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Price seasonality of citrus commodities in the Joburg Fresh Produce Market

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Abstract:

The objective of the paper was to study seasonality in citrus prices, for informing food security policy. Secondary data was collected from the Joburg Fresh Produce Market. Analysis of the data followed two steps. First was the construction of price indexes and second, statistical significance using the ARIMA model. Grapefruit, oranges, lemon and soft citrus were considered for analyses. Results show that the highest price index for grapefruit at 189% was recorded in February against a low of 51% in July. Orange came second, with a high of 157% in February and a low of 60% in June; Soft Citrus a high of 153% in December and a low of 66% in April whereas lemon had high of 120% in January and low of 80% in June. The average high price index for the four species was 156%. On average, the difference between high and low price index among the four species was 92%. For the Lemon, the aforesaid figure was 45%. ARIMA seasonal terms are statistical significant at 1%, 5% and 10%. The length of period for high price index and the rate of price index renders citrus seasonality high. Government to invest in agro processing and storage infrastructure.

Key words: Seasonality, price index, citrus species, nutrition, food security

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PRICE SEASONALITY OF CITRUS COMMODITIES IN THE JOBURG FRESH PRODUCE MARKET

1. INTRODUCTION

According to Kunst (2012), seasonality is the systematic, although not necessarily regular, intra-year movement caused by the changes of the weather, the calendar, and timing of decisions, directly or indirectly through the production and consumption decisions made by the agents of the economy. Generally, crop prices set their seasonal low at harvest followed by a post-harvest rally. Postharvest rallies occur because the supply of the crop depends on levels of production and consumption gradually uses up that supply, causing prices to rise (Kaminski et al., 2014).

The study was levelled on citrus industry, due to its strategic significance to the economy of South Africa. The citrus industry is the third largest horticultural industry after deciduous fruits and vegetables in terms of gross value. During the 2015/16 production season, the industry contributed R14.8 billion to total gross value of South African agricultural production. This represented 25% of the total gross value (R57.3 billion) of horticulture during the same period (DAFF, 2017). It is an important foreign exchange earner. Across the four species (oranges, lemon, grapefruit and soft citrus), on average approximately 70% is sold in export markets, 15% to the processing industry with National Fresh Produce Markets (NFPM) absorbing 10% (CGA, 2017). The commodity is widely cultivated in South Africa, with seven provinces out of nine, involved in its production (CGA, 2016) and thus from a food security perspective the fruit is available to a broader society. The industry employs approximately 125 000 people (CGA, 2017) and close to 12% of citrus products (Fresh Plaza, 2017a) are traded in the informal markets (DAFF, 2017). There are 123 black farmers operating 10.7% of citrus orchards and 42% of these farmers are exporting their products (PLAAS, 2018).

Seasonality in prices of agricultural products bears policy relevance, as it is often associated with the scarcity of food products in certain months-a factor that normally leads to increase in food prices (Kaminski et al., 2014). High food prices negatively impact poor people's ability to purchase fruit and vegetables (Miller et al., 2016). This might also impact negatively on their health (Miller et al., 2016), as consumption of fruits and vegetables reduces the risk of contracting diseases including stroke (Valpiani et al., 2015). When food prices display high seasonality, this can affect dietary intake and nutritional outcomes, This might results with episodes of nutritional deficiencies during the first 1000 days of life, particularly detrimental for cognitive development and future earnings (Temple et al., 2011; Dercon and Portner, 2014 cited in Gilbert et al., 2016). In SSA, it was discovered that seasonal movements in maize wholesale prices was responsible for 20% of Tanzania and Uganda's monthly volatility and same was found for Malawi but at 40% (Kominski et al., 2014;). In South Africa male adults consume 235 grams per day of vegetables and fruits whereas women consume 226 grams per day, these figures are lower than the threshold set by the World Health Organization, which is 400g per person per day (Naude, 2013). The reason for this low intake has to do with low household income and the per capita high cost of fruit and vegetables (Naude, 2013).

In the least developed countries located in Sub-Saharan Africa (SSA) where there are high incidence of micro nutrient deficiency, there is less consumption of citrus products. In this region, poor people on average consume 8 grams of citrus fruit per person per day and this is six times less than the world average. In the US for instance, consumption of citrus fruit is estimated at 147 grams per person per day (Turner & Burri, 2013). In South Africa, poor people rely mostly on social grants and cannot afford a balanced diet leading to serious incidence of macro and micronutrient deficiency in iron, iodine and vitamin A (Govender et al., 2016).

