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RESEARCH NOTE: SOME ASPECTS OF VARIABILITY AND SEASONALITY IN FOUR FRESH PRODUCE MARKETS

C P van Walbeek

Lecturer, Department of Economics, University of Stellenbosch, Stellenbosch

This study involved an investigation into the variability and seasonality in prices and quantities of five fresh vegetables (potatoes, tomatoes, onions, cabbage and carrots) sold on the four largest national fresh produce markets (Pretoria, Johannesburg, Cape Town and Durban). A variability index based on the coefficient of variation was used throughout the study. The results were based on monthly data for the period 1980 through 1993. Prices were generally found to be more variable than quantities. The five vegetables investigated were subject to a similar degree of variation in quantity. Potatoes and tomatoes were subject to substantially less price variation than onions, carrots and cabbage. The data were seasonally adjusted by means of the Census X-11 method and the variability in seasonal adjustment factors was subsequently calculated. The prices of the five vegetables were subject to substantially more seasonal variation than the quantities. However despite significant seasonal variations in the quantity and particularly the price of fresh vegetables, "non-seasonal" (random) variation still dominates the overall variability in the data.

NAVORSINGSNOTA: ENKELE ASPEKTE RAKENDE VARIABILITEIT EN SEISOENALITEIT IN VIER VARSPRODUKTEMARKTE

In hierdie studie is die variabiliteit en seisoenaliteit in die pryse en hoeveelhede van vyf groentes (aartappels, tamaties, uie, kopkool en wortels) wat op die vier grootste nasionale varsprodukte markte (Pretoria, Johannesburg, Kaapstad en Durban) verkoop word, ondersoek. 'n Variabiliteitsindeks gebaseer op die koëffisiënt van variasie is deurgaans in die studie gebruik. Die resultate is gebaseer op maanddata en strek oor die tydperk 1980 tot 1993. Pryse was oor die algemeen meer variabel as hoeveelhede. Die vyf groentes wat ondersoek is was aan min of meer dieselfde mate van variasie in hoeveelhede onderhewig. Aartappels en tamaties is aan beduidend minder prysvariasie as uie, wortels en kopkool onderworpe. Die data is deur middel van die Census X-11 metode aangepas vir seisoenaliteit, waarna die variabiliteit in seisoensindekse bereken is. Die pryse van die vyf groentes het heelwat meer seisoenale skommeling getoon as die ooreenstemmende hoeveelhede. Nieteenstaande groot seisoenale skommeling in die hoeveelhede en veral die pryse van groente, moet die grootste deel van die variabiliteit in die data toegeskryf word aan "nie-seisoenale" (stogastiese) faktore.

1. INTRODUCTION

It is a well-known fact that both retail and wholesale prices of fresh produce are remarkably unstable. This largely follows from fluctuations in the supply of agricultural produce, which are, amongst others, the result of seasonal variations and the so-called "cobweb cycle" (Lubbe, 1990:296).

The first aim of this paper was to investigate the magnitude of variations in the price and quantity of the five most important fresh vegetables (potatoes, tomatoes, onions, carrots and cabbage) traded on South Africa's four largest fresh produce markets (Pretoria, Johannesburg, Cape Town and Durban). The combined turnover of vegetables traded at these four markets was about 70 per cent of the total turnover of vegetables traded at all 15 national fresh produce markets. The second aim was to quantify the magnitude of the seasonal variations in the price and quantities of these vegetables.

The usefulness of this study lies in the fact that it provides a description of some of the underlying supply and demand forces and their effects on prices and quantities of fresh vegetables. More importantly, the results concerning seasonal fluctuations in the price of vegetables enable farmers, wholesalers and retailers to make better decisions about price movements on the fresh produce markets. Where it is practically possible, farmers can use the information presented here to regulate their planting times so that the harvesting times correspond with the seasonal peak in the price of the produce.

The structure of the paper is as follows: The first section deals with a discussion of the variability index employed in this study. This is followed by a discussion of the observed variability in the data. In the last section of the paper the seasonality in the data is examined. The magnitude of the seasonality is calculated and the salient features are highlighted.

