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An Ex Ante Evaluation of the National Pig Carcase Measurement and Information Service

G. R. Griffith*

This paper reports an *ex ante* evaluation of a proposed carcase description scheme for the Australian pig industry. Potential benefits and costs of the scheme are described and enumerated, and most likely estimates evaluated by benefit-cost analysis. The results indicate that the proposed scheme would generate net discounted efficiency benefits of almost $50m. A sensitivity analysis of important assumptions and parameter values is conducted, and in all cases NPV remains positive. The conclusion is that the *ex ante* pricing and operational efficiency benefits of the implementation of the scheme would outweigh the costs of achieving them.

"The problem of applying cost-benefit calculations to classification is akin to that of attempting to measure the advantage of replacing sign language with a verbal or written language."

G. Harrington,
Marketing Director, MLC.
1973.

1. Introduction

In recent years there has been continuing and increasing pressure from Australian pig producers (and indeed from most livestock producers) for the implementation of uniform and objective carcase description schemes. Such schemes are seen as providing a more accurate valuation of their product than existing procedures. This pressure for description schemes has also been reinforced in a number of research reports and government enquires into the area of meat and livestock marketing (see for example Australian Agricultural Economics Society (N.S.W. Branch) [2]. BAE [3], Cozens [5], Freebairn [7], Griffith and Knight [13], and Parliament of N.S.W. [27]).

In response to this groundswell of opinion, and with the financial assistance of the Australian Pig Industry Research Committee (APIRC), a proposal for a National Pig Carcase Measurement and Information Service (NPCMIS) was developed [35, 36]. Briefly, the scheme would involve the objective and uniform measurement of certain carcase characteristics and the transmission of this information to those market

* Economist, N.S.W. Department of Agriculture, Sydney, and University of Guelph, Canada.

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participants requiring it. The carcase characteristics used would be hot carcase weight, fat depth 6.5 cm off the midline at the last rib, and sex. Carcases would have the measurements attached to them for use by traders in buying and selling. Producers and buyers would receive advice showing the measurements recorded for each carcase in their shipment, and summary statistics would be generated for use by abattoirs and government regulatory and market intelligence agencies. Locational data and post-mortem information are also probable components of the NPCMIS.

Sets of conditions which the NPCMIS would have to satisfy before it could be regarded as a desirable market innovation were then constructed as a framework for evaluation. There were three of these sets of conditions, relating to the *appropriateness*, the *technical feasibility*, and the *economic feasibility* of the NPCMIS. In a companion paper [11], some carcase valuation experiments were reported and from these it was tentatively concluded that the NPCMIS was appropriate for providing an adequate and acceptable description of a carcase that would allow (1) carcase traders to better estimate likely yield, and (2) information on desirable carcase traits to be transmitted back to producers. With technical feasibility questions assumed exogenous, this paper concentrates on the third stage of the evaluation — an assessment of the economic feasibility of the proposed service. The pricing and operational efficiency benefits of the scheme are listed in section 2, first in descriptive terms and then in as quantitative a manner as possible, and this procedure is repeated in section 3 for the costs of the NPCMIS. Section 4 contains a brief discussion of the methodology employed, the most likely benefit-cost results, and a sensitivity analysis of the results to alterations in important parameter values. The conclusions of the study reside in section 5.

2. Benefits of the NPCMIS

2.1 A Descriptive Outline of Anticipated Benefits

Following an examination of earlier work, Freebairn [7] has suggested that there are two broad types of benefits flowing from meat carcase description schemes. They are:

(i) the physical efficiency of trading activities will be increased, *i.e.* cost savings will be made; and

(ii) the quality information specified by description will enhance the pricing efficiency of the market, *i.e.* marginal social costs and benefits will be closer together and inefficiencies in resource allocation will be decreased.

Attention will be concentrated in this section on these two broad types of benefits.[1]

[1] This paper concentrates on the efficiency aspects of the benefits expected from the adoption of the NPCMIS. Distributional considerations are qualitatively analysed in [10], and second best arguments are assumed outside the scope of the study.

2.1.1 Effects of a NPCMIS on Operational Efficiency

Within this general category of effects there are two levels — those accruing to individuals and those accruing to the market as a whole.

(a) Effects on Individuals

For each market participant who is affected by the NPCMIS two operational efficiency benefits may be distinguished.

Firstly, because the NPCMIS will provide information to every participant about the important characteristics of each carcase (carcase weight, backfat depth and sex), these participants will not have to expend as many resources searching for this quality information. Studies reported by McCall [24] and Stigler [32] have shown that the allocation of resources to information search is rational but is also usually very costly. If the NPCMIS provided a large proportion of the required information, (and it has been shown in [11] that this does seem to be the case), these search costs will be considerably diminished. For example retailers will make substantial savings by purchasing carcases from wholesalers by description. Wholesalers will save by reducing carcase handling costs.

Secondly, the risks of buying undesirable carcases will be reduced, and therefore buyers especially will not have to undertake as much risk-averting behaviour such as holding higher inventories, using more storage space, or buying greater insurance cover than they would in a less certain quality environment.

(b) Effects on the Market

Some operational efficiency benefits would accrue to the market as a whole rather than to any individual or firm.

Under a NPCMIS, the carcase characteristics will be measured only once and will then be transmitted to all sectors of the market, so cost economies in the collection, collation and transmission of this information can be expected. These economies will obviously be greater the higher the proportion of pigs killed that are measured.

Secondly, the simple, uniform and regular procedures involved in the NPCMIS will lead to reductions in errors of information transmission and will greatly simplify the interpretation and analysis of this information. This will be especially so if use can be made of the automated measurement procedures as outlined by Luckock [22].

Thirdly, the output of the NPCMIS will show the incidence of any diseases in each producer batch of pigs. This information will be a considerable improvement on that currently available, so substantial savings will accrue in the area of disease detection and eradication or control programmes.

Fourthly, provision of the output of the NPCMIS to such organizations as the Meat and Allied Trades Federation, the Retail Traders Association and the Wholesale Traders Association will enable them to plan purchasing and promotional strategies months ahead. Eventually this may lead to forward contracting of pigs which has many cost-reducing aspects.

