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PIG CARCASE PRICING MODELS: A PRELIMINARY INVESTIGATION

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This paper reports on a preliminary study which aimed to determine whether a proposed pig carcase description scheme could be regarded as appropriate for the needs of market participants in the Australian pig market. Regression techniques applied to carcase measurements and cut-out data revealed that those carcase characteristics used as the basis of the description scheme significantly explained wholesale and retail carcase values. Available evidence also suggests that market participants are using this measurement information in their trading activities.

1 INTRODUCTION

A common theme running through the 1976 Australian Meat Board Carcase Classification Symposium [1] was that, although considerable resources had been allocated to developing technically efficient carcase description proposals, little had been done to examine their economic efficiency. The study reported in this paper was a first attempt to economically evaluate one of the proposed carcase description schemes—the National Pig Carcase Measurement and Information Service (NPCMIS). This scheme is fully described in Wilson [16, 17] and Wilson and Giles [19].

For the NPCMIS to be an appropriate basis for pricing, two interdependent conditions must be satisfied:

(a) a significant proportion of buyers do, or should, differentiate between pig carcases on the characteristics of hot carcase weight, P2 backfat depth, and sex, which are the basis of the NPCMIS; and

(b) market participants generally accept these carcase characteristics and the procedures used to assess them.

The ultimate test of the success or failure of a carcase description scheme is, of course, its acceptance or rejection by producers and the meat trade

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as an aid in carcase trading and as a guide to production. Acceptance will only result if the description scheme provides a service better than the one it supersedes and if the benefits exceed costs.

Considerable care should be exercised in making this evaluation as there is usually a lengthy learning period before market participants become familiar with, and gain confidence in, the proposed service. Considerable time and money may have to be allocated to an education and promotion campaign.

Prior to this study, no formal evaluation of the NPCMIS had been attempted to determine whether "market participants generally accept the specification criteria and measurement procedures". There is quite a deal of evidence though which does suggest that market participants do consider the NPCMIS appropriate and do recognize the benefits available from its use.

For example, the South Australian Meat Corporation (SAMCOR) has been providing measurements on all pig carcases (except mature sows and boars) since June, 1974. Information on individual carcases is sent back to producers and on to buyers. Several producer groups are co-operating to market their pigs to processors or retailers who will utilize the measurement information and pay premiums for top-quality pigs. Retail butchers now request carcase measurement information with their carcases, and one large chainstore is prepared to pay a 5 cent premium for heavier carcases within a specified P2 backfat thickness range.

In the Australian Capital Territory, Red Hill Meat Supply measures all pig carcases killed and pays producers differential prices for grades based on this measurement information. Further, they also charge Canberra retail butchers differential prices for different grades purchased.

All wholesalers, except one, used NPCMIS measurements for trading purposes during pilot runs of the Service at Blayney County Council Abattoir, and in Tasmania about half the total pig kill was traded on objective measurements when pilot runs of the NPCMIS operated there.

In this study the question was asked whether this general acceptance of the NPCMIS is warranted; *i.e.*, can it provide information on each carcase so that buyers and sellers can better estimate the likely yield and "quality" of meat that would result from the carcase? If so, this would allow information on desirable carcase traits to be transmitted back to pig producers, and hence encourage, guide and speed up the rate of improvement in pig carcase quality.

This condition is one of the most important aspects of the whole process of formulating and implementing an effective pig carcase description scheme. It will be examined in section 2 by the use of two preliminary pig carcase valuation studies—one at the wholesale level and one at the retail level. Section 3 contains some conclusions and suggestions for further study.

2 PIG CARCASE VALUATION STUDIES

2.1 Wholesale Pig Carcase Valuation Study

In an attempt to determine whether the carcase characteristics of hot carcase weight, P2 fat depth, sex and carcase length[1] are related to those factors which determine the relative wholesale values of pigmeat to buyers, wholesale carcase valuation studies were commenced at two abattoirs in New South Wales[2].

