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THE EFFICIENCY OF PRICE DISCOVERY AT WOOL AUCTIONS

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The purpose of this paper is to determine whether the auction system is an efficient price discovery mechanism for wool. A number of hypotheses are postulated regarding the pattern of price movements within saledays. These are tested by analysing 80 price series at three selling centres. The procedure is to estimate quality adjusted prices and to examine whether lot position or order of sale is an important determinant of sale price.

An understanding of the price discovery mechanism in the open outcry auction system and quantitative information on pricing efficiency will assist the development of possible alternative selling systems. In particular, it is relevant to the increasing interest in and development of computerised selling systems for wool.

The analysis suggests that, in the majority of cases, prices within saledays at Australian wool auctions tend to fluctuate randomly around a stable mean. Nevertheless price trends do occur relatively frequently. The presence of price trends implies that all parties, growers, brokers and buyers, may be disadvantaged because of the effect of order of sale on prices paid. The paper concludes by suggesting some strategies for minimising the impact of order of sale on market participants.

Introduction

How well do auctions discover the price of wool? This issue is of importance to the wool industry because of the current interest in computerised selling. At this formative stage of computerised trading networks, it is desirable to improve our understanding of the current selling system and in particular to provide quantitative evidence of the efficiency of the price discovery mechanism at wool auctions. This information can then be used to help assess alternative pricing mechanisms which may overcome some of the deficiencies of the auction process.

The objective of this study is to test the efficiency of within day price formation at Australian wool auctions. This involves estimating quality adjusted prices and examining whether any bias (trend) occurs within a particular sale day. After briefly discussing the theory underlying price formation at auction, previous analyses relating specifically to the wool industry are reviewed. This is followed by a discussion of the methodology and data used in the paper. Results of the analysis of 80 sales are then discussed and the final section considers conclusions and the implications of the findings for market participants.

Price Movements Within Saledays : A Theoretical Discussion

A market is said to be operating efficiently when current prices fully reflect all available information. Movements in prices should reflect changes in available information and since there is no reason to suspect that new information forthcoming is not random, price movements themselves should also necessarily be random (Fama 1965). A priori, assuming perfect information and a competitive market, prices paid for similar lots are expected to be random around a stable mean.

Information flows are, however, far from perfect. For example, an order buyer is commonly faced with the problem of whether to purchase the current lot on offer or to wait for a subsequent interchangeable lot. The profit maximising strategy is to purchase the subsequent lot provided the expected cost of the subsequent lot in less than the purchase price of the current lot. The information required to implement this strategy is not available, however, since it requires knowledge of prices which have not yet been determined. To follow the profit maximising strategy, buyers would need to make explicit/implicit estimates of later prices and hence adjust their bids accordingly. This would require knowledge of the subjective values and upper limits of other bidders (Sosnich 1963). These information requirements are necessarily prohibitive, and as a consequence simple bidding strategies are often employed by buyers when on the auction floor[1].

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1. Major bidding strategies include 'full value' bidding percentage buying, or a profit maximising strategy based on implicit/explicit estimates of later prices, (Sosnich 1963).

A peculiar feature of auction markets is that they encourage buyers to discriminate against themselves. During an auction each lot offered will be sold one bid above the second highest reservation price. The result is that the bulk of the buyer's surplus is extracted by the seller (Sosnich 1963, Buccola 1982). Further, since buyers have unequal reservation prices, self-discrimination implies that prices of homogeneous lots trend downwards during the course of the sale[2]. This occurs because the most eager buyers with the highest reservation prices tend to meet their commitments early and leave the sale room.

Further insights into how buyers discover the equilibrium price at auction can be obtained from a study by Smith (1965). In this study experimental market sessions were specifically designed to test the nature of the equilibrating forces operating in competitive auction markets. In each of the six auction sessions held, aggregate supply was greater than aggregate demand so that equilibrium occurred at the sellers' minimum price. Each seller had one fictitious homogeneous commodity for sale at any price not below the given minimum reservation price of $3.10. Commodity buyers, on the other hand, could purchase at most one unit per trading period at a price not to exceed the limit price of $4.20. Each buyer received 0.05¢ for a purchase plus the difference between his limit price and his contract price. Similarly each seller received 0.05¢ for a sale plus the difference between his contract price and his limit price. Each subject trader had initial information only on his own limit price. The additional information provided in the course of the market session consisted of the ordered public bids announced by the individual traders. In all six sessions Smith found that contract prices showed a strong tendency to converge to the theoretical competitive equilibrium from above and that the tendency to equilibrium is an increasing function of the level of excess supply in the market.