In South Africa, there is dearth of literature covering studies on price seasonality. In terms of literature accessed, the closest study on this subject is Jordaan et al (2007), which looked into price volatility of certain field crops. Studies on price seasonality can shed insight on policy formation around issues of food security and marketing infrastructure, such as cold storage and agro-processing facilities (Mathenge & Tschirley, 2006). The objective of this study is to analyse price seasonality for citrus products in the South African Joburg Fresh Produce Market, with a view of informing policy formulation around food accessibility in line with price movements.

Socio Economic characteristics of citrus in line with seasonality

While citrus is largely consumed as raw products and as processed products e.g. juice, they also have greater application in the cosmetic and medicinal industry. For purpose of this study, the industrial use of citrus is not addressed. According CRI and CGA (2017) report, oranges are harvested from mid-March up to September.

Lemons are harvested as early as February up to mid-September, grapefruit April to august and soft citrus mid-march to end of July (CRI & CGA, 2017). The period, March to July represents an area of high activity across the four species, as February is for early maturing varieties and September for late maturing (CRI and CGA, 2017). Citrus species have different physiological characteristics. According to Fresh Plaza (2017), which is an online newsletter covering news for local and international fruit trade, after maturity, the grapefruit can be left long on the tree. On the other hand, soft citrus as compared to other species have a shortest shelf life.

2. METHODS AND MATERIALS

2.1 Data Collection

Secondary data on daily prices spanning for a period of 8 years, i.e. from 2010 January to 2018 April, was sourced from the Joburg National Fresh Produce Market. This constituted 96 observations if data is arranged into months. Chitra (2015) had 120 observation for the study of seasonality of vegetables in India. McCleary et al (1980), recommends a minimum of 50 observations. The Joburg market was chosen, as it is the largest fresh produce market in South Africa. While there are 18 National Fresh Produce Markets (NFPM) in South Africa (Lekgau, 2016), during 2014/15 season, the Joburg market accounted for 47.7% of the revenue generated among the major four markets (Lekgau, 2016; Jansen, 2017). According to NAMC (2017) during the 2016/17 season, the Joburg and Tshwane Markets were the largest sellers of soft citrus in South Africa. In South Africa, National Fresh Produce Markets (NFPMs) are a strategic meeting place between producers and consumers and they allow for equal trade opportunities between large-scale commercial producers and smallholder farmers. They are legally bound to allow anyone to engage in trade without discrimination (Louw, 2008).

The Joburg Fresh Produce Market only deals with local supply and exports to SADC countries, but does not receive imports coming from other countries. Furthermore, a high probability exists; that South African supermarkets such as Shoprite, Spar, Pick & Pay could be securing imports through their private channels (Shoprite, 2018) yet this study ran short from covering the effects of imports. Nevertheless, the Joburg market constitutes the largest marketing infrastructure through which poor people access citrus product. In this market, there is high activity of purchase by informal traders such as hawkers and Spaza-shop owners

(City of Tshwane, 2013). The hawkers and Spaza-shop owners serve as important distribution agents of citrus to poor people (Chikazunga & Paradza, 2012; Jooste, 2014; City of Tshwane, 2013).

2.2 Data treatment

The data set was arranged according to monthly cycles for five species comprising of Lemon, Grapefruit, Oranges, Soft Citrus and Limes. Since limes, in terms of volumes of productivity and gross value constitute a small share of the citrus market, it was excluded from the analyses. The data set was first re-arranged according to species. Daily prices were computed into monthly averages. This was to ensure uniformity in situations where certain months do not have equal number of days. Some validation was done to check for outliers and missing gaps. Averages figures were used to normalise the prices. Missing data gaps were discovered only for the soft citrus species during January 2012 and January 2013. Average prices for the similar months over the years were used to fill-up the gaps. In order to test if there was common pattern for the movement of prices a graph was drawn as shown in figure 1.