Fifthly, the implementation of the NPCMIS will reduce the need for some "persuasive" advertising, will eliminate much of the expense of arguments over carcase "quality", and it will reduce costs indirectly by changing the

structure of the pigmeat market. For example, weight and grade selling will increase, and this has normally been found to have lower operational costs than say auction selling. Further, savings will be obtainable by being able to ship carcases direct from country abattoirs to city retailers, rather than through city meathalls.

Sixthly, the introduction of a NPCMIS will stimulate other forms of technical innovation with attendant reductions in marketing costs, such as the teletype marketing systems used in Canadian pig marketing.

Finally, information from the NPCMIS showing the source of pigs slaughtered will be useful to abattoirs, for example, in planning new works or modifications to existing works.

2.1.2 Effects of a NPCMIS on Pricing Efficiency

Again, within this general category of pricing efficiency benefits, those accruing to individuals may be distinguished from those accruing to the market.

(a) Effects on Individuals

Objective measurements of carcase characteristics provide a common language for negotiation between buyers and sellers, and this allows mutually agreed prices for a given "quality" of carcase to be arrived at more accurately because competition is focussed onto price. Evidence from the U.S. [34] indicates that the introduction of their beef grading scheme allowed large buyers to purchase from a greater range of sellers, and by increasing competition, forced large sellers to be more efficient. Small buyers and sellers could also better compete for contracts to buy or supply carcases because the contracts were based on objectively determined specifications. Wholesalers, retailers and processors will be able to use the information provided by the NPCMIS to price carcases which better reflect back to the producer the value of his carcase to the final consumer.

The provision of information on the measurements and prices of particular carcases will, given adequate carcase identification, enable pig producers to better choose the type and level of inputs which will allow them to more closely approach an optimal production point, *i.e.* they will be able to more accurately select breeding stock, formulate rations and employ other management practices which produce pig carcases gaining higher valuations. In practice, pig production responds fairly gradually to the dictates of the market, this response being a function of the clarity of the signals received by the producer and the price incentives linked to them. The NPCMIS will provide more precise information and will allow more specific incentives to be applied. Economic studies of the effects of dietary changes on backfat and growth rates could then be conducted, as could studies of the relative economic weights to be used in the development of selection indices by geneticists [36]. The end result of all this will be to encourage, guide and speed up the rate of improvement in pig carcase quality.

Wholesalers, retailers and processors on being supplied with information from the NPCMIS will be able to more accurately estimate yield and value and so price carcases which better reflect to the producer the value of the meat to consumers, *i.e.* trade will be facilitated. The sharpening of these

grade/price differentials could be achieved in part by using carcase pricing models of the type outlined in [11]. Buyers can also make efficient use of carcases during processing by assembling more uniform lots than is possible under traditional procedures.

(b) Effects on the Market

Information from the NPCMIS will be made available to State and Australian Government market reporting agencies, to the Australian Bureau of Statistics and to forecasting agencies such as the Bureau of Agricultural Economics.

In the short-run, this market information, being supplied equally to all market participants, will lead to better buying decisions by retailers and processors and better selling decisions by producers and wholesalers. For example, producers will be able to compare more accurately offers from competing buyers and this should lead to more efficient producer marketing. Retailers will similarly be able to more accurately compare quotes from competing sellers. The aggregation of all these better individual decisions will result in an improved allocation of society's resources.

In the longer-term, the NPCMIS will provide a trend forecasting service based largely on the proportion and weights of breeding stock in the kill. If this information is accurate, is supplied equally to all buyers and sellers, is disseminated at the right time and relates to the decision needs of buyers and sellers, market participants will be able to forecast future market prices with a lower error. Benefits in terms of a more efficient pattern of resource allocation will then result as suggested by Freebairn [8], Hayami and Peterson [17], and Smythe [31].

Now many of these benefits outlined in the last section may appear to cancel out. For example, innovations aimed at greater long-term industry efficiency are not always compatible with greater short-term profitability for the firms that make up the industry. Furthermore, procedures which make trading easier for some people or some carcase types may make it more difficult for other people or other carcase types. However, the cumulative effect of all these factors will be to achieve greater competition, and through that, greater efficiency in pigmeat marketing. The question of how to measure these efficiency gains is now considered.

2.2 Empirical Estimates of Some Benefits of the NPCMIS

Quantifying a concept such as the value of better quality information poses problems. In the past the economics of information has been largely neglected by economists, and the literature has tended to talk around the problem without ever really coming to grips with it. This has been especially true of information about the quality of goods or services. For example Stigler [32, p. 224] noted, "Quality has not yet been successfully specified by economists and this elusiveness extends to all problems in which it enters", and Nelson [26, p. 313] reiterated the point a decade later, ". . . economists have not developed a systematic analysis of consumers' quests for information about quality differences". This problem persists even though several eminent economists have tackled it in recent years (see for example [18, 19, 20, 23, 24, 33]).

Narrowing the focus to discussions of meat quality, Cozens [5] reports a U.K. enquiry into meat marketing and grading which concluded that although no attempt was made to measure the advantages of grading in economic terms, they heavily outweighed the disadvantages. He continues [5, p. 83] "It is extremely difficult to measure the net benefits of a meat grading system and so justify its introduction. The direct costs of a grading system are measurable, but calculation of the benefits requires information that is rarely available. Nevertheless, it seems to be generally accepted that the advantages outweigh the disadvantages".

This sentiment may well be correct, but it is not sufficient for an economic justification of such a proposed scheme. Griliches [14, p. 431] has also noted this point when he cautions against uncontrolled investment in research, even that which in the past has had very high social rates of return, "The moral is that, though very difficult, some sort of cost-and-returns calculation is possible and should be made".

As alluded to above, there is a dearth of studies available which have measured the benefits of implementing meat carcase description schemes. The approach adopted here, following a method developed by Harrington [15], is to look at the advantages of the proposed Service in particular specific situations in order to roughly assess the magnitude of the anticipated benefits in these situations. It is recognized that this will be partial and incomplete, but given the restricted avenues of analysis available, it seems to be one of only a few ways that any quantitative estimates of expected benefits can be derived. An alternative approach, used in evaluating beef carcase classification, is given in [4].