These studies were designed along the lines of pig carcase valuation studies reported by Couvillion and Dubov [2], Ikerd and Cramer [10, 11] and Schupp *et al.* [14] in the United States, Green et al. [4] in Canada, Pichler et al. [13] in Austria, and Nelson [12] in Western Australia. A recent, similar study for beef has been done in the United Kingdom by Harries et al. [8].

The null hypothesis tested was that there were no significant relationships between the various carcase measurements taken and actual wholesale carcase values. Under the assumption that carcase value per kilogram is the best indicator of carcase value when carcases of different weights and "qualities" are being compared, ordinary least squares regression models were used to test the null hypothesis. As in previous studies [4, p. 4; 11, p. 243], the explanatory variables were thought to operate additively, so a linear functional form was specified; namely,

$$WV = \alpha_0 + \alpha_1 HCWT + \alpha_2 P2BF + \alpha_3 SEXC + \alpha_4 SEXE + \alpha_5 LGTH \quad (1)$$

where WV = wholesale value in \$/kg

$HCWT$ = hot carcase weight in kg

$P2BF$ = introscope backfat depth at $P2$ in mm

$SEXC$ = (1 for castrates
(0 for females

$SEXE$ = (1 for entire males
(0 for females

$LGTH$ = carcase length in mm

α_i $(i = 0, \ldots, 5)$ = regression coefficients to be estimated.

The stochastic error term is omitted for simplicity and time subscripts are irrelevant in cross-sectional studies such as this. *A priori*, sign

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[1] Although available evidence suggests otherwise, many market participants still view carcase length as an important determinant of yield. Length was included as a variable to test this hypothesis.

[2] Another method of doing this would be in a laboratory-controlled test situation. We wanted these trials to be in commercial situations, and we also wanted trade reactions to the trials, so we chose the reported method of analysis. One abattoir has continuously participated in a pilot run of the NPCMIS since July 1975. Unfortunately, a study at one of the two abattoirs had to be prematurely terminated because the processing firm doing the carcase valuations refused to supply details of the prices charged for individual carcases. Additionally, the processing plant weigh scales were found to be inaccurate, so only data from one abattoir were analysed.

expectations are α_1, α_2 and α_3 negative, α_4 positive, and α_5 negative but insignificant.

These data were collected as follows. Approximately 150 pig carcases were measured at the abattoir over a 4-week period in December, 1974. Hot carcase weight, P2 backfat thickness, carcase sex and carcase length were measured at the abattoir. The range of carcase weights was 50–70 kg and all male carcases turned out to be castrates, so the variable *SEXE* had to be ignored.

Fifteen carcases were selected each week: five from each of the three major P2 backfat ranges as shown in Figure 1—namely, below average, average and above average backfat thickness. The selected carcases were identified by the abattoir serial number and the list of serial numbers was given to the bacon factory foreman to allow carcase identification during processing.

All told, fifty-four carcases were processed by factory staff into wholesale cuts (ham, middle and shoulder). The weights of each cut and weight of bone and fat trimmed from each cut was recorded. Wholesale prices were assigned to each wholesale cut, and bone and fat trimmed. These prices were used to calculate wholesale value (cents/kg) for ham, middle and shoulder.

The wholesale study coincided with the Christmas market and because of a shortage of hams and shoulders at that time, no fat was trimmed from either of these cuts. Therefore, only the value from the middles were considered reliable and usable.

The results of this regression are summarized below, with standard errors of the coefficients in brackets, t values, the adjusted coefficient of determination and the F statistic.