2. DEFINING THE VARIABILITY INDEX

The purpose of a variability index (also known as an instability index) is to summarise the variation of a particular time series into a single figure. Such indices have found application in a number of fields in economics.¹ Some indices are based on regression techniques, where deviations from a fitted curve form the inputs of the variability index. Regression based techniques are appropriate when there is a long-term non-zero trend in the data. If the data do not display a significant positive or negative trend, the standard deviation or the coefficient of variation (that is, the standard deviation divided by the mean), may be an appropriate measure of variability in the data.²

The variability index used in this study was based on the coefficient of variation. The index was based on monthly data for the period 1980 through 1993. For each of the 20 product/market combinations the index was calculated as follows:

Step 1: The coefficient of variation, based on 12 monthly data points, is calculated for each year of the 14 year period.³

Step 2: The variability index is calculated as the average of the coefficients of variation of the individual years.

The underlying assumption of this approach is that there is no upward or downward trend in the data within a given year. However, the approach allows for (changing) trends between different years.

3. VARIABILITY IN FRESH PRODUCE MARKETS

Table 1 shows the variability indices of the seasonally unadjusted quantity movements in the 20 product/market combinations. All data were obtained from various issues of *Statistics on Fresh Produce Markets*, published by the Directorate of Agricultural Economic Trends. The most important findings are the following:

Of the five vegetables investigated, cabbage is the most unstable, having the highest variability index in three of the four geographical markets and the highest on average. Potatoes and onions are subject to the lowest variability in quantity. The difference in variability between the five vegetables is, however, not very large.

For the five vegetables under investigation, the Durban fresh produce market is subject to the most variation in the quantities traded. There is some evidence of an inverse relationship between the size of the geographical market and the variability in the quantity of the vegetables traded there. For example, the Johannesburg fresh produce market, being by far the largest in the country⁴, is subject to the least variation in the quantities of four of the five vegetables. Durban, which is the smallest of these four markets, is subject to the most quantity variability in all five vegetables

In Table 2 the variability indices concerning price movements in the 20 product/market combinations are shown. The most important findings are the following.

Variations in the price have been of a greater magnitude than variations in the quantity in each of the 20 product/market combinations. The increase in price variation, vis-à-vis the corresponding quantity variation, varies from 26 per cent (for tomatoes sold on the Pretoria market) to 175 per cent (for onions sold on the Cape Town market).

The simple correlation between the price variability and quantity variability, based on the 20 product/market combinations is 0,43, which is significant (using a one-sided test) at the 5 per cent level. The implication is that variation in price is positively related to variation in the quantity. This does not say anything about the direction of causality though.

There is slight evidence that vegetables with a high turnover are subject to less price variation than less traded vegetables. The simple correlation between the average price variation in the vegetables traded at the four markets (the last column of Table 2) and the national turnover of these vegetables, is -0,78, which is significant (using a one-sided test) at the ten per cent level of significance.⁵

On average it seems that the prices of vegetables sold on the Cape Town and Durban fresh produce markets are more variable than the prices of vegetables sold on the Johannesburg and Pretoria markets.

4. SEASONALITY IN THE DATA

The production of fresh vegetables is influenced to a large extent by climatic and weather conditions. This should, *a priori*, lead to substantial seasonal variation in both the quantity and price of vegetables.

There are basically two approaches to seasonally adjusting time series data. The first approach is to assume that the economic time series can be represented as the sum of a trend, cycle, seasonal and random variations (the *additive model*). In the second approach

Table 1: Variability in the seasonally unadjusted quantity of fresh produce traded at four national fresh produce markets, 1980-1993.

Product	Pretoria	Johannesburg	Cape Town	Durban	Average
Potatoes	0,157 (3)	0,148 (4)	0,167 (2)	0,170 (1)	0,161
Tomatoes	0,180 (3)	0,162 (4)	0,182 (2)	0,183 (1)	0,177
Onions	0,167 (2)	0,159 (3)	0,153 (4)	0,181 (1)	0,165
Carrots	0,171 (3)	0,144 (4)	0,206 (2)	0,242 (1)	0,191
Cabbage	0,198 (3)	0,182 (4)	0,210 (2)	0,234 (1)	0,206

Note: Rankings are shown in parentheses.

Table 2: Variability in the seasonally unadjusted price of fresh produce traded at four national fresh produce markets, 1980-1993

Product	Pretoria	Johannesburg	Cape Town	Durban	Average
Potatoes	0,274 (2)	0,275 (1)	0,242 (4)	0,269 (3)	0,265
Tomatoes	0,227 (3)	0,225 (4)	0,305 (1)	0,242 (2)	0,250
Onions	0,286 (4)	0,303 (3)	0,420 (1)	0,308 (2)	0,329
Carrots	0,306 (3)	0,254 (4)	0,357 (1)	0,344 (2)	0,315
Cabbage	0,372 (2)	0,363 (3)	0,300 (4)	0,376 (1)	0,353

Note: Rankings are shown in parentheses.