The analysis below is limited to the major efficiency benefits which are relatively easy to quantify, so many of the benefits outlined in section 2.1 are excluded. The benefits outlined below therefore represent a deliberate under-estimation of, or lower bound to, the potential benefits of the NPCMIS. If the Service appears favourable under these strict conditions, it will appear more favourable under more generalized, realistic conditions.

2.2.1 Cost Savings due to Trade by Description

The effect of carcase description schemes quoted most often is that buyers who do not wish to incur the costs of personal inspection may obtain their requirements from suppliers by ordering by specification over the telephone.

Evidence presented to the "Brewer Committee" (Parliament of N.S.W. [27]) showed that about 44 per cent of retailers' margins were due to labour costs. At 1976 pork retail margins of about 40 cents/kg (see Griffith and Hillman [12]), this means about 18 cents/kg is allocated to labour.

The extent to which savings can be made by buying on description depends on two factors — the percentage of labour costs allocated to buying, and the reduction possible in these buying costs. Obviously these two factors will vary widely between different situations, so it is useful to look at a range of possible combinations and this is done in Table 1. The effect of this uncertainty is also discussed in the sensitivity analysis of section 4.3.

Thus if buying costs represent 20 per cent of labour costs, and if buying pig carcases by description enabled a saving of 30 per cent of these, the savings

would be about 1.1 cents/kg or $0.55/carcase for the typical Australian 50 kg carcase.

Table 1: Savings From Buying by Description (c/kg)

Savings Possible in Buying Costs (%)	Buying Costs as Proportion of Labour Costs (%)				
	5	10	15	20	25
5	.045	.09	.135	.18	.225
10	.09	.18	.27	.36	.45
20	.18	.36	.54	.72	.90
30	.27	.54	.81	1.08	1.35
50	.45	.90	1.35	1.80	2.25

There is unfortunately very little evidence available on which to assess the "most likely" combination of those reported in Table 1. A survey of Sydney meat retailers conducted by the Bureau of Agricultural Economics [30] examined the effects of labour costs on retailing behaviour but provided no evidence as to the functions of the labour inputs.

It is probably reasonable to suggest that buying costs in an average retail butchery take about 10 per cent of total labour costs. This is equivalent to an hour a day or half a day a week. Similarly a saving of about a third in these buying costs would appear a reasonable estimate of the effects of a carcase measurement service that enables buying by description, given that many retailers already buy by description.[2] The most likely estimates of savings from buying by description are therefore 0.55 cents/kg or $0.28/carcase. Some retailers thought this was not too unreasonable.

A soundly based carcase description scheme also has the potential to reduce the costs of handling and selling incurred by wholesalers. Meathall selling costs for example account for about 12.5 per cent of wholesalers margins (A.A.E.S. [2]). At 1976 pork wholesale margins of about 20 cents/kg, selling costs represent 2.5 cents/kg. The extent to which wholesalers can obtain savings therefore depends on the reduction possible in these selling charges. Again there will be substantial divergences between wholesalers on the extent of possible reductions, so a range is calculated as shown in Table 2.

Table 2: Savings From Selling by Description (c/kg)

Savings Possible in Selling Costs (%)				
5	10	20	30	50
.125	.25	.50	.75	1.25

[2] It is recognized that in traditional butcheries there is often a problem of under-utilization of permanent labour during periods when customer traffic is light. However Smith *et al* [30] show that around 12 per cent of all employment in retail meat outlets is part-time, so that a reduction in the labour input required to purchase meat may easily reduce overall labour costs because of a change in the employment mix.

Thus if selling costs can be reduced by 20 per cent due to trade by description, the saving would be in the order of 0.5 cents/kg or \$0.25/50 kg carcase.

Again however there is virtually no evidence available to choose a "most likely" saving in wholesalers selling costs. Discussions with several wholesalers revealed that a 20 per cent reduction may not be too unrealistic, so this is accepted as the "most likely" estimate of wholesalers being able to sell by description.

2.2.2. Increasing the Rate of Improvement in Pig Carcase Quality

The second major benefit to be discussed is that of increasing the rate of improvement in pig carcase quality. Australian pig carcases are in general fatter than the market requires and excess fat often has to be trimmed off before the meat can be offered for sale, *i.e.* there are too many fat carcases produced and too few lean carcases produced.

Suppose that without any special incentives, the leanness of pig carcases is improving by an average of 1 per cent per annum. The reduced waste means that the price to the consumer can be lowered and still give the retailer the same return.[3] For example, say the Australian average 50 kg carcase yields 37.5 kg of saleable meat, which if valued at say \$1.50/kg gives a carcase value to the retailer of \$56.25.[4] If the saleable meat yield is increased by 1 per cent to 37.90 kg, the average cost to the consumer can be reduced to \$1.484/kg to still give a \$56.25 return to the retailer. The advantage of this short-term improvement in carcase quality is therefore \$0.016/kg of saleable meat or about \$0.60/carcase at constant weights and prices.

Now by measuring pig carcases, and using these measurements as the basis for paying premiums for leaner carcases and deducting discounts for fatter carcases, (with the same average price applying), the rate of improvement will obviously depend on the actual premiums and discounts paid, and on producers' reactions to this information. It is likely though that the imposition of such price differentials will, in the short term, produce a much bigger annual average response in a factor like fatness than 1 per cent. Table 3 shows the potential short-run effects on retail price of various increases in the rate of improvement in carcase quality.

If the rate of improvement was increased by 1 per cent to 2 per cent, the consumer price could be decreased another 1.4c/kg; if the increase was 3 per cent, consumer price could fall another 4.3c/kg. Of course these benefits are only due to the reduction in waste from a carcase. Other savings could accrue by reducing the actual costs of trimming, but it would be virtually impossible to estimate these given the great diversity in wholesale and retail butchers.

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[3] The division of these savings between producers, traders and consumers will depend on the elasticities of supply and demand and the market power of each sector. In this example for simplicity it is assumed that all savings accrue to consumers.

[4] In a draft of this section [9], a yield of 40 kg or 80 per cent was assumed. This assumption was based largely on [25]. However discussion with several traders has led me to reduce this yield figure. The effect of a saleable meat yield of 40 kg is however considered in the sensitivity analysis.