Preliminary analysis showed the coefficient of *LGTH* (α_5) to be insignificantly different from zero, and this confirms the supposition that carcase length is not a significant determinant of the wholesale value of pig carcase middles. Deleting this variable and re-estimating gave

$$\begin{array}{lllll} WVM = 3.21 & - 0.007\,HCWT & - 0.017\,P2BF & + 0.038\,SEXC & (2) \\ & (.003) & (.003) & (.025) & \\ & -2.51 & -5.34 & 1.51 & \\ & \overline{R}^2 = 0.52 & & F^3{}_{50} = 17.96 & \end{array}$$

where WVM = wholesale values of middles in \$/kg and the other variables are as previously defined.

Coefficients α_1 and α_2 are significantly different from zero at the 5 per cent level, and α_3 is significantly different from zero at the ten per cent level. Additionally, the F value is significantly different from zero at the one per cent level. These results indicate that separately and together the three variables *HCWT*, *P2BF*, and *SEXC* explain 52 per cent of the variation in *WVM*. The pattern of errors shows no signs of heteroscedasticity, and the generally low values of the partial correlation coefficient matrix suggest that multicollinearity is not present at damaging levels.

The null hypothesis of no significant relationships between the various carcase measurements and wholesale value of middles can therefore be rejected for the carcase characteristics hot carcase weight, backfat thickness and sex, but cannot be rejected for the characteristic carcase length.

Equation (2) can be interpreted as follows:

On average, (a) an increase in *HCWT* of 1 kg is associated with a 0.7 cent drop in *WVM*;

(b) an increase in *P2BF* of 1 mm is associated with a 1.7 cent fall in *WVM*;

(c) castrated males are worth 3.8 cents more than females in terms of *WVM*; and

(d) *HCWT*, *P2BF* and *SEXC* explain 52 per cent of the variation in *WVM*.

The results of *HCWT* and *P2BF* accord reasonably well with other wholesale carcase valuation studies, such as Nelson [12], Ikerd and Cramer [10, 11] and Green [4]. In other U.S. studies, Engleman et al. [3] found that a pork pricing system based on carcase weight and backfat thickness eliminated 82 per cent of the pricing errors that occurred under the usual liveweight method. Couvillion and Dubov [2] reported that carcase weight was consistently significant in explaining variations in wholesale values and that the addition of backfat to the equation improved the estimation of the wholesale values. Finally, Pichler et al. [13] noted that backfat thickness had some influence on Austrian pig carcase prices and that the carcase quality of females was higher than that of males.

Our result involving SEXC is opposite to that expected, however, as Wilson [16] has shown that castrated males have a higher average backfat measurement at any given weight than their female equivalents. This discrepancy may be sample-generated, or it could be related to the different distributions of fat within carcases of different grades. For example, Wilson [15] found that the percentage of middle in a carcase increased from premium through to second grade. Harrington and Pomeroy [9] and Wilson and Holder [18] found that the proportion of middle increased with increased carcase fatness. These results would support the findings of this wholesale valuation study.

2.2 Retail Pig Carcase Valuation Study

In a similar manner to the previous section, a retail carcase valuation study was set up in conjunction with a service abattoir in an effort to determine whether the carcase characteristics carcase weight, fat depth, sex and carcase length are related to the relative retail values of pigmeat.

The hypothesis tested was that there were no significant relationships between the various carcase measurements taken and actual retail carcase values. The same assumptions regarding methodology and functional form were employed as in the wholesale value study, so the equation specification was

$$RV = \alpha_0 + \alpha_1 HCWT + \alpha_2 P2BF + \alpha_3 SEXC + \alpha_4 SEXE + \alpha_5 LGTH \quad (3)$$

where RV = retail carcase value in \$/kg

α_i ($i = 0, \ldots, 5$) = regression coefficients to be estimated and the other variables are as previously defined.

Again, the stochastic error term is omitted for simplicity, and again, the same signs on the coefficients would be expected as at wholesale.

This retail study was planned to run over a 10-week period from late October, 1974. All carcases purchased by the retailer were to be measured at the service abattoir.

The range in hot carcase weight was 35–50 kg and because of problems in identifying entire male carcases during slaughter, carcase sex was classified as either male or female. As most of the pigs were purchased in the saleyard, the males were expected to be predominantly castrates, so the variable *SEXE* was excluded.