Table 3: Variation in the seasonal adjustment factors of the quantity of fresh produce traded at the four national fresh produce markets, based on 1980-1993 data

Product	Pretoria	Johannesburg	Cape Town	Durban	Average
Potatoes	0,077 (3)	0,078 (2)	0,099 (1)	0,069 (4)	0,081
Tomatoes	0,127 (1)	0,105 (3)	0,116 (2)	0,090 (4)	0,110
Onions	0,103 (2)	0,096 (3)	0,088 (4)	0,118 (1)	0,101
Carrots	0,120 (2)	0,098 (3)	0,088 (4)	0,186 (1)	0,123
Cabbage	0,126 (3)	0,102 (4)	0,129 (2)	0,160 (1)	0,129

Note: Rankings are shown in parentheses.

it is assumed that the time series can be represented as a multiplicative model of a trend, cycle, seasonal and random variations. For both additive and multiplicative models it is possible to decompose the time series into the four components. Mohr *et al.* (1987:120) recommend the multiplicative model for economic time series which exhibit an exponential trend. In this study the multiplicative model was chosen, because in the long term the prices of vegetables increase exponentially, approximately in line with the average rate of inflation. In order to compare the seasonality in the price and quantity data, the multiplicative model was also applied to the quantity data. The actual seasonal adjustment was performed by the EViews computer package, using the well known Census X-11 method.

The multiplicative seasonal adjustment factor indicates the seasonal variation in the time series for a particular "season" (for this purpose a "season" was taken to be a month). If the calculated seasonal adjustment factor in a particular month is greater (less) than unity, this indicates that, on average, the series assumes a greater (smaller) value in that month than in an "average" month.

Twelve seasonal adjustment factors, coinciding with the twelve months of the year, were calculated for both price and quantity in each of the 20 product/market combinations. The greater the variation in the seasonal adjustment factors, the greater the degree of seasonal variation. For each of these 40 combinations the variability index is thus defined as the coefficient of variation of the applicable seasonal adjustment factors. In Tables 3 and 4 these variability indices are shown for quantity and price respectively.

Seasonal variability in quantity

In comparison to the variability indices presented in Table 1, the variability indices in Table 3 are comparatively low. This suggests the seasonal variation in the quantity of vegetables to be rather limited. The implication is that cyclical and particularly random factors are largely responsible for variability in the

quantity of fresh vegetables. Potatoes are subject to the least seasonal variation in quantity in three of the four geographical markets. The other four vegetables are subject to slightly more seasonal variation in the Johannesburg, Pretoria and Cape Town markets. Carrots and cabbage traded on the Durban fresh produce market are subject to substantially more seasonal variation than in any of the other three markets.

Seasonal variability in price

In Table 4 the variation in the seasonal adjustment factors of the price of the 20 product/market combinations are shown. The practical use of this information should be clear: if a product is subject to considerable variation in price, an individual farmer can expect to obtain a higher than average price for his product if he reaps the harvest when the price is at a seasonal high.⁶ The calculated seasonal adjustment factors for the five vegetables under consideration are provided in the Appendix.

In all four fresh produce markets there is little seasonal variation in the price of potatoes. Tomatoes are subject to a similarly low degree of seasonal price variation in the Pretoria, Johannesburg and Durban markets. However, tomatoes sold on the Cape Town market are subject to considerable seasonal price variation. This is mainly the result of a sharp seasonal peak in early spring.

In all geographical markets considerable seasonal price variations were found in onions, carrots and cabbage. Both the magnitude and the pattern of the seasonality in onion prices are very similar in the Pretoria, Johannesburg and Durban markets. The seasonal peak is in early winter while the seasonal trough is in early summer. In the Cape Town market the seasonality in onion prices is much more pronounced. Furthermore, the seasonal peak is reached only in the latter part of winter and early spring.

With the exception of the Cape Town market, there is a large degree of seasonal variation in the price of carrots.

