THE NATURE OF PRICE MOVEMENTS DURING SINGLE SALES FOR THREE INDIVIDUAL WOOL TYPES SOLD IN SYDNEY

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Price series for three wool types sold in Sydney are tested for the presence of serial correlation using the von Neuman ratio. The results indicate that it is unusual to find significant serial correlation between prices during a single sale. These results have implications for the use of various statistical techniques in wool marketing research and for buying tactics in the market generally.

Introduction

Prices paid at wool auctions vary from sale lot to sale lot and the magnitude of these price fluctuations within a sale[1] depends on a number of factors. Skinner [9] has demonstrated that the physical characteristics of the wool which affect its processing performance will have a significant bearing on the price paid for different lots. Such price differences will be reflected in the average prices received for individual types. Although it is recognised that each type of wool is not perfectly homogeneous, it is considered that any price variation within a single type due to technical features would be minimal. Research carried out by the B.A.E. has demonstrated that prices may also vary due to differences in the preparation of wool for market [2], size of lots and time of selling [8, 10, 11]. Variations in price due to errors in wool buyers' estimates of value have been examined in detail by Whan and Fourlinnie [12]; however, in a later article Willett and Whan [15] demonstrated that such errors only have a slight influence on the price and show up as a residual source of variation after the more important sources have been defined and isolated.

Although the literature reveals a reasonably exhaustive coverage of the various sources of price variation within sales, there does not appear to be any evidence of work which has examined the nature of such price movements, a consideration which is very important since most of the techniques used to analyse wool prices are dependent on the assumption that they fluctuate randomly during a sale. In the present study it is proposed to test the hypothesis that prices fluctuate randomly about a stable mean throughout the duration of a sale.

Data and Methodology

A number of price series for types 62A, 62AB and 203K have been analysed. Types 62A and 62AB are common fleece wools while type

[1] Within the context of this article a sale will refer to a single afternoon as opposed to the usual denotation of two to four afternoons which comprise a sale series.

203K is a carbonising wool containing both fleeces and skirtings. A description of the three wools is presented in Table 1.

TABLE 1

A Description of the Wool Types Analysed

Type	Description
62A	An 'average spinners, best topmaking' merino fleece wool with a 64/60's quality number and a warp and half warp staple length.
62AB	Same as above with up to 3% burr and/or seed.
203K	Merino pieces and bellies with a 60's and up quality number and greater than 12% burr and/or seed.

By using price series for individual types those variations in price due to the physical characteristics and presentation of the wool are eliminated. It is believed that the price behaviour of the three types included in this study will be representative of many similar types.

The data were supplied by the Statistical Service of the Australian Wool Board. All lots of types 62A and 62AB were sold in Sydney in 1962-63 while the lots of 203K were sold in Sydney during the 1963-64 season.[2] The price series examined in this study are composed of clean prices calculated by converting the greasy price actually paid for each lot into clean equivalents. This is achieved by adjusting the greasy price according to a yield which is estimated by the Wool Board appraisers. The use of Wool Board data introduces the possibility of compounded errors due to double estimation [15]. Studies demonstrating discrepancies between different buyers' estimates of value have been undertaken and were referred to earlier. However, it is considered that such discrepancies will only have a marginal effect on the magnitude of price fluctuations and no effect on their pattern of movement, the latter being the subject of this study. Each price series examined is considered as a continuous series with no account being taken of the time span between the sale of successive lots of each type.

From the available data a total of 73 price series have been examined. It was not possible to include in the analysis all sales held during the selling season due to the seasonal nature of supply of individual types. There were a number of sales which did not provide sufficient price observations of the respective types for appropriate statistical analyses to be carried out. Any series which possessed less than ten observations was excluded from the study. A summary of the series analysed is presented in Tables 2, 3 and 4.