The carcases were classified into below average, average and above average backfat ranges. Three carcases (one from each backfat range) were allocated each week to each of six supermarket retail outlets. The selected carcases were tagged at the abattoir with the carcase measurements on one side of the tag and the supermarket destination on the reverse side. The carcases were railed from the abattoir to the retailer's meat distribution centre and the tagged carcases were distributed to the designated supermarkets. The meat managers at each supermarket processed the carcases into standard pork cuts according to their regular procedures. Each cut was weighed and valued and the retail carcase value was then calculated. This value plus the measurement details for each carcase were entered on a standard form and sent to the authors by return mail.

Once again, however, the study plan was not adhered to. Of approximately 200 carcases sent from the abattoir, only 92 data sheets were received. Of these, 42 came from supermarket *A*, 30 from supermarket *B* and the remaining 20 were an amalgam of the other stores.[3] A simple plot of the results indicated that there were likely to be substantial differences between the valuation methods used in each of these three sets of data, so four separate models were estimated—one for each set and one for the total.

Two further problems arose. Only eighteen length measurements were received, so this variable could not be tested over all sets of data. A supplementary analysis was conducted on these 18 observations and these results indicate that carcase length is not significantly related to retail carcase values. Secondly, because of the low number of initial returns, the trial was extended to July, 1975. Therefore, the retail values were deflated to bring them to a common base (adjusted retail value) to retain

[3] The butchers involved in the retail study were volunteer co-operators. Unforeseen circumstances, such as sick leave and price "specials", which caused increased workloads were the cause of the low number of returns of carcase values compared to the total number of carcases tagged.

the cross-sectional nature of the study. The deflator used was the average monthly retail price per kg of pork carcases as calculated in an on-going meat marketing margin study (*see* Griffith [5], Griffith and Whitelaw [6, 7]).

The results of the regressions are summarized below, with standard errors of the coefficients in brackets, t values, the adjusted coefficient of determination and the F statistic.

The following equations analyse the four sets of data showing between-store differences in the explanation of the adjusted retail carcase value in \$/kg (ARV).

$$\begin{array}{lllll} ARV_A = 3.01 & - 0.028\ HCWT_A & - 0.011\ P2BF_A & - 0.124\ SEXC_A & (4) \\ & (.005) & (.007) & (.051) & \\ & -5.41 & -1.48 & -2.44 & \\ & \bar{R}^2 = 0.52 & F^3{}_{38} = 13.24 & & \end{array}$$

$$\begin{array}{lllll} ARV_B = 1.23 & + 0.019\ HCWT_B & - 0.037P\ 2BF_B & + 0.031\ SEXC_B & (5) \\ & (.010) & (.011) & (.074) & \\ & 1.91 & -3.28 & 0.43 & \\ & \bar{R}^2 = 0.33 & F^3{}_{2\mathfrak{E}} = 4.13 & & \end{array}$$

$$\begin{array}{lllll} ARV_O = 2.01 & - 0.003\ HCWT_O & - 0.018\ P2BF_O & + 0.025\ SEXC_O & (6) \\ & (.011) & (.010) & (.071) & \\ & -0.27 & -1.81 & 0.35 & \\ & \bar{R}^2 = 0.20 & F^3{}_{16} = 1.28 & & \end{array}$$

$$\begin{array}{lllll} ARV_T = 2.21 & - 0.008\ HCWT_T & - 0.018\ P2BF_T & - 0.035\ SEXC_T & (7) \\ & (.005) & (.007) & (.045) & \\ & -1.52 & -2.60 & -0.78 & \\ & \bar{R}^2 = 0.13 & F^3{}_{38} = 4.11 & & \end{array}$$

where subscripts A, B, O and T refer to supermarket A, supermarket B, other and total respectively.