Table 4: Variation in the seasonal adjustment factors of the price of fresh produce traded at the four national fresh produce markets, based on 1980-1993 data

Product	Pretoria	Johannesburg	Cape Town	Durban	Average
Potatoes	0,089 (3)	0,094 (1)	0,082 (4)	0,090 (2)	0,089
Tomatoes	0,095 (3)	0,087 (4)	0,221 (1)	0,101 (2)	0,126
Onions	0,215 (4)	0,224 (3)	0,347 (1)	0,231 (2)	0,254
Carrots	0,299 (2)	0,233 (3)	0,161 (4)	0,338 (1)	0,258
Cabbage	0,204 (3)	0,200 (4)	0,213 (2)	0,244 (1)	0,215

Note: Rankings are shown in parentheses.

Table 5: Variability in the seasonally adjusted quantity of fresh produce traded at four national fresh produce markets, 1980-1993

Product	Pretoria	Johannesburg	Cape Town	Durban	Average
Potatoes	0,138 (88)	0,127 (86)	0,130 (78)	0,155 (91)	0,138
Tomatoes	0,126 (70)	0,118 (73)	0,142 (78)	0,159 (87)	0,136
Onions	0,140 (84)	0,127 (80)	0,120 (78)	0,140 (77)	0,132
Carrots	0,140 (82)	0,108 (75)	0,185 (90)	0,177 (73)	0,153
Cabbage	0,155 (78)	0,150 (82)	0,161 (77)	0,179 (76)	0,161

Note: The variability indices based on seasonally adjusted data as a percentage of the variability indices of the seasonally unadjusted data (Table 1) are shown in parentheses.

Table 6: Variability in the seasonally adjusted price of fresh produce traded at four national fresh produce markets, 1980-1993

Product	Pretoria	Johannesburg	Cape Town	Durban	Average
Potatoes	0,253 (92)	0,250 (91)	0,236 (98)	0,247 (92)	0,247
Tomatoes	0,206 (91)	0,206 (92)	0,203 (67)	0,223 (92)	0,210
Onions	0,241 (84)	0,260 (86)	0,277 (66)	0,248 (81)	0,257
Carrots	0,185 (60)	0,180 (71)	0,317 (89)	0,183 (53)	0,216
Cabbage	0,319 (86)	0,318 (88)	0,252 (84)	0,337 (90)	0,307

Note: The variability indices based on seasonally adjusted data as a percentage of the variability indices of the seasonally unadjusted data (Table 2) are shown in parentheses.

In the Pretoria, Johannesburg and Durban markets the cyclical peak is reached in autumn, followed by the cyclical trough in spring. The seasonal variation at the Durban market is particularly pronounced. The price of carrots traded at the Cape Town market has two small cyclical peaks - in early autumn and late winter - and a definite trough in summer.

The seasonal variation in the price of cabbage is somewhat lower than that of onions or carrots. There is no one market which is subject to substantially more or less seasonality than the other markets. Furthermore, in all four geographical markets the timing of the seasonality is similar: a long, relatively modest peak in autumn and early winter, followed by a short deep trough in spring and early summer.

An important question which needs to be answered is: How much of the overall variation in the price and quantity of these five vegetables is explained by seasonal variation? Stated otherwise: If the price or quantity is unstable, and the seasonal adjustment factor indicates a large measure of seasonal variation, how sure can we be that the overall variability is attributed mainly to seasonal variations? In order to answer this question, variability indices were calculated for seasonally adjusted data and the results were compared with the variability indices obtained from seasonally unadjusted data. In Tables 5 and 6 the results are shown.

The variability in the seasonally adjusted data is lower than that of the seasonally unadjusted data in all 20 product/market combinations; on average the quantity variability was reduced by about 20 per cent and the price variability by about 17 per cent. There is, however, substantial variation in these percentages for particular product/market combinations, particularly with regard to price variability.

The overall conclusion of this section is that, despite the fact that there are very significant seasonal variations in the quantity and particularly the price of fresh vegetables, the "non-seasonal" (random) variability still dominates the overall variability in the data. This should make us cautious about the use of the seasonal adjustment factors as a guide to movements in the market.

5. CONCLUSION

The aim of this study was to investigate the variability and seasonality in the price and quantity of five vegetables traded at South Africa's four largest fresh produce markets. The variability in the seasonally unadjusted data was investigated first. It was found that prices are generally more variable than quantities. There was also slight evidence that the larger markets were subject to less variability.