The conclusion which can be drawn from Smith's analysis is that downtrends in auction prices are not necessarily a function of unequal reservation prices, but may simply occur because buyers wish to minimise the risk of failure to make a purchase during the sale. Hence, highly risk averse buyers tend to meet their commitments early during a sale at contract prices close to their (maximum) reservation price. The result is that buyers are satiated in order of their risk aversion, and this leads to a downward price trend.

While risk aversion and unequal reservation prices of buyers are conducive to downward price trends, other factors may negate their effect. For instance, variations in demand may occur as buyers enter or leave the sale room, prices realised early may be below the average for the day as lots offered initially may not entice a full complement of bidders because buyers are developing their expectations about price levels for the sale; and/or buyers may make explicit/implicit estimates of later prices and hence adjust their bids accordingly.

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2. Reservation prices of buyers are a function of the competitive position of the firm from which the order was received, and buyer margins. Differences in reservation prices may also occur due to errors in specification resulting from the subjective appraisal of lots on offer.

Clearly, in the absence of knowledge of the bidding strategies employed by buyers the direction of price movements within saledays remains an empirical question. A priori if the market is operating efficiently prices paid for homogeneous lots should be randomly distributed around a stable mean. However because of imperfect knowledge buyers often adopt simple trading rules whilst bidding on the auction floor. These simple trading rules may cause price trends to occur within saledays. Because of the uncertainty of future supply opportunities and the risk attitude of buyers, it is expected that if the trends are observed, downward price trends will predominate.

Previous Studies

Most empirical studies relating to the Australian wool market have tested the efficient market theory and whether this hypothesis is appropriate for wool futures (Tier 1970, Hunt 1974 and Praetz 1975). Few studies however have examined price formation at Australian wool auctions. Four studies of direct relevance to the present paper are those by Payne and Whan (1971), Whan and Richardson (1969) and Burns (1984), (1982). The first paper examines the nature of price movements within a saleday and is similar in objective to the present study. The article by Whan and Richardson provides information on the level of competition required at wool auctions for buyers to bid up to their full valuations. The third study compares the bidding strategies of inexperienced student subjects with those of highly experienced wool buyers. The last article suggests an alternative to the auction process which the author believes would lead to a more efficient selling system.[3]

Payne and Whan tested the hypothesis that prices fluctuate randomly about a stable mean during a sale. Three wool types were analysed and a total of 73 price series examined at sales in Sydney during the 1962/63 and 1963/64 seasons. Serial dependence between prices of successive lots of the same type were examined using the von Neumann ratio. Trend lines were estimated for those in which significant serial dependence was found.

Of the 73 series examined, 10 were found to exhibit serial dependence between prices of sequentially ordered lots. Significant trend lines were obtained in 6 of these 10 series of which 5 had negative trend co-efficients. On the basis of these findings the authors' concluded that price trends are rarely found in wool price data relating to sale lots containing the same wool type sold in a single afternoon. They argue that the absence of price trends suggests that either individual buyers spread their purchases evenly over the sale period and/or different buyer strategies tend to cancel each other out in aggregate.

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3. Burn's definition of an efficient market is broader than the one used earlier in this paper. She defines an efficient market as having the following characteristics.

- The market should have the ability to generate average prices close to the theoretical market clearing level with no decided bias.

- The market should also ensure that the range of prices around the 'correct' average is small.

This latter aspect is not considered here.

Whan and Richardson developed a model of an auction market which attempted to explain the relationship between the variation in buyers' valuations, the price variation and the number of independent bidders in the market. Their finding was that an auction held with less than four bidders does not provide enough competition to force buyers to pay their pre-determined valuation. The implication of their analysis is that in relatively "thin" markets, average prices may fall as buyers meet their commitments and leave the sale.

