Chapter 1

BACKGROUND TO THE STUDY

1.1 General Introduction

Food inspection and the imposition of food quality standards are practiced worldwide to counter foodborne disease. However the incidence of foodborne disease is poorly appreciated. Data and published reports of foodborne disease incidents are poorly distributed (Todd 1978). In addition, many minor cases of food poisoning are not notified to the relevant authorities.

The maintenance of food quality standards involves considerable cost. For example, meat inspection in Australia (all livestock species) costs approximately $100m per annum. However the value in terms of the risk reduction in foodborne diseases which accrue from this financial outlay is uncertain. Clearly there is a tradeoff between risk and cost for meat inspection. How much food safety should the public purchase? This question appears to have been largely ignored with respect to meat inspection in Australia and in other countries. The reason is partly due to the difficulty involved in evaluating the benefits of a food inspection system. Risk reductions from a given inspection system are difficult to estimate. Moreover, the demarcation between a physical health risk and an aesthetic risk to consumers will complicate any decision concerning the level of inspection required. As such, meat inspection procedures in Australia are based upon standards used in other countries and may be quite divorced from the health status of Australian livestock.

Meat inspection operations in Australia involve both Commonwealth and State Government intervention. Such intervention is often warranted on the grounds of 'market failure'. That is, in the case of meat inspection, if inspection procedures were dictated by private decision makers, a socially non-optimal level of inspection may result. The reason for this situation is the existence of external benefits; the benefits to society as a whole arising from meat inspection are likely to exceed the benefits accruing to individual livestock producers or individual consumers. In particular, the benefits from improved public health are important benefits to society. Without government intervention, inspection services are likely to be provided at a socially sub-optimal level. Furthermore, economies of scale in the provision of meat inspection services may necessitate a single firm provide the service, rather than a number of small firms. This being the case, a government body is preferred since a private monopoly may follow a socially sub-optimal pricing strategy.

Nevertheless, if government intervention represents an attempt to correct market failures, it is not certain that the forms or levels of intervention are socially optimal. This is particularly the case where intervention is the result of successful lobbying of the government by groups pursuing their own interests. With respect to pigmeat inspection in Australia, evidence is presented in the following chapters to suggest that such lobbying may have resulted in a level of intervention which exceeds the socially optimal level. In particular, the specification of inspection procedures by importing countries has a major impact upon the level of meat inspection services provided. This may have been confounded by subtle changes in the rationale for the existence of a meat inspection service in Australia, as discussed in the following section.

1.1.1 The rationale for meat inspection in Australia

An historical review indicates that the original rationale for the introduction of meat inspection services in Australia had a public health basis, as is evident from various pieces of legislation existing at the turn of the century. The Victorian Licensed Butchers and Abattoirs Act (1864) referred to 'inspectors of slaughterhouses' and represented an attempt to bring some degree of outside regulation to bear upon the livestock slaughtering industry. The Victorian Public Health Act (1865) provided inspectors of slaughterhouses, police officers and officers of local health boards with the power to inspect slaughterhouses, butchers, poulterers, fishmongers or shops selling articles of food intended for human consumption. Food deemed unfit for human consumption could be seized and used as evidence to warrant a more detailed inspection of the premises.

The threat of animal disease to human health (i.e. the threat posed by animal zoonoses) was specifically addressed in the 1888 amendment to the Victorian Public Health Act. In particular, reference was made to the threat to human health from diseases such as pleuro-pneumonia, tuberculosis, anthrax and fluke infestations. Victorian parliamentary debates on the Meat Supervision Act (1900) suggested further rationales for meat inspection, although these were not as strongly emphasised as public health. For example, it was noted that Victoria was relatively free of livestock diseases (tuberculosis in particular) and the detection of diseased meat was seen as a means of detecting and isolating livestock herds with disease problems. Further, it was implied that livestock producers would not object to detailed examination of their livestock and would benefit from information on the disease status of their herds (Graham 1900, pp. 3749-3750). Hence, a disease-traceback rationale for inspection may be inferred. Reference has also been made to trade facilitation through inspection, whereby inspected meat is viewed as a 'better quality' product (Murray 1900, pp. 3761-3763).

Reference to early Commonwealth Government involvement in meat inspection may be drawn from the Commerce (Trade Descriptions) Act (1905) and the Pure Food Act (1908). The former Act dealt with export inspection and detailed penalties for goods falsely described, indicating that facilitation of overseas trade was an important benefit accruing from inspection procedures. The Pure Food Act (1908) provided health board officers with the power to inspect all premises dealing with food products to detect food that was unfit for human consumption.

The second decade of the 1900s saw some degree of change in the rationale for meat inspection away from public health toward satisfying the requirements of importing countries. The discovery of worm nodules in Australian beef exported to the United Kingdom (UK) prompted the Commonwealth Government to become more specifically involved in the field of meat inspection (Rodgers 1915, pp. 4145). In January 1911, under the authority of section 51 of the Constitution, a veterinary officer was appointed to supervise the inspection of beef in Queensland (Collins 1981). Following further investigations into Australian meat inspection methods by the United States Department of Agriculture (USDA), veterinary supervision was extended to cover the export meat trade in all states. Commonwealth Government involvement was further extended in 1916 with the introduction of Commonwealth meat inspectors to export-registered meat works in all states. By 1958 the service included over 500 inspectors supervised by 20 veterinarians. In addition, the Commonwealth service assumed responsibility for inspection at some local abattoirs at the request of local authorities (Collins 1981).