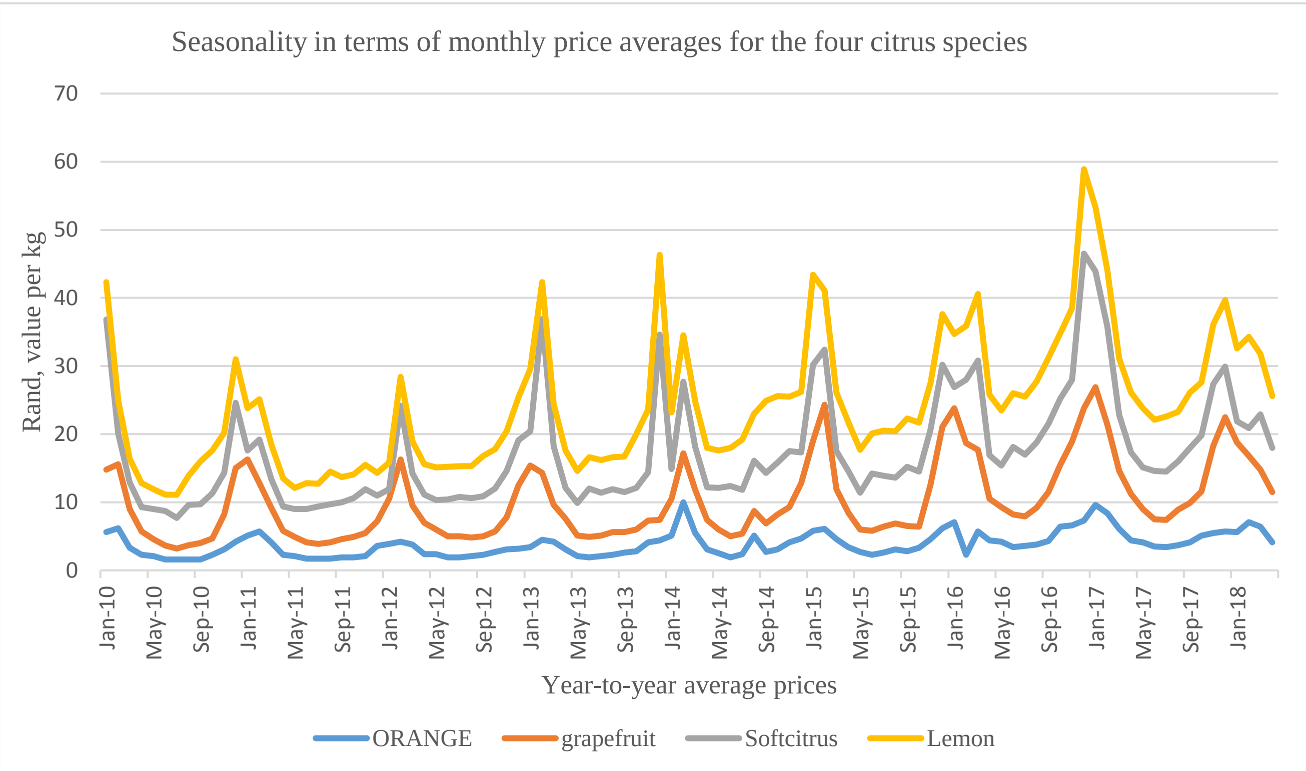

Figure 1: Year-to-year patterns for price movements, based on initial data

Source: 2018 data from Joburg Fresh Produce Market

2.3 Data analyses

Two steps were taken in analysing the data following the approach used by chitra (2015). For purpose of establishing seasonality, some price indexes for the four citrus species was constructed and for purpose of analyses for the statistical strength of seasonality and for forecasting, the Autoregressive Integrated Moving Average (ARIMA) method was employed.

2.3.1 Construction of the price index

An index is constructed in order to have a standard and common measurement tool for comparing movements in prices across the four citrus species. Index numbers of cost and prices provide a convenient means of expressing changes over time in the cost or prices of a group of related products in a single measure (O'Neil, 2015). In constructing an index, only the data-set from January 2010 to December 2017 was considered, while excluding data for January 2018 to April 2018, as this was going to complicate attainment of full year cycles. Drawing insight from the work of Chitra (2015), an index was constructed following a four-step procedure. First, monthly average prices (seasonal prices) were constructed using daily averages, for each of the species. This was followed by the calculation of an average for each of the month over the years (2010-2017). Third, annual averages were derived from monthly average prices in respective years (2010-2017) and lastly; the calculation of the index involved dividing the monthly average of the years for each of the species by the average of the annual averages. Table 1 presents the summary for the procedures followed in constructing indexes.

Table 1: Summary for the procedures followed towards construction of orange price index

100	**Orange over 12 months period (prices in Rand/kg)**												Annual Averages
Index calculations	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	
2010	5,6	6,2	3,3	2,3	2,1	1,6	1,6	1,6	1,6	2,3	3,1	4,2	2,9
2011	5,1	5,7	4,1	2,3	2,1	1,7	1,7	1,7	1,9	1,9	2,1	3,6	2,8
2012	3,9	4,2	3,8	2,4	2,4	1,9	1,9	2,1	2,3	2,7	3,1	3,2	2,8
2013	3,4	4,5	4,2	3,1	2,1	1,9	2,1	2,3	2,6	2,8	4,1	4,4	3,1
2014	5,1	10	5,5	3,1	2,5	1,9	2,4	5,1	2,7	3,1	4,1	4,7	4,2
2015	5,8	6,1	4,6	3,4	2,7	2,3	2,6	3,1	2,8	3,3	4,6	6,2	3,9
2016	7,1	2,3	5,7	4,4	4,2	3,4	3,6	3,8	4,3	6,4	6,6	7,3	4,9
2017	9,6	8,4	6,1	4,4	4,1	3,5	3,4	3,7	4,1	5,1	5,5	5,7	5,3