Burns (1984), using a simple model of the auction market, compared the bidding strategies of a group of experienced wool buyers with that of a group of inexperienced student subjects. She utilized a number of experimental market sessions designed specifically to examine which of three strategies buyers used: to maximise their profits by attempting to predict the market equilibrum price, to maximise their purchases subject to not making a loss, or to implement a bidding rule such as full value bidding. The results demonstrated that buyers tended to adopt a full value bidding strategy. Conversely, the inexperienced student subjects tended to adopt a profit maximising strategy during the experimental auction sessions. Burns argued that the strategy adopted by the buyers reflected their awareness of the importance of making their quota. Because of this concern, each auction session featured a sharp decline in price during the course of the sale, with prices falling by an average of 15 per cent over each of the sessions.

Burns (1982), on the other hand, began by noting the limitations of sequential auctions, in particular, the importance of order of sale on price received. Her analysis is a natural extension to the current work. Because of the ramifications of order of sale for pricing efficiency and equity she advocates an alternative to the auction process, namely a simultaneous selling system. Under such a (necessarily computerised) system, bids are offered on all sale lots simultaneously. Bids are made progressively on all lots until prices have risen sufficiently to eliminate enough of the least favoured buyers so that the remaining demand is equal to the number of lots available. At this stage bidding ceases and the various lots are awarded to their highest bidders. One advantage of this system is that buyers always know the strength of the competition for each lot, so the amount of competition is spread evenly over all lots. On the basis of a large number of computer simulations, Burns found that simultaneous selling would have advantages in terms of higher prices to sellers, higher profits to buyers and a smaller price variance - provided the spread of valuations is large.

Methodology and Data

The procedure to estimate the price effect of lot position at a particular sale is based on the consumer demand theory of Lancaster (1971). The approach is based on the hypothesis that goods are valued for their utility bearing (hedonic) characteristics. The model simply involves regressing the main quality characteristics of greasy wool and lot position against clean prices paid for each wool type. Previous applications of the Lancaster methodology to the Australian wool market include Stott (1987), Bramma et al. (1985), Jackson and Spinks (1982) and

Simmons (1980). The basic estimating equation can be represented symbolically as

P = (M, VM, L, G, LP)

where P = price per kg clean wool, derived by dividing the per kg greasy price bid for each lot by the Schlumberger Dry Combing yield of the lot.

M = mean fibre diameter which is the major value determining characteristic of the lot.

VM = percentage of vegetable matter content in the wool.

L = fibre length. Dummy variables are used to capture the effect of fibre length on clean prices paid. Fibre length is divided into three categories, A long, B medium and C short: A-length wools are generally longer than 90 mm, B-length wools are those between 80 to 90mm and C length wools are shortest and range between 70 to 79 mm. These specifications will vary marginally (1-5 mm) depending on micron and grade. Finer and better style wool tends to have a slightly shorter specification.

G = wool grade or style. Dummy variables are used to allow for different style wool. Style is a term which covers a number of features of the wool, related in part to general appearance. These can include 'tippiness', greasy colour and other subjective characteristics such as 'bloom' and 'handle'. Style is a characteristic of wool which has traditionally indicated the end use purpose i.e. spinners, best topmaking, good topmaking etc.

LP = lot position or order in which lot was offered for sale.

The data sample on which the price equations are estimated includes both additionally measured (AM) and non-AM, wool but excludes wool sold by separation, interlotted, bulk classed or sold without objective measurement. No distinction is made in the price analysis between AM and non-AM wool. The impact of differences in fibre strength on prices realised at auction has been minimised by including only sound wool (greater than 30 Newtons per kilotex) in the data sample. This approach is justified because an analysis of premiums and discounts paid for length and strength measurements by Stott suggests that no premium was being paid in the market for incremental increases in fibre strength above 30 Newtons per kilotex, over the analysed period.

The selection of wool types and saledays was largely dependent on there being a sufficient quantity of grower brand lines to allow for statistical estimation of price equations. Weeks selected were usually those during which Corporation activity in the market was minimal. This was necessary to ensure that a downward price trend in the market wasn't truncated because the market price had reached the floor for that particular type.

The selling centres selected for the analysis were Melbourne, Adelaide and Brisbane. Melbourne is the largest centre in Australia with 26 percent of the total offering. Adelaide has about 12 percent of the offering, and Brisbane is a relatively small centre with 7 percent.

Table 1 presents the micron profile of the offerings for the three centres in 1986/87.