The explanatory power of equation (7) is extremely poor. Coefficients α_1 and α_3 are insignificant although the F statistic is significant, and the $\bar{R}^2$ is very low. This result could be expected given the nature of the data, as could the results for equation (6).

Equations (4) and (5) from supermarket A and supermarket B stores do provide some significant results, and of these more reliance can be placed on the former, principally because the meat manager at supermarket A took more time and showed more interest in the trial. All coefficients in equation (4) are significantly different from zero at the 10 per cent level, they have the signs expected *a priori*, and the equation provides a significant explanation of ARV_A. No signs of heteroscedasticity or multicollinearity are evident, so the hypothesis that carcase weight, backfat thickness and sex are not significantly related to retail carcase value can therefore be rejected.

Equation (4) can be interpreted as follows:

On average, (a) increases in $HCWT$ of 1 kg induce a 2.8 cent fall in ARV_A;

(b) increases in $P2BF$ on 1 mm cause a 1.1 cent fall in ARV_A;

(c) castrated males are worth 12.4 cents less than females in terms of ARV_A; and

(d) the three explanatory variables explain 52 per cent of the variation in ARV_A.

Equation (5) also shows some significant results. Greater emphasis is placed on *P2BF* as a determinant of *ARV* and this effect is more significant than in equation (4). *HCWT* has a positive effect on ARV_B, which would not be expected to hold in the whole population, and *SEXC* is positive but insignificant (but considerably weaker than in equation (4)), and the $\overline{R}^2$ is lower. This difference in explanatory power of different variables points to the desirability of a measurement service, where different market participants can place different values on carcases of similar measurements, rather than in a grading scheme where values are set for carcases of given specifications.

2.3 Conclusions of Carcase Valuation Studies

The wholesale and retail carcase valuation studies reported above have suggested that significant relationships do hold between the measurements proposed as the basis of the NPCMIS and wholesale and retail pig carcase values. Comparing equations (2) and (4) indicates that these effects are quite similar at the wholesale and retail levels. For example, the $\overline{R}^2$ values are identical, and the *F* values are similar. *P2BF* has the greater influence in wholesale valuations, but *HCWT* is dominant at the retail level. The importance of the size of retail cuts for packaging purposes and the positive relationship between carcase weight and size of cuts probably explains this reversal. Further, the coefficients of *HCWT* and *P2BF* are greater in (4) than in (2), but this could be at least partly explained by the higher absolute level of retail values and the consequent greater relative effects of the independent variables on *ARV*.

The major difference between the two equations is in the variable *SEXC* which is the most important variable in both equations in terms of absolute effects on the dependent variables, but the signs are opposite. In section 2.1, some reasons were suggested for *SEXC* being positively associated with *WVM*.

The specific conclusions of these valuation studies are, therefore:

(a) as carcase weight and backfat depth increase, wholesale middle values and retail carcase values per kg decrease;

(b) middles from castrated males are worth more per kg at wholesale than middles from females, but castrated male carcases are worth less per kg at retail than female carcases;

(c) the limited number of observations of carcase length showed no significant influence on the wholesale value of middles or the retail values of carcases; and

(d) the combination of carcase weight, backfat depth, and carcase sex explain (coincidentally) 52 per cent of the variation in wholesale middle and retail carcase values.

What then is the relationship between these results and the necessary conditions outlined earlier? One way of assessing this is to compare the explanation of carcase values obtained by using objective measurements with those obtained under existing subjective assessment or grading procedures.

Nelson [12] found that objective carcase measurements explained some 60 per cent of the variation in wholesale values, whereas a grading scheme operating in Western Australia, generally considered the best then available, explained only one-third of the real variation in value from carcase to carcase. The point about this comparison is not that Nelson's carcase measurements could explain 60 per cent of the variation in wholesale carcase values, but that they could explain *twice as much* as current grading procedures.