Average over time	5,7	5,9	4,7	3,2	2,8	2,3	2,4	2,9	2,8	3,4	4,2	4,9	3,8
Formula	Example for the price index for the month of march: (4,7/3,8) * 100 =123,9												
Indexes	151,9	157,5	123,9	**84,4**	**73,4**	**60,5**	**64,2**	77,7	74,1	91,7	110,3	130,6	100

2.3.2 ARIMA model for testing the strength of seasonality

Adhikari (2009) put forward that selection of a proper model is extremely important in time series modelling as it a reflection of the underlying structure of the series. This is because many time series follow different stochastic process thus making general models for time series data to differ. There are two widely used time series models in literature of time series modelling, Autoregressive (AR) and Moving Average (MA) models (Chitra, 2015). The former model implies that a series in time t, say $Y_{t,}$ is determined by its previous lag values and a constant (u) and a trend (t) in some cases, while the latter implies that a series is determined by some random error and the lagged values of the error term. In literature, these models have been combined to form comprehensive models including Autoregressive Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA) models.

Initially developed by Box and Jenkins (1976), the popularity of the ARIMA model is mainly due to its flexibility to represent several varieties of time series with simplicity as well as the associated Box-Jenkins methodology (Hamzacebi, 2008; Zhang, 2007) for optimal model building process. The limitation of these models is the pre-assumed linear form of the associated time series, which becomes inadequate in many practical situations. To overcome this drawback, various non-linear stochastic models have been proposed in literature (Parrelli, 2001), however from implementation point of view these are not so straight-forward and simple as the ARIMA models. For seasonal data, a variation of ARIMA called the Seasonal ARIMA model has been developed.

The Seasonal ARIMA model was used to model the real price data for four types of citrus markets (Grapefruit, Orange, Soft citrus and lemon) to detect seasonality and the degree to which it exists. 2010 was used as the base year in construction of real prices in each market. The average prices of citrus fruits tend to always be high in some months and low in other months. The result of this may be a non-stationery series because seasonality causes differences in average values at some particular times within the seasonal span. For example, sales of Oranges will always be higher in winter months. The concept of a stationary series is an important concept in time series literature because that is where the validity of the normal

Ordinary Least Squares (OLS) depend-on. Applying the normal OLS on non-stationery data makes standard errors, T tests and F tests and thus incorrect inferences. Chitra, Shanmathi and Rajesh (2015) applied the ARIMA model in a study for vegetable seasonality in India. Following Chitra (2015), in short, the ARIMA model can be written as:

ARIMA (p,d,q) * (P,D,Q)S .

Where p= non-seasonal AR order, d= non-seasonal differencing, q= non-seasonal MA, P = seasonal AR order, D = seasonal differencing, Q = seasonal MA order, and S =time span of repeating pattern.

Model specification

A *pth*-order autoregressive model: AR (p), which has the general form

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + ... + \phi_p Y_{t-p} + \varepsilon_t$$

Where:

Y_t = Response (dependent) variable at time t

Y_{t-1}, Y_{t-2},…… Y_{t-p} = Response variable at time lags $t-1$, $t-2$,….. $t-p$, respectively.

ϕ_0 , ϕ_1, ϕ_2,………, ϕ_p = Coefficients to be estimated

ε_t = Error term at time t

A qth-order moving average model: MA (q), which has the general form:

$$Y_t = \mu + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - ...... - \theta_q \varepsilon_{t-q}$$

Where

Y_t = Response (dependent) variable at time t

μ = Constant mean of the process

θ_1, θ_2,…….., θ_q = Coefficients to be estimated

ε_t = Error term at time t

ε_{t-1}, ε_{t-2},….. ε_{t-q} = Errors in previous time periods that are in cooperated in the response Y_t

Autoregressive Moving Average Model: ARMA (p,q), which has the general form

$$Y_t = \theta_0 + \theta_1 Y_{t-1} + \phi_2 Y_{t-2} - ......\phi_p Y_{t-p} + \varepsilon_t - \phi_1 \varepsilon_{t-1} - \phi_2 \varepsilon_{t-2} - ..... - \phi_q \varepsilon_{t-q}$$