TABLE 1: MICRON PROFILE OF OFFERING BY SELECTED CENTRE (%)

Grade	Melbourne	Adelaide	Brisbane
19m and finer	3.8	0.4	3.1
20m	10.0	3.2	10.8
21m	14.9	9.2	25.4
22m	19.3	23.9	30.2
23m	13.2	22.3	16.8
24m-26m	20.7	34.1	10.2
27m-29m	7.4	3.5	0.6
20m & coarser	7.9	1.5	0.4
Oddments	2.8	1.9	2.5
TOTAL	100.0	100.0	100.0

For all centres the offering was centred around 22 micrometres. The offering in Brisbane was highly concentrated in the 21-23 micrometre range while the Melbourne offering tended to be more evenly spread. The Adelaide selection had a slightly coarser range of types with the majority of its offering in the 22-26 micrometre range.

Wool types selected for analysis were the more common types on offer. Only Merino combing fleece was considered and the data were grouped into the following categories:

- best and good topmaking Merino combing fleece of 20.6 to 21.5 microns for Melbourne and Brisbane, and 20.6 to 22.5 microns for Adelaide, and

- best and good topmaking Merino combing fleece of 22.6 to 23.5 microns for Melbourne, Brisbane and Adelaide.

For Adelaide it was necessary to combine the data across a two micron range, 20.6 to 22.5, to ensure a reasonable sample with which to estimate the price equations (Table 1).

The data was grouped by micron category primarily to minimise the impact of any non-linear relationship which may exist between fibre diameter and price (Bramma et al. 1985). Also by grouping the data it enabled the estimation of a number of price equations on any one particular sale day. Implicit in this approach is the assumption that the demand for the various grades of wool, which differ by at least one micron, are distinct from one another. This assumption can be defended given spinner tolerances on the micron range of typical raw wool blends.

Finally, to undertake the analysis selected types were ordered according to the sequence in which they were sold. This involved ordering the data by broker and then by lot number.

Results

The results for the three sale centres are reported in Tables 2,3 and 4. There was no evidence of first order serial correlation in the residuals in any of the equations estimated. A total of 80 price series were examined, of which 63 fluctuated randomly about a stable mean, while the remaining 17 were found to have a significant lot position co-efficient. This suggests that on the majority of saledays the wool market is operating efficiently. Of the 17 price series which exhibited a trend, 14 or 82 per cent had negative co-efficients. This supports the earlier hypothesis that, if price trends were observed, downward price trends would predominate.

As discussed previously, the direction of price movements within any single sale day is largely a function of the bidding strategies pursued by buyers. As we have no strong prior view as to whether prices on average trend upwards, downwards or fluctuate randomly around a stable mean during the sale period, a chi-squared test was used to determine whether the observed frequencies within the sample of 80 sales differed from a population in which the probability of the three outcomes is uniform. This hypothesis was strongly rejected as the estimated chi-squared value was 76. Earlier it was also hypothesised that if price trends were observed downtrends would predominate. This hypothesis also was tested using a chi-squared test on the sample of 17 sales for which trends were observed. The estimated chi-squared value was 7.11 and the critical value at the 5 percent level of significance with 1 degree of freedom is 3.84. Hence, the difference between the observed and expected frequencies is sufficient to conclude that downtrends do predominate over upward price trends.

The occurrence of price trends did, however, differ between the three centres. In Melbourne only 4 (14%) of the 29 price series examined were found to have a significant lot position co-efficient, three of these being negative. For Adelaide 8 (28%) of the 29 series examined were found to have a significant lot position co-efficient, of which all but one were negative. Five (23%) of the 22 price series in Brisbane had significant lot position co-efficients, with three of these being negative.

The evidence suggests that price trends may be more prevalent in the smaller centres. This may reflect the different levels of competition in the three markets or it may be a direct consequence of the higher costs associated with not meeting an order commitment. That is, the costs associated with not meeting an order commitment may be greater in Adelaide and Brisbane because they have less frequent sales and shipping services. Consequently, in these centres, to meet an order buyers may be more willing to offer their full reservation price early in the sale. Further analysis needs to be undertaken, however, before any strong conclusions can be drawn on whether price trends are more prevalent in small centres relative to the larger centres.