The hypothesis that wool price movements within sales are random is tested by subjecting each series to an examination for the presence of serial correlation between successive price observations. An absence of serial correlation suggests that the prices actually paid were serially independent and that the factors responsible for price movements during a sale behave in a random fashion. The statistic which has been applied

[2] Two separate seasons were required because the price data for all three types were not available in either season taken singularly; this, however, should not detract from the study since there is no *a priori* reason to suspect that the pattern of price variability will differ significantly between seasons.

to each price series is commonly referred to as the von Neuman ratio.[3] This ratio is a first order noncircular correlation statistic which relates the mean square of successive price differences to the variance of the entire series. It is defined as follows.

Consider a stochastic series of normally distributed wool prices x_i $(i = 1, 2, 3, \ldots, n)$ where the subscript i refers to the temporal order of the observations. The sample mean is defined as:

$$\bar{x} = \left(\sum_{i=1}^{n} x_i\right)/n,$$

the variance as:

$$s^2 = \left[\sum_{i=1}^{n} (x_i - \bar{x})^2\right]/n$$

and the mean square of successive difference as:

$$\delta^2 = \left[\sum_{i=1}^{n-1} (x_{i+1} - x_i)^2\right]/n - 1$$

The von Neuman ratio (k) is represented by the following expression:

$$k = \delta^2/s^2.$$

By comparing the computed value of the ratio (k') with the distribution of k a suitable test for the independence of observations x_1, x_2, $\ldots$, x_n is achieved. A set of tables have been constructed by Hart [4] to test the significance of computed values of the von Neuman ratio. These tables constitute upper and lower bounds and values of the computed von Neuman statistic falling outside these limits suggest the existence of serial correlation. There is evidence of positive serial correlation when the computed statistic is less than the lower limit and negative serial correlation when the upper limit is exceeded by the computed von Neuman ratio.

One of the conditions underlying the von Neuman ratio is that the observations come from a normally distributed population. In accordance with this, appropriate statistical tests were performed on the data and there was no evidence of any significant departure from normality.

Although applied in this study primarily to test for the presence of serial correlation between successive observations, the von Neuman ratios can also be used to test for trends in time series. As an extension of the analysis, each of those series which gave evidence of significant serial correlation was further examined to determine whether prices showed a tendency to increase or decrease during a sale; this was achieved by fitting linear trends to each series.

It has been suggested by Houthakker [5] that with traditional tests for randomness such as the serial correlation coefficient it is not possible to prove that series *are* random but only to prove that they are definitely not random. That is, if the von Neuman ratio is significant then it can be safely concluded that the series was definitely not random, however, a non-significant von Neuman ratio does not necessarily imply that a

[3] This was originally defined by von Neuman [6, 7] as a test for isolating trends in time series data but has since been described by Yamane [16] as a suitable statistic to test for serial independence in time series.

series is random though the evidence for randomness is strong. In other words, serial independence is a necessary but not a sufficient condition for randomness.

Results and Discussion

Details of the von Neuman ratio together with the coefficients of variation (c.v. $= s/\bar{x}$) for each series included in the study are presented in Tables 2, 3, and 4 for types 62A, 62AB, and 203K respectively. Table 5 consists of a summary of the trend tests which are performed on each of those series which had significant serial correlation.

It will be noted that the coefficients of price variation for type 203K are higher than is the case for types 62A and 62AB. The high price variations for 203K could arise from either the higher estimator error associated with the estimation of vegetable matter fault content or the indefinite range of fault covered by the suffix K (e.g:– all vegetable fault

TABLE 2

A Summary of the von Neuman Ratios and the Coefficients of Variation for Various Series of Type 62A Sold in Sydney, 1962–63