3. Data input and procedure for running ARIMA

E views software was used to select appropriate the model which best fit the data. Accordingly, Automatic ARIMA forecasting was performed to select the best model. Akaike Information Criteria was used as a selection criterion, thus selecting the model with the smallest Akaike Information Criteria value. Auto option was set on E views so that the software could select the dependent variable model. To ensure that the results obtained are robust, the procedure was combined with Wald Test. Accordingly, the test was performed on the coefficients of the seasonal terms, Seasonal AR (SAR) and Seasonal MA (SMA). Specifically, the Wald Test tested null hypothesis, which placed a zero restriction on these coefficients of the seasonal terms. Where there were more than two seasonal terms in the equation output, an F Wald test was performed and the coefficients were statistical significant. In running the ARIMA, individual months from January 2010 to April 2018 were considered, for the four species. In this regard seasonality was expressed in terms of months. The analysis consisted of 99 observations for the four citrus species. Convergence were achieved at different iterations for each of the species considered. For Grapefruit it was achieved after 43 iterations, for lemon at 82, orange 154, whereas for soft citrus there were 80 iterations. Across the four species the ARIMA ran lags at different levels depending on the nature of the data for each of the species. For Lemon, orange and soft citrus a lag of 12 months was imposed automatically, whereas for grapefruit lags of 12 and 24 months were imposed. ARIMA automatically took care of issues relating to non-stationarity of data.

4. RESULTS AND DISCUSSION

4.1 Price indexes

Table 2 presents the results for the price indexes of the four species. The highest index reported is for the grapefruit of which was higher than other species during the months of October to February. The highest index for grapefruit of 189% was recorded during the month of February against a low of 51% in July. Orange came in second place, with a high of 157% in February and a low of 60% in June; Soft Citrus a high of 153% in December a low of 66% in April, whereas lemon had high of 120% in January and low of 80% in June. Across the four species, prices were low during the period April to September. This concurred with the information received from CRI and CGA (2017), which indicated that the citrus harvest season starts from February and end in September.

Making a comparison between the highest and lowest price indexes for each of the species, in the order of high to low, yielded the following: grapefruit (189%:51%), orange (157%:60%), lemon (125%:80%) and soft citrus (153%:66%). The difference between high and low price index was 138% for grapefruit, 97% for orange, 87% for soft citrus and 45% for lemon. Generally, lemon constituted a moderate seasonality and this could be attributed to its year-round application in restaurants and its long shelf life. The high price index for the grapefruit perhaps can be explained by the physiological characteristics of the crop. According to Fresh plaza (2017b), compared to other citrus varieties, during harvest grapefruit can be left longer on the tree. This enables farmers to speculate for prices in markets. The important factor is that local producers supply high quality fruit to export markets and inferior crop to local markets.

A direct quote from Fresh Plaza (2017b) suggest that "the grapefruit that the South African consumer eats and the one sent to export markets are two totally different, even for the same variety". It is also stated that the least expensive storage space for the grapefruit is on the tree (Fresh Plaza, 2017b). Even though in aggregate terms between 7% to 10% of citrus is sold in local markets (DAFF, 2017), the proportion for the grapefruit, in this regard is low. According to CGA (2016), only 1% of the total output was sold to the local market in 2016.

Table 2: Seasonality indexes for the four citrus species

Seasonal factor %				
Month	**Orange**	**Grapefruit**	**Soft citrus**	**Lemon**
Jan	151	186	110	120
Feb	157	189	141	98
March	124	114	92	100
April	84	78	66	91
May	74	58	69	83
June	60	53	93	80
July	64	51	88	88
August	78	58	92	91
September	74	64	96	107
October	92	72	98	109
November	110	111	102	110
December	131	168	153	125

Figure 2 and figure 3, show the schematic presentation of the price indexes with alternating seasons. In figure 2 where the season is starting in January, except for the lemon species, which recorded a low index, the other 3 species reached the peak-price in February. By checking, the data received from the Joburg market, during the month of February it is clear that there was less volume of citrus traded in the market. The other important observation in figure 2, is that the rally in high prices ends in February.