Table 3: The Short-Run Effects on Retail Price of Various Increased Rates of Improvement in Carcase Quality

Item	Rates of Improvement					
Increased rate (%)	1	2	3	4	5	10
Total rate (%)	2	3	4	5	6	11
Carcase weight (kg)	50	50	50	50	50	50
Yield of saleable meat (kg)	38.3	38.6	39.0	39.4	39.8	41.6
Gross carcase revenue ($)	56.25	56.25	56.25	56.25	56.25	56.25
Price of saleable meat ($/kg)	1.469	1.457	1.442	1.428	1.413	1.352
Savings from quality change (c/kg)	1.6	2.8	4.3	5.7	7.2	13.3

What rates of improvement in carcase quality are likely to be achieved by the introduction of a NPCMIS? A number of overseas studies [1, 6, 16, 21, 34] have shown that the effects of carcase description schemes on carcase quality can be marked and rapid.[5] Of course there may be other factors influencing carcase quality besides the implementation of a carcase description scheme, but it could be expected that the majority of the decrease in fat thickness was due to the impact of payment for quality, and the transmission of carcase information back to producers. It must be expected, however, that although producer response to incentives to improve quality can be rapid and substantial, it cannot continue indefinitely because of the biological constraint of the percentage of lean meat in a carcase. This upper limit on the lean content would vary markedly with location, breeding, feeding and other management practices, but in this study it is set at 85 per cent.

The benefits of increasing carcase quality may then be analyzed using a procedure similar to that employed by Scobie and Franklin [29] and depicted in Figure 1. The gross benefits of increasing the rate of improvement in carcase quality is the area between the two curves.

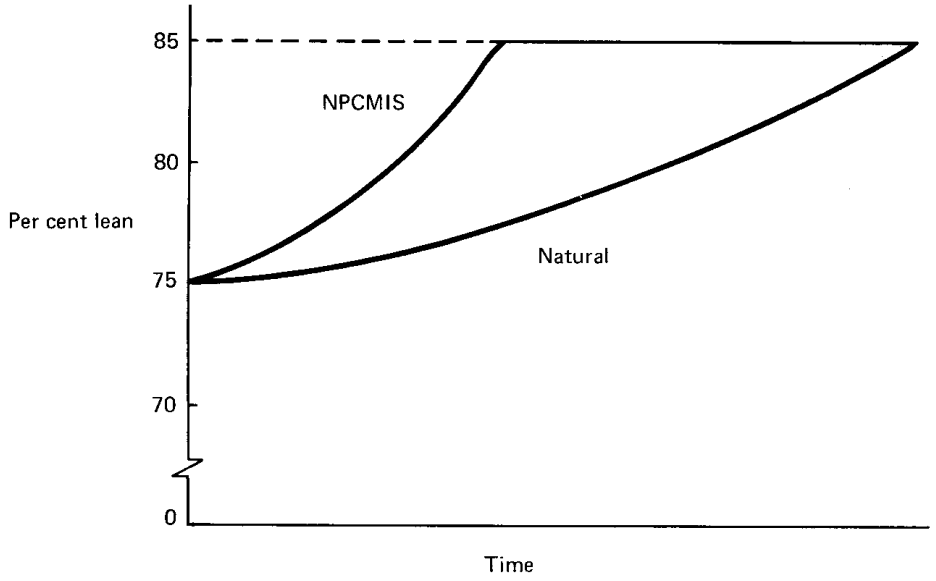

Figure 1: Impact of the NPCMIS on Carcase Quality Over Time

[5] A detailed review of these studies is given in [10].

Taking a conservative line, and to reflect the facts that excess fat does have some value and that there are positive costs of producing a leaner carcase, it was assumed that the most likely annual increase in pig carcase quality due to the NPCMIS will be 2 per cent until the upper lean content limit is reached.

To place this discussion of the benefits of carcase quality improvement more in line with the concepts underlying Figure 1, the effects over time are illustrated in sections A, B and C of Table 4. As shown in section C, the savings from quality changes increase up to years four and five and then decline as the natural rate of increase approaches the upper lean content limit. In year four the benefit from carcase quality improvement is in the order of 11c/kg or $4.00/carcase.

As shown in Table 4 section E, the use of assumptions of what are regarded as "most likely" situations provides gross efficiency benefits of the NPCMIS (for the types of effects outlined above) ranging from about 1c/kg or $0.50/carcase to about 12c/kg or $4.60/carcase, depending on the time period. These estimates compare favourably with estimated benefits of up to 4c/kg for a beef carcase classification scheme [4, p. 51]. As a general conclusion then, there are likely to be substantial benefits from introducing the proposed NPCMIS.

Table 4: The Long-Run Effects on Retail Price of Increasing the Rate of Improvement in Carcase Quality, and Total Benefits of the NPCMIS

	Item	Time (Years) 1	2	3	4	5	10	15
A	Natural Increase							
	Yield (kg)	37.9	38.3	38.6	39.0	39.4	41.4	42.5
	Price ($/kg)	1.484	1.469	1.457	1.442	1.428	1.359	1.324
B	NPCMIS Increase							
	Yield (kg)	38.6	39.8	41.0	42.2	42.5	42.5	42.5
	Price ($/kg)	1.457	1.413	1.372	1.333	1.324	1.324	1.324
C	Savings from Quality							
	Change c/kg	2.7	5.6	8.5	10.9	10.4	3.5	0
	$/carcase	1.01	2.10	3.19	4.09	3.90	1.23	0
D	Cost Savings							
	c/kg	1.05	1.05	1.05	1.05	1.05	1.05	1.05
	$/carcase	0.53	0.53	0.53	0.53	0.53	0.53	0.53
E	Total Benefits							
	c/kg	3.75	6.65	9.55	11.95	11.45	4.55	1.05
	$/carcase	1.54	2.63	3.72	4.62	4.43	1.76	0.53

3. Costs of the NPCMIS

3.1 Descriptive Outline of Anticipated Costs

In this section the costs involved in researching, implementing and maintaining the NPCMIS are examined. These costs may be more conveniently divided into the following three types: the cost of measurement, the cost of information analysis and transmission, and the "other" costs involved.

3.1.1 Measurement Costs

The costs included here are those incurred in actually measuring the pig carcase characteristics hot carcase weight, P2 backfat depth, and sex, and any other factors which are relevant in particular situations, such as disease monitoring data.

