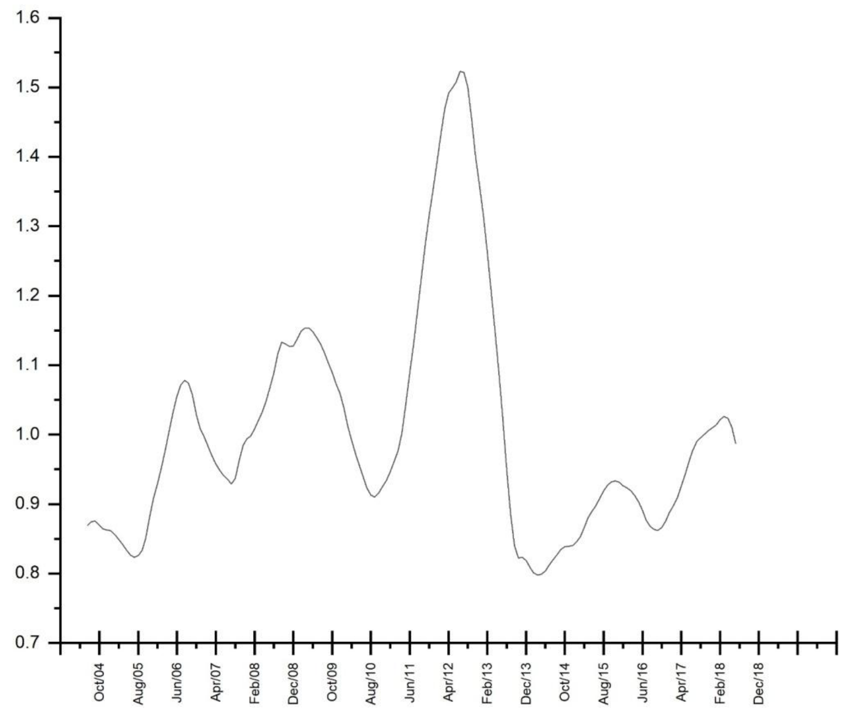

Fig. 4. Presence of cyclical variations in the price of 100 kg bag of rice from July 2004 to June 2018

3.3 Cyclic Variations

The moving average series (Table 3) was constructed in such a way that there was no irregular variation, and it was possible to test whether there are cyclical variations (C) that had influences in the price of the sack of rice. We then calculated the C values of the multiplicative model.

It can be observed in Fig. 4 that there is systematic change between higher and lower values; that is, prices do fluctuate from one month to another, and hence it is possible to identify the existence of cycles. Similar behaviors are observed for the remaining years of the time series. Then we cannot neglect the effect of cyclical variations on the time series.

4. CONCLUSION

Analysis for the price pattern of rice marketed in the wholesaler markets in the Mbeya region indicated that there is a well-characterized seasonality in this marketing, as the best prices received by producers occurred from November to May of each year, influenced by the low stocks of the products in that period, and the lowest prices received occurred between June and October, during and immediately after harvesting period. Furthermore, it was found that despite the higher price received from November to May, producers are at the risk of selling it at a meager price between February, April, and May. During the period from June to October, although producers receive less remuneration for their products, there not so much at risk of selling at a lower price, with chances even of selling it at a higher price based on the LCL and HCL limits. Therefore, with the current behavior of rice prices, producers must market their product from November to May of each year, since between these months the values paid for the product are relatively higher.

However, it should be noted that, for most smallholder producers, sales of rice are mostly made at the time money is needed or immediately after harvest and are often stored and sales extended over a long period. Farmers are generally unable to target their sales at the time prices are highest, therefore a concern for policymakers about the ability of the marketing system to contain price instability. Thus, to ensure maximum return, much work must be done to identify and assist producers in finding the best marketing opportunities and information. The development of productive agricultural activities requires innovations in terms of production, desirable place, time, and form in which the product could be marketed and, if possible, capitalization of their producers. Technologically adapted and well-informed farmers get better marketing conditions, making the activity profitable and enjoy the economies of scale.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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