Sale	Day	Lots	Coefficient of Variation %	Variance s^2	M.S.S.D.[a] δ^2	von Neuman Ratio[b] (k')
4	3	19	2·46	6·8977	11·1012	1·6094
5	1	11	2·07	5·2000	10·3464	1·9897
	3	18	1·96	4·5528	7·9100	1·7374
6	1	18	2·18	6·0008	5·4503	0·9083***
	2	12	1·42	2·3826	3·9335	1·6579
	3	23	1·41	2·9789	5·3357	1·7912
	4	13	1·86	4·3662	9·5511	2·1875
7	1	21	1·50	2·9802	4·5613	1·5305
	2	15	2·04	5·3725	7·0076	1·3043
	3	18	1·78	4·0871	10·5491	2·5811
	4	33	1·58	3·2988	6·1857	1·8752
8	1	34	1·65	3·9529	6·8945	1·7442
	2	13	1·04	1·4000	2·8583	2·0416
	3	23	1·13	3·1922	5·8816	1·8425
	4	21	2·09	5·7657	10·1061	2·7934
9	1	14	1·37	2·5221	7·2459	2·8730
	2	24	1 36	2·7313	6·1041	2·2349
	3	26	1·87	4·6319	5·1028	1·1017***
	4	30	1·87	2·6040	5·7295	2·2003
10	1	22	1·96	6·1505	9·1729	1·4914
	2	44	1·95	6·4302	9·5466	1·4847**
	3	26	1·64	4·4178	7·6333	1·7279
	4	25	1·94	6·0624	9·4755	1·5630
11	1	34	2·28	8·5785	10·1012	1·1775***
	2	36	2·26	8·9939	14·8292	1·6488
	3	38	2·14	7·1182	11·1023	1·5597
	4	38	1·49	3·7532	7·5406	2·0091
12	1	44	1·58	4·0461	6·2840	1·5531
	2	42	1·75	4·6088	9·0278	1·9588
	3	28	1·76	4·7000	6·1885	1·5205
	4	16	1·42	3·3444	5·7380	1·7157

(a) M.S.S.D.—Mean square of successive differences
(b) *** Significant at 1%, ** Significant at 5%.

TABLE 3

A Summary of the von Neuman Ratios and the Coefficients of Variation for Various Series of Type 62AB Sold in Sydney, 1962–63

Sale	Day	Lots	Coefficient of Variation %	Variance s^2	M.S.S.D.[a] δ^2	von Neuman Ratio[b] (k')
1	1	21	1·49	3·0154	6·8217	2·2623
	2	12	1·11	1·0032	1·9094	1·9033
2	1	22	1·79	3·4065	7·5767	2·2242
	2	18	2·05	4·5871	10·2903	2·2433
	4	21	1·71	3·3413	5·2627	1·5750
3	1	20	2·39	6·4896	8·1412	1·2545**
	3	15	1·02	1·1845	1·8114	1·5293
4	2	15	2·10	5·3724	6·6007	1·2286**
	3	11	1·64	3·3908	9·3996	2·7721
5	2	12	2·24	6·1603	6·9513	1·1284**
	3	11	1·55	2·8062	5·4836	1·9541
	4	15	2·58	8·0396	3·4562	0·4299***
6	1	15	1·41	2·5126	6·6440	2·6443
	2	12	1·58	1·9612	3·3120	1·6888
	3	13	1·41	2·4943	5·7549	2·3072
7	2	10	1·43	2·5862	6·4306	2·5040
8	1	19	1·38	2·4788	4·7236	1·9056
	2	12	2·33	7·1664	13·3469	1·8624
18	1	11	1·14	3·3172	5·4363	2·3336

(a) M.S.S.D.—Mean square of successive differences
(b) *** Significant at 1%, ** Significant at 5%.

levels above 10 per cent or 12 per cent depending on the type of wool [1]).

From the 73 series analysed only ten exhibited significant serial correlation, five of which were significant at the 1 per cent level of statistical probability and the remainder were significant at the 5 per cent level. There does not appear to be any association between the pattern of price movements and the wool type, however, conclusions of this nature should be reserved until more types are considered.

Calculated regression coefficients for the ten series having significant serial correlation are set out in Table 5. Of these only six series displayed a significant linear trend.

In each case the correlation of price against time was low indicating that linear functions did not adequately describe the trends. Low correlation coefficients were also obtained when polynomial functions were fitted to the data. It was concluded that no systematic price movement could be detected in the series.

The analysis indicated that price trends are rarely found in wool price data relating to sale lots containing the same type of wool sold in a single afternoon. No consistent trend could be detected in the few series displaying serial correlation.

If it is accepted that the price behaviour of the three types examined in this study are representative of other wool types, the results have a significant bearing on statistical analyses of wool prices and also on the tactics adopted by buyers and sellers in the auction market.