A similar procedure could be adopted for our valuation studies. The processor who did the wholesale valuations operated a grading system for paying producers based on visual appraisal of the split carcase. Unfortunately, these grades could not be obtained for the carcases which were individually valued. Results, though, from a previous study of 652 carcases which compared the processors' grades with 4 of the 5 backfat ranges of the NPCMIS are shown in Figure 1 and the comparisons are listed in table 1 (no carcases were sampled in the 5 per cent very fat backfat range).

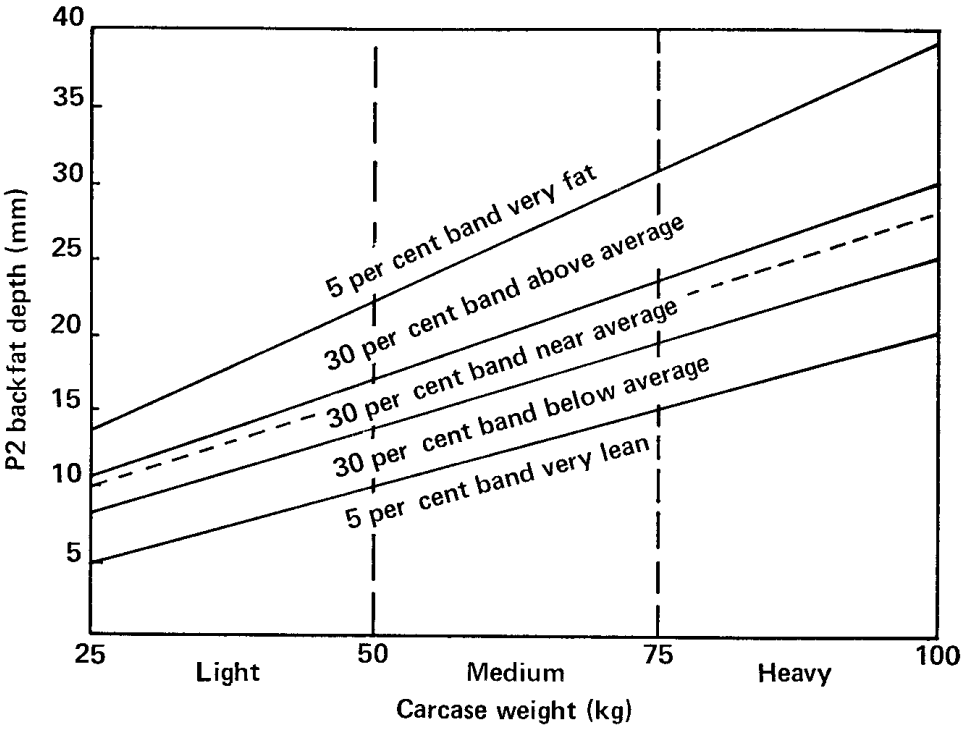

FIGURE 1: *Contemporary frequency distribution showing relationship between backfat depth and carcase weight*

As shown in the table, the processors' grades do not accord all that well with the more logical specifications based on the NPCMIS. For example, of the sixty-one carcases specified by the measurements as very lean, ten were graded as "firsts" whereas we would expect them all to be "prime". Alternatively, of the eighty-eight carcases specified to have above average backfat, forty-two or nearly half were graded "prime". Thus the grading scheme used by the processor is inconsistent with the objective measurements of the NPCMIS. The production of overfat carcases is encouraged by grading some of them "prime" while the production of lean carcases is penalized by downgrading some of them to "first". When actual average carcase weights and *P*2 measurements are compared, the inconsistency is even more obvious—the forty-two overfat carcases graded "prime" average 59.6 kg and 24.6 mm backfat, yet the ten lean carcases graded "first" average 66.3 kg and 15.4 mm backfat.