Initially there will be the capital costs of the measurement and recording equipment such as introscopes or electronic probes, calculators, weigh books or some other form of data logging device, and any additions or modifications to the chain necessary for the effective operation of the measurement procedures. Some of the larger Australian abattoirs will already own much of this capital equipment and in general the NPCMIS will fit neatly into existing chains, so in these cases extra capital expenditure will be low. Smaller abattoirs may be faced with a higher level of expenditure, but since it is envisaged that the NPCMIS will be, initially at least, voluntary for abattoirs as well as for individual market participants, they will always have the option of not being part of the Service.

The second major measurement cost will be the labour costs of taking and recording carcase measurements. It is currently anticipated that meat inspectors could do the measuring as part of their normal job.[6] Whether this would involve an increase in costs would depend on whether the inspectors were fully utilized before the advent of the NPCMIS. If, as seems likely, they are fully utilized, an extra inspector would be required to do the measuring. Whether extra recorders would be required would depend on the particular abattoir situation: in most cases existing employees could do this job.

The third major item will be the other non-labour operating costs. These will include repairs and maintenance, depreciation and insurance on capital equipment, materials such as paper and writing implements, and any extra electricity needed to operate the electronic components of the measurement and recording equipment.

Most of the above measurement costs are fixed and lumpy, so average costs per carcase or per kg will depend crucially on the number of carcases measured in any particular time period. For example, the faster the chain speed and/or the greater the throughput of the abattoir, the lower these measurement costs will be on a per unit basis.

3.1.2 Information Analysis and Transmission Costs

The costs included here are those incurred in collecting, collating, analyzing and disseminating the information on carcase measurements and other factors to those market participants who require it. There will be four major areas of costs. The first will be the costs incurred in collecting the information and transforming it into data suitable for analysis. If the raw data is recorded on the abattoir floor in an acceptable form, for example directly into an electronic calculator, then this cost will be negligible. If

[6] Since this paper was written Australian Agricultural Council has decided that meatworks employees will be responsible for beef carcase classification with some government supervision. At the time of revision the situation with pig carcase measurement was unresolved.

however the raw data has to be punched onto telex tape or computer cards then this cost will be quite significant.

The second area of costs will be those of transmitting the raw or transformed data to the analysis centre and back to the distribution point after analysis. Where the data processing unit is in the abattoir this type of cost will be greatly reduced. If however the processing has to be done away from the abattoir, for example in a state capital city, there will be high costs involved in transmitting this information, either physically by messenger service or electronically on telex or telephone networks.

The third area will be the cost of actually processing the data into the form required by users. This will involve providing statistics on individual carcases to producers and buyers, and aggregate statistics on abattoir, region or State bases to government departments and authorities and industry bodies.

The last cost area will be that of distributing the processed information to the recipients. This will occur when abattoirs send output of the NPCMIS to producers, buyers or other organizations, and will usually involve either telex charges or postal charges or some combination of the two.

Some of the above costs will be on a per unit basis and so will be largely independent of the level of throughout of the information processing system. Other types of costs will however be lumpy, so the per unit costs will again depend on the rate of use of the processing facility.

3.1.3 Other Costs

There are several "other" types of costs related to the implementation of the NPCMIS.

The first of these is the research and development expenditure required to formulate, test and develop the carcase description proposals. Since the project was conceived in late 1971, expenditure by the APIRC has been considerable, so this cost must be taken into account in the analysis. Also included would be the labour costs of people associated with the project but not covered in APIRC funding, the costs of enacting any necessary legislation, and the costs of training staff to do the work.

The second type of cost would be the losses in income to these market participants who currently profit by trading pigs under the current marketing system. There may be adjustment costs of retraining some of these people to do different jobs, either still associated with the pig market or completely outside the market.

Another cost type would be that of buyers altering their purchasing patterns in response to the implementation of the NPCMIS, and that of producers altering their production function to take account of the information provided by the NPCMIS. Both these specific costs would be short-term as market participants adopted and adjusted to the implementation of the NPCMIS.

3.2 Assumed NPCMIS Costs

This section examines the costs of the NPCMIS in what is regarded as two "most likely" situations of implementation — a completely manual configuration and an almost completely automated configuration.

Discussions with abattoir operators and evidence from the pilot runs suggest that these two extreme systems are the only ones likely to provide the rapid analysis of information required by the trade. Research and development costs are also estimated.

3.2.1 Manual Implementation

This will be the system most likely to be adopted by the smaller abattoirs who deal with only a limited number of buyers each week.

The measurement will be done by a meat inspector using an introscope. He will write the fat depth on the carcase. At the weigh scale an abattoir employee will read out this measurement together with the sex of the carcase, the producer tatoo and code, and any post mortem data attached to the carcase. The weigh scale clerk, using NPCMIS raw data sheets, records all this information together with hot carcase weight and the buyer's code number. These sheets are self-carboning with two or more copies. The abattoir retains the top copy as its official kill record, and the buyer receives two copies immediately the daily kill has stopped. He keeps one for his records and distributes the other to individual producers (since only one buyer and one producer are listed on any one raw data sheet) with their cheques. If more than two copies are made, they can be regularly sent to the organization handling the NPCMIS computing so that aggregate statistics and frequency distributions can be computed, and to state veterinary services for disease monitoring.

Under this configuration, the only extra costs incurred by the NPCMIS would be the salary of a meat inspector, the introscopes, the multi-copied raw data sheet books and a small amount for depreciation, repairs and maintenance, and miscellaneous items of operating equipment such as felt pens. The weekly cost of the NPCMIS under these conditions would then be in the order of $213 (composed of one meat inspector at $200 per week, two introscopes at $500 each, depreciation on 2 introscopes over 5 years, repairs and maintenance at 5 per cent annually, raw data sheet books, $8 for 50 pages, 30 pigs per page, and miscellaneous $50 per year).

In this situation the number of pigs killed each week will directly influence the cost per pig. For example on a slow speed chain it would be expected that about 1800 pigs would be measured each week. The cost of the NPCMIS would therefore be about 12 cents/carcase. On a faster chain though about 3000 pigs would be measured each week, and in these circumstances per carcase NPCMIS costs would decrease to about 7 cents. For the purposes of the analysis in the following section the slower chain speed, higher cost alternative has been chosen as being probably the more realistic situation in these smaller abattoirs.