These findings differ somewhat from those of Payne and Whan (op cit). The current analysis suggests that price trends occur far more frequently within saledays, particularly in the smaller centres. The differences in the findings can probably be attributed to the fact that Payne and Whan analysed price movements at only one centre, Sydney (a comparatively large selling centre), and their method of analysis. Payne and Whan were restricted to analysing single wool types and had to assume that price variations within a single type due to technical features would be minimal. It is possible that the small sample size of some of the series examined could have reduced the reliability of the statistical procedures used. When trends were observed, downward price movements were found to predominate although the significance of the direction of any price movement was not discussed or recognised in the earlier analysis.

The size of the co-efficients for order of sale suggests that on average, prices paid are about $100 lower per lot at the end of the sale than at the beginning when a downward price trend occurs. This represents about 2 per cent of the value of an average 8 bale lot. There is, however, a significant level of dispersion around this figure. The finding suggests that the rate of decline of prices at wool auctions within saledays is significantly less than that found by Burns (1984). Burns' analysis, based on a number of experimental market sessions, suggested that prices fell on average by 15 percent over the course of a sale.

A notable feature of the results reported here was the number of significant price trends in Melbourne and Brisbane in the last sale week prior to the Christmas recess in December 1986. Significant downward price trends for best and good topmaking Merino combing fleece of 22.6 to 23.5 microns were observed in both Melbourne and Brisbane on the 15th and 16th of December 1986. This may reflect buyers' concerns with meeting their order commitments prior to the Christmas recess and the resulting adoption of a full value bidding strategy. On the other hand, on the last sale day prior to the Christmas recess, the 17th of December, an upward price trend was observed in Melbourne for the same wool types. A possible explanation is that buyers were forced to abandon their full value bidding strategy to ensure that they made their quota. Hence prices rose during the course of the sale as buyers sought to fill their orders.

In general, however, there is no evidence to suggest that if trends prevailed on any one saleday, the remaining saledays within the same saleweek would exhibit a similar trend. This is not unexpected since it is likely that on each saleday, different buyers and buying strategies would be operating. Moreover, having filled some orders on the previous day, buyers would be placing bids on the basis of a new set of orders. The implication of these findings is that lot position is likely to be a very poor predictor of sale price.

Discussion and Conclusions

The analysis suggests that in the majority of cases prices within sale days at Australian wool auctions tend to fluctuate randomly around a stable mean. Nevertheless, price trends do occur quite frequently and when observed are predominantly downwards. It is argued that downward price trends are largely a function of unequal reservation prices, and different levels of risk aversion between buyers. It was also found that while order of sale was an important determinant of the price paid for a particular lot it nevertheless remains a poor predictor of sale price.

When a downward price trend does occur, it suggests that sellers are more successful in extracting the buyers' surplus early in the sale. Conversely, windfall losses occur to sellers late in the sale as buyers bid below their reservation prices. The implication is that all parties growers, brokers and buyers may be disadvantaged on certain sale days because of the effect of order of sale on prices paid.

A number of strategies may be implemented to minimise the impact of order of sale on market participants.

- Growers and brokers should improve the quality of information in brokers sale catalogues. Objective information on wool characteristics, for instance, would reduce differences in reservation prices between buyers due to errors in specification.

- Brokers should continue the practice of altering their order of selling between sales. This would ensure that in the long run each broker would be on par with other brokers from the point of view of the time of selling with prices averaging out across all sales.

- Buyers should space out their purchases over the entire sale session. A percentage buyer, for instance, should remain throughout the sala session buying irregularly but often enough to ensure that his percentage of sales never differs substantially from his intended final percentage by more than a few lots. This will ensure that his average costs will not be significantly above the market average thereby automatically avoiding the problem of self-descrimination.

- Competition between buyers should be encouraged to ensure that buyers bid up to their full reservation prices. For example, wool lots could be withdrawn from sale if the number of active bidders fell below some specified minimum. Available evidence suggests that the level of concentration in the woolbuying industry has increased over the last decade. This may have resulted in less than desirable levels of competition at some wool sales.

In the long term however the presence of price trends at wool auctions may result in the adoption of an alternative selling system, particularly if computerised selling became a reality. For instance, price formation may be achieved more equitably and efficiently if a simultaneous selling system along the lines suggested by Burns were adopted by the wool industry.