TABLE 1: *A Comparison of Processor Grades and NPCMIS Specifications*

NPCMIS specification	Carcase characteristic	Prime	NORCO grade first	Second
1, 1 } 5 per cent very lean	HCWT	61.0 (51)*	66.3 (10)	– (0)
	P2BF	14.1 (51)	15.4 (10)	– (0)
1, 1 } 30 per cent below average	HCWT	58.8 (257)	63.9 (53)	– (0)
	P2BF	16.8 (257)	10.8 (53)	– (0)
2, 2 } 30 per cent near average	HCWT	58.0 (126)	61.7 (66)	69.5 (1)
	P2BF	20.3 (126)	21.7 (66)	25.0 (1)
3, 3 } 30 per cent above average	HCWT	59.6 (42)	62.5 (43)	63.8 (3)
	P2BF	24.6 (42)	25.2 (43)	25.3 (3)

* The first figure in each of these pairings is the average value for the particular carcase characteristic (HCWT in kg and P2BF in mm). The second figure is the number of carcases in that position in the table.

Thus it seems quite clear that specifications based on the pig population sampled in the NPCMIS would provide a different explanation of actual wholesale values than the currently used processor grading system.

Turning to the retail study, some similar conclusions are evident. Local weekly saleyard prices ($/kg) paid to producers were collected along with the other information; including this variable in the regression for supermarket *A* gives the following results:

$$ARV = 3.19 - 0.028\,HCWT - 0.011\,P2BF - 0.119\,SEXC - 0.002\,PV \quad (8)$$

$$\begin{array}{llll} (.005) & (.008) & (.054) & (.006) \\ -5.34 & -1.44 & -2.20 & -0.28 \end{array}$$

$$\bar{R}^2 = 0.50 \qquad F^4{}_{37} = 9.70$$

where PV = price paid to producers in \$/kg, and the other variables are as previously defined.

PV is insignificant in explaining ARV when compared to $HCWT$, $P2BF$ and $SEXC$, so the NPCMIS can be expected to provide a much better prediction of actual retail carcase values than current pig pricing systems. In both wholesale and retail cases, therefore, the necessary condition (a) (above) does hold; i.e., a significant proportion of buyers should differentiate between carcases on the basis of the measurements provided by the proposed NPCMIS. The general acceptance of the NPCMIS by market participants is therefore warranted.

3 CONCLUSIONS

The preliminary results reported in this paper have shown that by providing information about the carcase characteristics of hot carcase weight, $P2$ backfat depth and sex to pig carcase purchasers, and by introducing a pricing system which uses this information, there will be a more accurate discrimination between carcases of different characteristics. A significant proportion of buyers should therefore differentiate between carcases on the basis of the NPCMIS measurements.

Available evidence also suggests that market participants do regard the NPCMIS measurements as appropriate for their purposes.

The above analysis has several obvious limitations, but it is considered that these results provide some justification for regarding the NPCMIS as basically well-founded, and, as far as we are able to determine at this stage, appropriate for the needs of market participants in the pig market.[4] This does not mean, however, that we are content with what has been done. A much larger, more widespread carcase valuation experiment needs to be instigated in conjunction with some of the long-term pilot runs of the NPCMIS. This would involve the pricing, measuring and cutting up of a large number of carcases in different regions in Australia. Comparisons could then be made between current pricing procedures and those expected to operate if the NPCMIS were implemented. For example, wholesalers and retailers could be asked to value identical individual carcases knowing and not knowing the objective carcase measurements. Actual prices paid at each level of the marketing chain could be compared to those that would result under a formula or model pricing system.

Undertaking this type of research would provide a much firmer basis for recommendations regarding the appropriateness of, and ultimately the feasibility of, proposals for carcase description schemes.

[4] The most important of these deficiencies relate to the data—the restriction to N.S.W. carcases, the relatively small sample sizes, the lack of a formal experimental design, and the adjustments required to surmount practical problems as they arose during the course of the study. Closely supervised data collection under the auspices of an authoritative industry or government organization would do much to alleviate these problems. Alternative model specifications could also be considered.

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