3.2.2 Automated Implementation

This section refers to the Australian Meat Board's "black box" approach to carcase measurement and information recording and analysis. It would be the system most likely to be adopted by the larger abattoirs who are in a position to finance the purchase of their own computing facilities.

This system has been explained in detail by Luckock [22]. Briefly it will comprise a controller (currently a programmable calculator) which will co-ordinate a number of inputs (producer and buyer identification, weight, fat

depth and sex) and outputs (data storage, ticket printer, and teletype printer) and solve simple statistical functions for each carcase, *e.g.* predict yield or value, and allocate processor grades. It would require only one extra man on the chain to measure backfat and determine sex, and key these into the controller. Carcase weight would be automatically read into the controller via automatic weigh scales. If an electronic introscope or the Meat Board's conductivity probe are used to measure backfat, these too can be directly attached to the controller. A ticket showing the measurement information is automatically printed and attached to the carcase by an abattoir employee — he can then use this information to allocate carcases into different lots or into different chillers. Carcase details would be automatically printed out by the teleprinter located remotely in the abattoir office. This provides the abattoir with its official kill record, and facilitates a more efficient accounting process.

At the completion of the days kill the controller would be programmed to search through the data stored during the day and to summarize and print out via the teleprinter the carcase details for each producer and for each buyer. Buyers would receive their own statement plus those of individual producers they bought from, and these would be sent out with settlement.

A summary of the measurement details could be sent by telex to market reporting authorities on the afternoon of each slaughter day. More comprehensive details could be sent at the end of the week to the central NPCMIS organization for the calculation of aggregate industry statistics, trend forecasts, and updating of frequency distributions.

Luckock [22] suggests that the likely capital cost of this equipment would be in the order of $20,000-$25,000 at 1976 prices. Choosing the lower figure as being more relevant to the expected pig chain configuration, and assuming depreciation over five years, would result in a weekly capital cost of about $150. Adding a weekly labour cost of $200, and $30 per week for miscellaneous operating costs, results in a weekly cost of some $380 for carcase measurement and information transmission and analysis.

Again the number of pigs killed each week will directly influence the costs of the NPCMIS under these conditions. On a slow, 1800 pigs per week chain, the cost would be 21 cents per carcase; on a faster, 3000 pigs per week chain, the cost would fall to 13 cents per carcase. Again the slower chain speed was chosen as being more typical of the general situation in abattoirs in Australia.

3.3 Research and Development Costs

APIRC research and development costs allocated to the proposed NPCMIS totalled almost $100,000 over the five years to 1975/76 and reached about $143,500 by the end of 1976/77. These costs, obtained from APIRC, are shown in Table 5.

In addition to these APIRC funded costs, there has been a fairly substantial allocation of State Departments' of Agriculture resources to this project, particularly in labour costs. For example, the project's co-ordinator and the six principal pig extension officers in each State have been involved in the project since initiation in 1972/73, as has a biometrician. During 1974/75 and 1975/76 the co-ordinator has had a full-time assistant and during 1975/76 the economist has also been working full-time on the

Table 5: Direct Research and Development Costs of the NPCMIS

Year	Research Project				
	Grading Feasibility Study ($)	National Carcase Survey ($)	Development of NPCMIS ($)	Economics of NPCMIS ($)	Total ($)
1971/72	3000	—	—	—	3000
1972/73	—	10000	—	12700	22700
1973/74	—	10200	—	10650	20850
1974/75	—	1450	16600	12250	30300
1975/76	—	—	19500	3400	22900
1976/77	—	—	43720	—	43720
Total	3000	21650	79820	39000	143470

project. In terms of salaries alone this investment would be considerable, but since these costs cannot be accurately accounted for they are omitted from the analysis.

4. Results

4.1 Methodology of Evaluation

Since the investment in the NPCMIS would be of a long-term nature involving initial setup costs and variable cash flows of benefits and costs over the life of the project, the technique of benefit-cost analysis has been used as the methodology for the following analysis. As previously noted, the emphasis in application is on efficiency effects alone. Non-efficiency effects which modify or extend the initial results are not reported here although they are discussed in detail in [10].

Traditional benefit-cost analysis may be regarded as containing two sequential components. The first is the enumeration and valuation of the benefits and costs of the project as they occur in time. This has been done in the previous two sections of this paper. The second is the valuation and

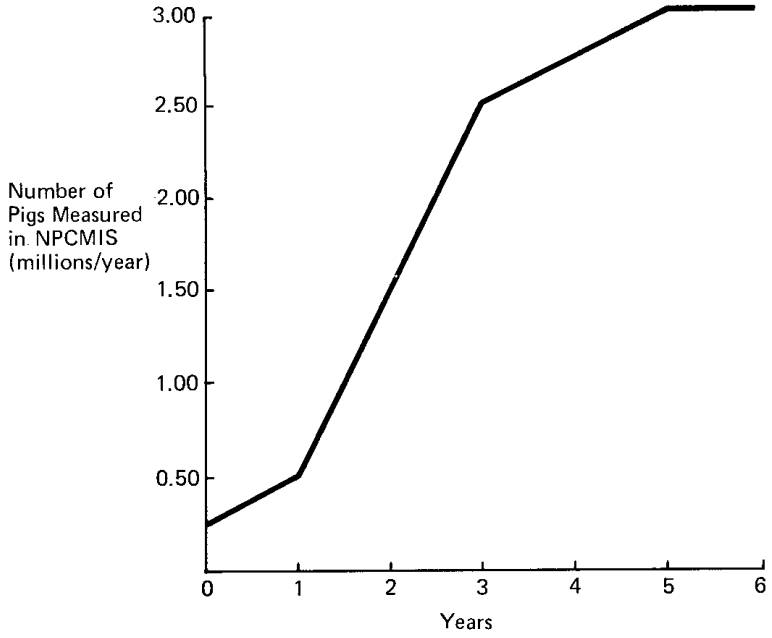

Figure 2: Assumed Most Likely Adoption Rate for NPCMIS

comparison of these benefits and costs at some common point in time, and the comparison of this net effect with some criteria to determine whether the project is acceptable in terms of economic efficiency. To accomplish this second component, the following assumptions were made — a time horizon of 15 years; net present value (NPV) as the decision criterion; a discount rate equal to the social time preference rate (which was about 10 per cent using the long-term government bond rate as an approximation); immediate implementation; and a most likely adoption rate based on overseas evidence and pilot run experiences, and as shown in Figure 2.