TABLE 2 EFFECT OF LOT POSITION ON PRICES PAID AT AUCTION IN MELBOURNE

Style	Saleday	Lot Position Co-efficient	$\bar{R}^2$	Number of Observations
Best and Good TM Merino Combing Fleece 20.6 to to 21.5 Micron				
	280786	0.29	0.71	35
	300786	0.36	0.63	44
	310786	-0.31	0.60	74
	101186	0.02	0.55	74
	111186	-0.09	0.31	48
	121186	0.05	0.49	85
	131186	0.18	0.80	16
	151286	-0.001	0.72	41
	161286	0.01	0.72	54
	171286	0.03	0.82	60
	130187	0.08	0.82	67
	140187	0.14**	0.51	99
	150187	-0.10	0.63	73
Best and Good TM Merino Combing Fleece 22.6 to 23.5 Micron				
	280786	-0.14	0.85	48
	300786	0.001	0.88	58
	310786	0.03	0.79	80
	271086	0.06	0.85	86
	281086	0.05	0.81	64
	291086	-0.04	0.86	81
	301086	-0.30	0.66	57
	101186	0.03	0.57	30
	111186	-0.04	0.80	71
	121186	0.01	0.83	83
	151286	-0.21**	0.88	53
	161286	-0.22*	0.85	84
	171286	0.15**	0.83	68
	130187	-0.07	0.85	65
	140187	0.14	0.69	77
	150187	0.02	0.85	79

Notes: * and ** signify significance at the 5 and 10 percent levels, respectively.

TABLE 3 EFFECT OF LOT POSITION ON PRICES PAID AT AUCTION IN ADELAIDE

Style	Saleday	Lot Position Co-efficient	$\bar{R}^2$	Number of Observations
Best and Good TM Merino Fleece 20.6 to to 22.5 Micron				
	270885	0.05	0.72	63
	280885	0.16	0.70	30
	170985	0.16*	0.71	83
	180985	-0.26	0.79	56
	190985	0.35	0.83	30
	81085	0.02	0.94	84
	91085	-0.01	0.95	45
	291085	0.06	0.83	58
	301085	-0.10	0.90	35
	311085	-0.47**	0.94	28
	181186	-0.11*	0.57	128
	191186	-0.07	0.47	91
	201186	0.29	0.88	22
	91286	-0.06*	0.41	134
	101286	-0.09	0.52	68
	111286	0.11	0.42	26
Best and Good TM Merino Combing Fleece 22.6 to 23.5 Micron				
	200886	-0.04	0.88	53
	300986	-0.03	0.95	46
	211086	0.07	0.78	107
	221086	0.09	0.79	70
	181186	-0.10*	0.77	144
	191186	-0.04	0.74	121
	91286	0.01	0.83.	145
	101286	-0.11**	0.82	85
	111286	-0.12	0.81	43
	280187	-0.06*	0.90	133
	290187	-0.12*	0.82	98
	260287	-0.13	0.83	76
	250287	0.03	0.72	99

Notes: * and ** signify significance at the 5 and 10 percent levels, respectively.

TABLE 4 EFFECT OF LOT POSITION ON PRICES PAID IN BRISBANE

Style	Saleday	Lot Position Co-efficient	$\bar{R}^2$	Number of Observations
Best and Good TM Merino Fleece 20.6 to to 21.5 Micron				
	280885	-0.08	0.90	59
	290885	-0.15	0.90	42
	301085	-0.04	0.73	103
	311085	-0.02	0.74	115
	281086	-0.04	0.74	58
	291086	0.08**	0.75	63
	301086	0.12**	0.58	60
	191186	-0.11*	0.72	70
	201186	-0.05	0.65	62
	161286	-0.04	0.63	74
	171286	-0.01	0.62	74
Best and Good TM Merino Combing Fleece 22.6 to 23.5 Micron				
	270886	0.08	0.82	51
	280886	-0.10	0.88	30
	230986	0.30	0.77	26
	240986	0.05	0.89	55
	281086	0.09	0.78	61
	291086	-0.06	0.74	85
	301086	0.07	0.81	61
	191186	-0.01	0.72	117
	201186	0.15	0.68	69
	161286	-0.12*	0.86	81
	171286	-0.11*	0.82	78

Notes: * and ** signify significance at the 5 and 10 percent level, respectively.

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