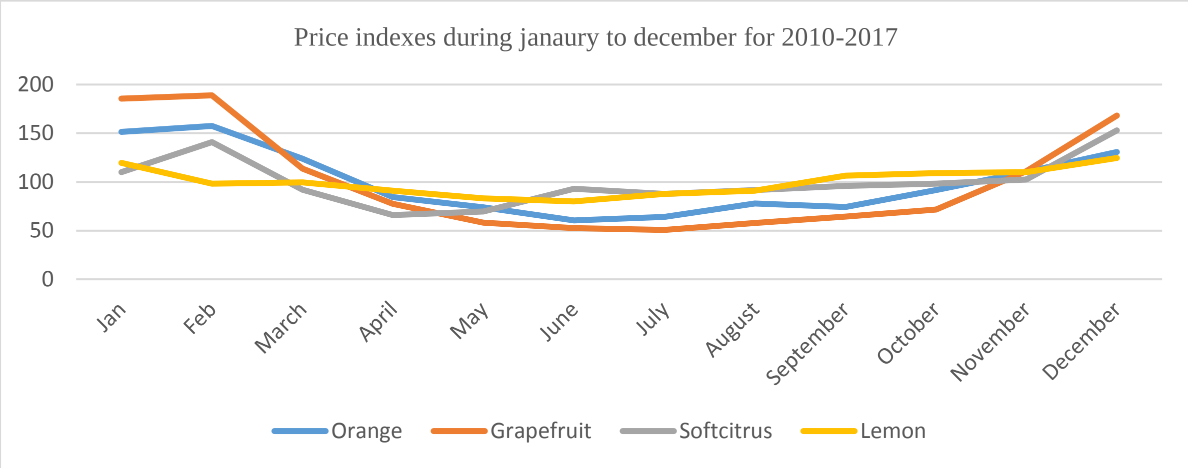

Figure 2: Price indexes from January to December

Source: Indexes constructed with data from Joburg market

In figure 3, where the season was set to start in March, it can be seen that during the period of June to October the price index is flattening.

This suggests that prices are low for almost all the four species. However just after the month of October, the price indexes increases at an alarming rate.

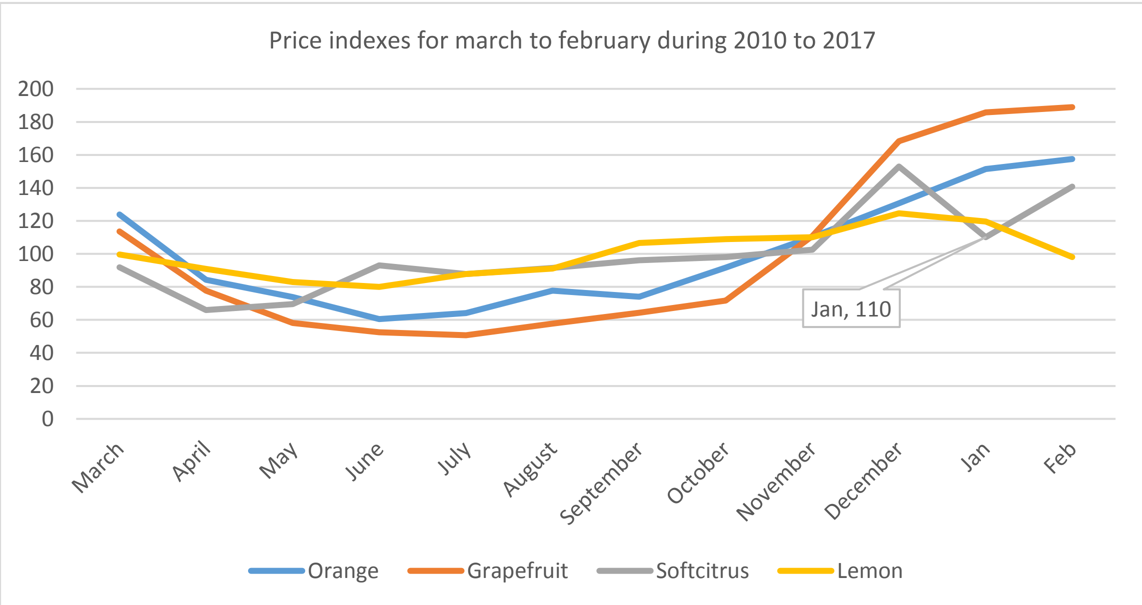

Figure 3: Price indexes from March to December

Source: Indexes constructed with data from Joburg market

4.2 ARIMA model results

In table 4 and table 5, all the series shows some existence of seasonality in the four citrus markets. This can be seen by seasonal terms (SAR and SMA) in the equation outputs of the markets. The Seasonal terms are statistically significant in all the markets except SMA (12) in the market for Grapefruit (see table 4). Checking the equation output table, the Durbin Watson stat is close to 2 in all the models implying that the errors are free from serial correlation. Adjusted R squared: R-squared of the models are high suggesting that the models explain most of the variation in the dependent variables. F tests show that the explanatory variables are statistically significant when considered together. The ARIMA results are showing that the seasonal terms are statistically significant at 1%, 5% and 10%.