4.2 Calculation of Most Likely NPV

In this section the NPV calculations are made based on the set of "most likely" assumptions of various parameters developed in the two previous sections.[7]

4.2.1 Manual Implementation

The NPV for the manual implementation of the NPCMIS is in the order of $49.4m. The cash flow used to calculate this figure is outlined in Appendix 1. This result suggests that on pure efficiency grounds the proposed NPCMIS can be accepted as being an economically feasible investment under the conditions specified above, *i.e.* the net returns from investing in the NPCMIS exceed the net returns from investing in a project with a return of 10 per cent per annum.

4.2.2 Automated Implementation

The NPV for the automated version of the NPCMIS is approximately $48.3m and the cash flows used to derive this figure are included in Appendix 2. Again, this result suggests that on pure economic efficiency grounds the proposed NPCMIS in automated format is an economically feasible investment under the specified conditions.

4.3 Sensitivity Analysis

This section examines the sensitivity of the above NPV results to variations in some of the key parameters of the foregoing analysis from their assumed most likely values. As defined by Reutlinger [28, p. 67], it is ". . . essentially an investigation of how, and to what extent, individual factors and parameters are likely to influence the benefits and costs derived from a project". This investigation is required because there are a large number of

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[7] Several of those assumptions probably require further clarification. First, the figure of three million carcases as an estimate of the future use of the NPCMIS is a rough measure of the mean annual number of carcases slaughtered over the past decade. To the extent that the estimated cost savings induce greater supplies and the estimated improvements in carcase quality stimulate demand, this figure will be an under-estimate of the future capacity of the NPCMIS and net benefits will consequently be under-estimates as well. Conversely, adjustments in substitute markets will dampen the demand for pigmeat and constrain the increase in net benefits. Second, the two most likely cost configurations are polar cases, and actual implementation would be some combination of the two. If the NPV results for the two cases were substantially divergent this may cause some problems, but since the NPV estimates are quite close they represent a reasonable approximation to a more realistic pattern of implementation across different abattoirs. Finally, the cost and benefit estimates are in constant 1976 prices. Without access to a reputable forecasting model I was unwilling to hazard any guesses on future price movements.

situations in which the NPCMIS could be implemented, so it is necessary to determine how the uncertainty associated with these situations is reflected in the NPV results. The sensitivity analysis is therefore the method chosen for incorporating uncertainty into the study.

Some of the important parameters also relate to the benefit-cost methodology employed, so these are examined as well. Initially only the particular parameter specified will be varied with all others held at their most likely values, and then some comments will be made about possible interactive effects if a number of parameters vary simultaneously from their assumed most likely value.

4.3.1 Changes in Individual Parameter Values

Table 6 reports the results of this part of the sensitivity analysis, and they are fairly self-explanatory. Alterations in the time horizon of the project, the rate of adoption, and in the cost savings accruing to retailers have little impact on the overall feasibility of the project.

Table 6: Sensitivity of NPV to Changes in Individual Parameter Values ($M)

Parameter	Type of NPCMIS	Alternate Values				
Time ↓ Horizon (years)	Manual	10	12	Assumed (15)	17	20
	Automated	45.6	47.4	48.3	48.8	49.3
	Manual	46.5	48.4	49.4	49.9	50.5
Adoption ↓ Rate (% difference from most likely rate)		−25	−10	Assumed (0)	+10	+25
	Manual	43.7	47.6	49.4	51.2	52.4
	Automated	42.8	46.3	48.3	50.0	51.3
Discount ↓ Rate (%)		5	Assumed (10)	15	20	
	Manual	65.0	49.4	38.5	30.2	
	Automated	63.5	48.3	37.7	30.0	
Implementation ↓ Delays (years)		Assumed (0)	1	3	5	
	Manual	49.4	44.6	34.8	29.1	
	Automated	48.3	43.6	33.7	28.3	
Quality ↓ Improvements (%)		1	Assumed (2)	3	5	
	Manual	38.3	49.4	54.1	57.8	
	Automated	37.1	48.3	53.0	56.6	
Retail Cost ↓ Savings (c/Carcase)		20	Assumed (28)	40		
	Manual	47.9	49.4	52.0		
	Automated	46.7	48.3	50.5		
Av. Carcase ↓ Weight (kg)		25	Assumed (50)	75		
	Manual	24.9	49.4	76.6		
	Automated	23.8	48.3	75.5		
Saleable Meat ↓ Yield (%)		Assumed (75)	80			
	Manual	49.4	24.4			
	Automated	48.3	23.8			

However, with other parameters constant, it is seen that variations in discount rates do quite markedly affect NPV. Decreasing the discount rate to 5 per cent increases NPV to about $64m while increasing the rate to 20 per cent reduces NPV to about $30m. Delays in implementation have

substantial adverse effects, especially if the delay is as long as five years when NPV falls to around $29m, and changes in the rate of improvement in carcase quality also generate significant changes in the NPV's. For example, increasing the rate by 5 per cent results in NPV's of almost $60m, or $10m more than those based on the most likely rate of 2 per cent, while decreasing the rate to 1 per cent reduces the NPV's to around $37m. The sensitivity analysis indicates that carcase weight plays an important role in the determination of the feasibility of the project, and this result provides an impetus for the continuation of the current trend toward heavier carcases. Finally, increasing the estimate of the current saleable meat yield results in a reduction of NPV's to around $24m. This effect agrees of course with intuition since the gap between actual and potential lean content is diminished considerably.

In all cases however the adverse effects on NPV of altering individual parameter values were not severe enough to deem the NPCMIS infeasible from an economic efficiency viewpoint.