Furthermore, it was found that prices are subject to more distinct seasonal variations than quantities. This information is useful for farmers who have a measure of discretion over their planting seasons. In order to aid these planting decisions, the timing of the seasonal movements in the price is shown in the Appendix. However, as a word of caution, even if seasonal variations are taken into account, the resulting (seasonally adjusted) series are still very unstable.

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NOTES:

1. For example, portfolio theory, the demand for international reserves and export instability (Gelb, 1979:149)
2. For a discussion of variability indices, see, amongst others, Cuddy and Della Valle (1978) and Van Walbeek (1993).
3. This index incorporates changes in the prices and quantities between months but not within months. This means that the variability in the variables is biased downward. Ideally one would want to base the index on weekly or even daily data, but these were not available in the published sources.
4. In 1993 the share of the Johannesburg fresh produce market was about 30 per cent of the total turnover of all vegetables traded on the 15 national fresh produce markets. The corresponding values for the Pretoria, Cape Town and Durban markets were 14, 15 and 11 per cent respectively.
5. On a national level, the turnover of these vegetables as a proportion of total vegetable turnover is as follows: potatoes (41 per cent), tomatoes (22 per cent), onions (11 per cent), cabbage (4 per cent) and carrots (3 per cent).
6. Of course this reasoning does not apply if a large number of farmers change their planting patterns in order to harvest their produce when the price is at its seasonal peak. The combined action of farmers may increase the supply of the produce to the extent that prices will actually decrease when they were expected to increase. It is important to keep this proviso in mind.

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Appendix

Seasonal adjustment factors of the price of fresh produce in four national fresh produce markets

Month	Potatoes				Tomatoes			
	Pta	Jhb	CT	Dbn	Pta	Jhb	CT	Dbn
1	0,935	0,947	0,935	1,013	0,997	1,014	0,780	0,848
2	0,835	0,841	0,967	0,855	0,948	0,959	0,820	0,898
3	0,882	0,873	1,061	0,873	1,002	0,994	0,845	0,993
4	1,021	0,996	1,122	0,974	0,990	1,018	0,884	1,072
5	1,060	1,025	1,098	0,993	0,952	0,966	0,756	1,011
6	0,994	0,982	0,977	0,970	1,134	1,125	0,987	1,156
7	0,969	0,963	0,931	0,963	0,879	0,863	0,916	0,902
8	0,963	0,958	0,936	0,960	0,914	0,885	1,061	0,957
9	1,107	1,091	1,089	1,125	1,217	1,175	1,471	1,176
10	1,128	1,150	1,069	1,154	1,051	1,030	1,257	0,941
11	1,020	1,056	0,935	1,051	0,967	0,992	1,248	1,052
12	1,086	1,119	0,879	1,069	0,948	0,978	0,975	0,995

Month	Onions				Carrots			
	Pta	Jhb	CT	Dbn	Pta	Jhb	CT	Dbn
1	0,853	0,832	0,656	0,774	1,082	1,066	0,778	1,136
2	0,852	0,814	0,663	0,749	1,242	1,140	0,882	1,228
3	0,985	0,948	0,685	0,923	1,574	1,417	1,174	1,408
4	1,123	1,136	0,783	1,054	1,493	1,442	1,147	1,619
5	1,311	1,292	1,002	1,202	1,072	1,047	1,069	1,258
6	1,344	1,344	1,190	1,345	0,870	0,879	1,064	0,949
7	1,153	1,189	1,319	1,295	0,796	0,881	1,178	0,863
8	1,137	1,184	1,574	1,250	0,811	0,874	1,193	0,734
9	0,998	1,017	1,540	1,062	0,708	0,773	1,009	0,640
10	0,778	0,785	1,137	0,851	0,723	0,795	0,915	0,564
11	0,718	0,737	0,827	0,786	0,722	0,760	0,760	0,603
12	0,749	0,723	0,623	0,709	0,908	0,927	0,831	0,999

Month	Cabbage			
	Pta	Jhb	CT	Dbn
1	0,853	0,832	0,656	0,774
2	0,852	0,814	0,663	0,749
3	0,985	0,948	0,685	0,923
4	1,123	1,136	0,783	1,054
5	1,311	1,292	1,002	1,202
6	1,344	1,344	1,190	1,345
7	1,153	1,189	1,319	1,295
8	1,137	1,184	1,574	1,250
9	0,998	1,017	1,540	1,062
10	0,778	0,785	1,137	0,851
11	0,718	0,737	0,827	0,786
12	0,749	0,723	0,623	0,709