Table 4: ARIMA and Wald Test results for the grapefruit

Dependent variable	**Grapefruit price**			
Variable	**Coefficient**	**Std. Error**	**t-statistic**	**Probability (P-values)**
C	0.039418	0.090399	0.436048	0.6639
AR(1)	2.616341	0.093605	27.95080	0.0000
AR(2)	-3.450113	0.209363	-16.47913	0.0000
AR(3)	2.448553	0.194206	12.60801	0.0000
AR(4)	-0.887455	0.077175	-11.49924	0.0000
MA(1)	-2.766020	0.154316	-17.92441	0.0000
MA(2)	3.459200	0.391806	8.828850	0.0000
MA(3)	-2.264352	0.400369	-5.655666	0.0000
MA(4)	0.654541	0.172558	3.793168	0.0000
SMA(12)	-0.145477	0.102039	-1.425695	0.0000
SMA(24)	0.262181	0.126671	2.069777	0.0000
SIGMAQ	3.016481	0.39807	7.582783	0.0000
R-squared	0.593723	Mean dependent variable		-0.018788
Adjusted R-squared	0.542355	S.D. dependent variable		2.738696
S.E. of regression	1.852713	Akaike info criterion		4.260114
Sum squared residual	298.6316	Schwarz criterion		4.574674
Log likelihood	-198.8756	Hanna-Quinn criterion		4.387385
F-statistic	11.55816	Durban-Watson statistics		1.975562
Prob(F-statistic)	0.00000			

Walt test Equation Results			
Test Statistic	Value	df	Probability
t-statistic	3.793168	87	0.0003
F-statistic	14.38812	(1.87)	0.0003
Chi-square	14.38812	1	0.0001
Null Hypothesis: C (9) = 0			
Null Hypothesis Summary			
Normalised restriction (=0)		Value	Std. Err.
C(9)		0.654542	0.172558

Restrictions are linear in coefficients			
Walt test Equation: untitled			
Test Statistic	Value	df	Probability
F-statistic	7.744973	(2,87)	0.0008
Chi-square	15.48995	2	0.0004
Null Hypothesis: C(9)=0, C(10)=0			
Null Hypothesis Summary:			
Normalized Restriction (=0)		Value	Std. Err
C(9)		0.654542	0.172558
C(10)		-0.145477	0.10239

In table 5, the SAR (12) and SMA (12) for lemon, orange and soft citrus, came out very strong in terms of coefficient and P values, this shows high degree of seasonality.

Table 5: ARIMA results for Lemon, Orange and Soft Citrus

Equation output for Lemon prices				
Variable	**Coefficient**	**Std. Error**	**t-statistic**	**Prob (P-values)**
C	0.009214	0.003127	2.946481	0.0041
AR(1)	0.757541	0.071294	10.62558	0.0000
SAR(12)	1.000000	4.08E-05	24525.79	0.0000
MA(1)	-0999491	0.992112	-1.007438	0.3163
SMA(12)	-0.999810	8.84E-05	-11312.81	0.0000
SIGMAQ	0.019276	0.019498	0.988594	0.3254
R-squared	0.352334	Mean dependent variable		0.003130
Adjusted R-squared	0.317514	S.D. dependent var		0.173395
S.E. of regression	0.143246	Akaike info criterion		-0.800752
Sum squared residual	1.908317	Schwartz criterion		-0.643472
Log likelihood	45.63722	Hannan-Quinn criter		-0.737116
F-statistic	10.11853	Durbin-Watson stat		1.848861
Prob(F-statistic)	0.000000			
Equation output for orange prices				
Dependent variable:	D(Orange price)			
Variable	Coefficient	Std. Error	t-Statistic	Prob (P value)
C	0.028034	0.007431	3.772508	0.0003
AR(1)	0.570090	0.073754	7.729615	0.0000
SAR(12)	0.999999	3.36E-05	29804.17	0.0000
MA(1)	-1.000000	35.88136	-0.027870	0.9778
SMA(12)	-0.998156	0.000847	-1178.844	0.0000
SIGMASQ	0592841	0.463287	1.279641	0.2039
R-squared	0.588692	Mean dependent variable		-0.017993
Adjusted R-squared	0.566579	S.D. dependent variable		1.206875
S.E. of regression	0.794411	Akaike info criterion		2.737914
Sum squared residual	58.69128	Hannan-Quinn criterion		2.895194
Log likelihood	-129.5267	Durban-Watson Stat		2.801550
F-statistic	26.62158			1.965978
Prob(F-statistic)	0.000000			
Equation output for Soft citrus price				
Variable	**Coefficient**	**Std. Error**	**t-statistic**	**Probability (P-values)**
C	0.006587	0.002047	3.217800	0.0018
AR(12)	0.999987	0.000116	8596.096	0.0000
MA(1)	-1.000000	121.4595	-0.008233	0.9934
SMA(12)	-1.409731	0.126400	-11.15297	0.00000
SMA(24)	0.412341	0.1276675	3.229616	0.0017
SIGMAQ	0.138614	0.378793	0.365937	0.7152
R-squared	0.581941	Mean dependent variable		-0.012351
Adjusted R-squared	0.559465	S.D. dependent variable		0.578748
S.E. of regression	0.384132	Akaike info criterion		1.262278
Sum squared residual	13.72282	Schwarz Criterion		1.419558
Log likelihood	-56.48274	Hannan-Quinn criterion		1.325913
F-statistic	25.89132	Durban-Watson stat		1.68233
Prob(F-statistic)	0.0000000			