4.3.2 Some Interactive Effects

This section briefly examines the effects on the NPV calculations of simultaneous variations in several of the key parameters outlined in the previous sections. Rather than distinguish every possible combination, it was decided to take only two situations — one which could be regarded as severely pessimistic and one which could be regarded as supremely optimistic, *i.e.* in the first case the worst is expected to happen and in the second the best is expected to happen. In both cases all of the parameters outlined above were set at their respective maximum or minimum to achieve the pessimistic and optimistic outcomes. The results of these calculations are listed in Table 7.

Table 7: Sensitivity of NPV to Pessimistic and Optimistic Combination of Parameters ($M)

Type of NPCMIS	Combination of Parameters		
	Pessimistic	Most Likely	Optimistic
Manual	2.061	49.386	121.119
Automated	1.855	48.298	119.472

The results are self-explanatory. If a supremely optimistic view is taken, NPV is calculated to be about $120m, while if a severely pessimistic view is taken, NPV is calculated to be less than $2m. The range is great, but the important point to note again is that even with the most restrictive set of assumptions, the NPCMIS still appears as an economically feasible investment.

5. Summary and Conclusions

This paper reports a study which aimed to establish *ex ante* the effects on pricing and operational efficiency of pigmeat marketing in Australia of the implementation of the proposed NPCMIS. Benefit-cost analysis was applied to a set of "most-likely" assumptions of benefits and costs of the Service. The results indicate that the proposed scheme would generate net

discounted efficiency benefits of almost $50m. A sensitivity analysis of important assumptions was also conducted and in all cases NPV remained positive. The overall conclusion of the study was that the *ex ante* pricing and operational efficiency benefits of implementing the NPCMIS would outweigh the costs of achieving them in terms of NPV.

The analysis reported above was of necessity broad and general. Being an *ex ante* study there was a marked lack of reliable data on which to base a rigorous analysis. This lack of good data introduced a considerable degree of uncertainty into the analysis, and although this was accounted for to a large extent by the sensitivity analysis, there inevitably remains a tone of "hypothesising" rather than of "evaluating". In addition there are a number of areas in the study that demand improvement. For example, there is a need to estimate the additional costs incurred by pig breeders and feeders in changing practices to produce leaner pigs. The effects of changing from manual to automated versions of the Service could be examined in more detail, and more attention should be given to external benefits such as the use of NPCMIS data in improving plant efficiency and in generating more accurate and reliable market information and forecasts. Finally, the distributional aspects of the project need to be outlined quantitatively. A start has been made on this last aspect but it appears progress will be slow until more consistent estimates of the relevant parameter values are available.

The greatest contribution of the study therefore may not be the actual numerical results, but the formulation of a framework in which a much more rigorous analysis can be conducted as the pilot run stage of this and other carcase description schemes is extended and as more reliable and representative data is generated. It is in this regard that the study is seen as an improvement upon previous studies and a (hopefully valuable) addition to the present debate on carcase description schemes.

APPENDIX 1

Table A 1: Cash Flow Calculations for Manual Implementation in Most Likely Format

Year (n)	Adoption (No. pigs)	Abattoirs (No.)	Benefits ($)	Operating Costs ($)	Net Benefits ($)	Discounted Net Benefits ($)
−5				3,000	− 3,000	− 4,830
−4				22,700	−22,700	−33,230
−3				20,850	−20,850	−27,750
−2				30,300	−30,300	−36,660
−1				22,900	−22,900	−25,190
0				43,720	−43,720	−43,720
1	500,000	5	770,000	60,000	710,000	645,450
2	1,500,000	15	3,945,000	180,000	3,765,000	3,111,580
3	2,500,000	25	9,300,000	300,000	9,000,000	6,761,790
4	2,750,000	27	12,705,000	330,000	12,375,000	8,452,250
5	3,000,000	30	13,290,000	360,000	12,930,000	8,028,490
6	3,000,000	30	11,610,000	360,000	11,250,000	6,350,290
7	3,000,000	30	10,020,000	360,000	9,660,000	4,957,130
8	3,000,000	30	8,460,000	360,000	8,100,000	3,778,730
9	3,000,000	30	6,690,000	360,000	6,330,000	2,684,550
10	3,000,000	30	5,280,000	360,000	4,920,000	1,896,860
11	3,000,000	30	4,080,000	360,000	3,720,000	1,303,820
12	3,000,000	30	2,280,000	360,000	1,920,000	611,770
13	3,000,000	30	1,590,000	360,000	1,230,000	356,280
14	3,000,000	30	1,590,000	360,000	1,230,000	323,860
15	3,000,000	30	1,590,000	360,000	1,230,000	294,450

NPV = $49,385,920

APPENDIX 2

Table A 2: Cash Flow Calculations for Automated Implementation in Most Likely Format

Year (n)	Adoption (No. pigs)	Abattoirs (No.)	Benefits ($)	Operating Costs ($)	Capital Costs ($)	Net Benefits ($)	Discounted Net Benefits ($)
−5				3,000		− 3,000	− 4,830
−4				22,700		−22,700	−33,230
−3				20,850		−20,850	−27,750
−2				30,300		−30,300	−36,660
−1				22,900		−22,900	−25,190
0				43,720		−43,720	−43,720
1	500,000	5	770,000	82,500	100,000	587,500	534,090
2	1,500,000	15	3,945,000	247,500	200,000	3,497,500	2,890,510
3	2,500,000	25	9,300,000	412,500	200,000	8,687,500	6,527,000
4	2,750,000	27	12,705,000	453,750	40,000	12,211,250	8,341,500
5	3,000,000	30	13,290,000	495,000	60,000	12,735,000	7,907,420
6	3,000,000	30	11,610,000	495,000		11,515,000	6,499,870
7	3,000,000	30	10,020,000	495,000		9,525,000	4,887,850
8	3,000,000	30	8,460,000	495,000		7,965,000	3,715,750
9	3,000,000	30	6,690,000	495,000		6,195,000	2,627,300
10	3,000,000	30	5,280,000	495,000		4,785,000	1,844,810
11	3,000,000	30	4,080,000	495,000		3,585,000	1,256,510
12	3,000,000	30	2,280,000	495,000		1,785,000	568,750
13	3,000,000	30	1,590,000	495,000		1,095,000	317,180
14	3,000,000	30	1,590,000	495,000		1,095,000	288,350
15	3,000,000	30	1,590,000	495,000		1,095,000	262,130

NPV = $48,297,640

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