TABLE 4

A Summary of the von Neuman Ratios and the Coefficients of Variation for Various Series of Type 203K Sold in Sydney, 1963–64

Sale	Day	Lots	Coefficient of Variation %	Variance s^2	M.S.S.D.(a) δ^2	von Neuman Ratio(b) (k')
1	2	12	7·45	50·0045	136·2578	2·7249
	3	15	5·27	24·6179	57·5462	2·3376
2	2	14	7·38	43·4230	77·0888	1·7753
	4	10	3·38	10·1446	22·5507	2·2229
3	2	17	8·13	56·3516	81·2666	1·4421
	3	11	6·45	37·3287	62·4143	1·6720
	4	10	4.69	19·4226	39·4731	2·0323
4	1	12	7·06	39·6515	65·4564	1·6508
	3	11	3·08	8·2908	15·3006	1·8455
	4	19	4·70	19·6167	31·6531	1·6136
13	2	12	7·45	52·4876	70·6110	1·3453
	4	16	8·38	69·0877	138·0407	1·9980
14	2	10	7·74	56·4310	46·8490	0·8302***
	3	21	8·07	46·3360	97·8779	2·1124
	4	10	8·46	52·6364	76·2150	1·4480
15	2	11	11·60	94·8535	150·4629	1·5863
	3	12	5·05	16·8232	27·6055	1·6409
16	1	12	10·66	62·2975	164·8498	2·6461
	2	12	9·14	59·0839	83·4284	1·4120
17	1	10	9·58	76·1618	90·5868	1·1894
	4	10	13·08	138·0077	290·9030	2·1079
18	1	12	6·13	30·8731	32·2778	1·0455**
	2	13	6·77	38·3312	90·7439	2·3674

(a) M.S.S.D.—Mean square of successive differences
(b) *** Significant at 1%, ** Significant at 5%.

A random movement of prices throughout a sale afternoon suggests that probabilistic models of an auction market, such as that developed by Whan and Richardson [13] and later extended by Whan and Tier [14], which are based on the assumption of randomness, have a practical application. Furthermore, these results support the use of regression and analysis of variance techniques in the examination of price variation within sales.

In regard to buyer strategy, it has been inferred by Gruen [3] that the most rational buying tactic is one in which purchases are spread evenly over the whole sale. If buyers were to attempt to fill their orders too quickly they would tend to raise the price above the average. On the other hand, a delay in purchases could result in a failure to fill orders or, if competition is strong, an undue bidding up of prices in the closing stages of the sale. The absence of price trends in the majority of the series examined suggests that either individual buyers do spread their purchases evenly over the sale period or different buyer strategies tend to cancel each other out in the aggregate.

TABLE 5

A Summary of the Regression Analysis Applied to each Series[a]

Type	Sale	Day	Regression Constant	Regression Coefficient[b]	R^2	Degrees of Freedom	"t" Test on Regression Coefficient[c]
62A	6	1	114·76	−0·0258 (0·054)	0·11	16	−0·478 N.S.
	9	3	117·61	−0·0750 (0·025)	0·27	24	−3·000 ***
	10	2	128·01	−0·0421 (0·014)	0·18	42	−3·007 ***
	11	1	127·23	−0·0378 (0·022)	0·09	32	−1·718 N.S.
62AB	3	1	106·09	−0·1111 (0·045)	0·25	18	−2·468 **
	4	2	109·51	0·2812 (0·120)	0·27	13	2·340 **
	5	2	111·81	−0·2407 (0·084)	0·45	10	−2·865 ***
	5	4	112·44	−0·5194 (0·112)	0·63	13	−4·638 ***
203K	14	2	96·89	0·1807 (0.457)	0·16	8	0·395 N.S.
	18	1	91·39	0·1893 (0·247)	0·15	10	0·766 N.S.

(a) Only those series which had significant von Neuman ratios are analysed.
(b) The standard errors of the regression coefficients are given in parentheses.
(c) *** Significant at 1%, ** Significant at 5%. N.S. Not significant at 5%.

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