ARIMA linear model results

Based on the results in the tables, the ARIMA models for eth different citrus species can be forecasted and modelled as follows;

(1) $GP_t = 0.0394 + 3.616P_{t-1} - 3.450GP_{t-2} + 2.449GP_{t-3} - 0.887GP_{t-4} - 2.766e_{t-1} + 3.459e_{t-2} - 2.264e_{t-3} + 0.655e_{t-4} - 0.145e_{t-12} + 0.262e_{t-24} + e_t$

where $GP_t$is the price of grape fruit in time t, $GP_{t-i}$is the price of grape fruit in previous period i, $e_t$is the error in time time t.

(2) $LP_t = 0.00921 + 0.758\ LP_{t-1} + 1.000\ LP_{t-12} - 1.000e_{t-1} - 1.000e_{t-12} + e_t$

where $LP_t$is the price of lemon fruit in time t, $GP_{t-i}$is the price of lemon fruit in previous period i, $e_t$is the error in time time t.

(3) $\Delta OP_t = 0.0280 + 0570\ OP_{t-1} + 1.000\ OP_{t-12} - 1.000\ e_{t-1} - 0.998e_{t-12} + e_t$

where $OP_t$is the price of orange fruit in time t, $OP_{t-i}$is the price of orange fruit in previous period i, $e_t$is the error in time time t and e_{t-i} is the random error in previous period i.

(4) $SP_t = 0.006587 + 1.000SP_{t-12} - 1.000\ e_{t-1} - 1.410e_{t-12} + 0.412e_{t-24} + e_t$

where $SP_t$is the price of soft citrus fruit in time t, $OP_{t-i}$is the price of soft citurs fruit in previous period i, $e_t$is the error in time time t and e_{t-i} is the random error in previous period i.

Benchmarks and comparisons on the results obtained

Based on literature accessed, there is no set international standard for comparing seasonality. This is because various studies used different methodologies for measuring seasonality. For example the study by Gilbert et al (2017) which covered 7 African countries, found that a seasonality of 60.8 percent for fruit and vegetables was 3 times higher than the world average. The study however used the seasonality-gap approach. However, in two studies where seasonal index was used as a methodology, there are comparable results. Chitra (2015) investigated the seasonality index for vegetables in India and reported a high rate of seasonality reported for brinjal crop at 130%.

The high seasonality index for grapefruit and soft citrus found in this study, although high and could be worrying considering that in South Africa; poor households at minimum spend more than 30% of their disposable income on food (Statistics SA, 2017).

When it is considered however that grapefruit is not a common part of the diet for most households, then the concern could be considered not overly significant. Oranges are more commonly consumed, and despite the seasonality index not being the highest in the species considered, likely have a greater impact on poorer households' food consumption.

5. SUMMARY AND CONCLUSION

From a social welfare perspective, there are two areas of interest, which concerns the welfare of commercial citrus producers and poor consumers. When looking at the interest of citrus producers, the season of low and high prices is well balanced, with low prices experienced during the period March-to-September and high prices during October-to-February (see figure 2). The commercial producers do have an advantage of exporting a larger proportion (up to 70%) of the produce to overseas market where they receive high premium price (DAFF, 2017). However when it comes to consumers, an extended period of up to six months of high citrus prices can result in lower ability of poor households' access to citrus as nutritious food. One way of addressing this shortcoming could be through development of storage infrastructure that is targeted at the needs of the poor in South Africa. Agro-processing and fruit distribution to the poor via the Social-Development programme is another possible strategy.

Van Dyk & Maspero (2004) and Gerber (2015) posits that in the commercial agricultural sector, the infrastructure still has inefficiencies in the area of storage, transportation and logistics, so generally more work is needed giving attention to issues of storage towards enhancing food security. The results are important in informing some of the South Africa's food security programme. As an example, in the financial year 2012/13, the National School Nutrition programme under the Department of Basic Education, spent more than R4 billion on distribution of food (NEPAD, et al 2014), based on these results, future studies investigate if citrus forms part of the food basket in this programme. The study used price indexes and the ARIMA to establish the extent of seasonality in the citrus products. The results show that in South Africa, the problem is not just occurrence of seasonality in citrus prices, but that it is too high and that it exists for a prolonged period. High price index threaten food security among the poor in South Africa. The study recommends that similar studies be conducted for commodities that form a vital part of the food basket for the poor.

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