The changing rationale for meat inspection in Australia was again highlighted in the early 1960s when the USDA questioned inspection standards in Australian abattoirs. At the time, the Commonwealth Government was responsible for export inspection, while inspection of meat intended for domestic consumption was a function of the various state governments. Authorities in some of Australia's important export markets expressed the desirability for the introduction of a single inspection service, implying that the overall control of export registered premises, including those which process meat for home consumption as well as for the export market, must be under Commonwealth control (Anderson 1964, pp. 1603-1604). The Meat Inspection Arrangements Act (1964) allowed the Commonwealth to enter into an agreement with a State or State Meat Authority such that Commonwealth inspectors were also responsible for domestically destined meat. Some states preferred to retain their own inspection services leading to a dual inspection system in some export works.

The major switch in the Australian meat trade to U.S. markets in the early 1970s prompted the USDA to insist upon a higher level of veterinary involvement in export inspection. The Commonwealth Department of Primary Industry (DPI) employed a large number of veterinarians (many from overseas) to satisfy the USDA requirements (Woodward 1982). Debates surrounding the introduction of the New South Wales Meat Industry Act (1978) suggested that inspection standards may have become too stringent, since there had been no recent evidence to suggest that members of the public had been adversely affected by eating bad meat. Certain officials involved with meat inspection felt that much of the export control of meat was brought about when the U.S. Government attempted to restrict the amount of meat exported to the U.S.A. It was believed that the U.S. Government, more than any other authority, was probably responsible for raising the hygiene standard of abattoirs and the quality of meat consumed domestically as well as for export (Brewer 1976, pp. 12368-12375).

A meat inspection service was also seen as maintaining the aesthetic quality of meat . It has been argued that, from an aesthetic point of view, meat should not be passed fit for human consumption if it is afflicted with a disease or condition that would produce a "feeling of disgust in the mind of the consumer" (Curnow 1973, pp. 4217). Clearly there must be instances where meat is condemned from an aesthetic viewpoint (e.g. extensive bruising), even though, from a public health perspective the meat is free of disease and fit for human consumption.

In summary, it appears that the original rationale for meat inspection services in Australia, namely, the protection of public health has given way to a rationale founded upon meeting the inspection requirements of importing countries. The ability of importing countries to set these requirements at artificially high levels is a valid concern. At this point it is sufficient to raise the question as to whether the public health rationale for meat inspection has lost some of its relevance, given the relative absence of animal disease in Australia.

1.1.2 The resource costs of meat inspection in Australia with particular reference to pigmeat inspection

Consumer demand and producer returns are directly influenced by product price. Product price is influenced by marketing margins. The marketing margin for a product is often expressed as the difference between its retail price and its price at the farm gate, for an equivalent quantity. Typically the retail price exceeds the farm gate price due to the presence of marketing costs such as transport storage, processing and marketing services.

Meat inspection represents a Government imposed marketing service and forms part of the marketing margin for meat. This is significant since it is generally the consumer (as opposed to a Government authority) who determines the nature and extent of marketing services (Campbell and Fisher 1981). Furthermore, it has been suggested by Fisher (1981) that the major adjustment to a change in marketing charges will be made by farm prices. If more stringent and, therefore, more costly meat inspection is required, the supply function for marketing services will shift upwards producing a corresponding increase in the marketing margin. A larger proportion of this increased margin appears as a fall in farm prices as opposed to a rise in retail price, since supply is generally more price inelastic than demand.

Clearly then, as noted by Fisher (1981), producers have a strong incentive to promote efficiency in the marketing services sector. This incentive may be even greater for pig producers in Australia as opposed to producers of beef and sheepmeats, since pig carcases are often inspected to export standards, yet less than two per cent of pigmeat is exported annually (ABARE 1987).

Most meat inspection operations in Australia are under the control of the Commonwealth Animal Quarantine and Inspection Service (AQIS). This agency is responsible for meat inspection in all export-registered abattoirs and in abattoirs/slaughterhouses supplying the domestic market in all Australian states other than Victoria and Queensland. In Victorian domestic abattoirs, inspection is undertaken by the State Abattoir and Meat Inspection Authority (though at the time of writing, negotiations are underway to transfer this responsibility to the Commonwealth). In Queensland, inspection in domestic abattoirs is the responsibility of the State Veterinary and Public Health Branch of the Department of Primary Industries.

The total cost of AQIS meat inspection services for 1985-86 are detailed in Table 1.1. The total figure of $84m does not represent total Government expenditure on the AQIS meat inspection services. Meat inspection charges are levied at the abattoir in accordance with the Government's policy of a 50 per cent recovery of the cost base. This source of revenue is estimated at $40m (DPI 1986) indicating that some $44m of the total cost comes from Consolidated Revenue. Nevertheless, $84m represents the total resource cost of AQIS meat inspection.

The total cost of Victorian domestic meat inspection services was $11m in the 1985-86 financial year with 100 per cent cost recovery (Victorian Department of Agriculture and Rural Affairs 1987, unpublished data). The cost of Queensland domestic meat inspection services totalled $3.2m in the 1985-86 financial year with a 65 per cent cost recovery (Queensland Department of Primary Industries 1986, unpublished data). Hence the total resource cost of meat inspection services in Australia is approximately $98m.

The proportion of these inspection costs attributable to pigmeat inspection is difficult to ascertain. However, based upon a Commonwealth inspection charge of $0.87 per carcase, a 50 per cent recovery basis, state inspection charges which are typically double this figure and pig slaughterings of 4.6m for 1987 (ABARE 1987), the cost is likely to be $6-7m.

1.2 Problem Identification

A review of the relevant literature and discussions with medical and veterinary researchers, has suggested that the current pigmeat inspection system may be devoting too many resources to identifying diseases/conditions in pig carcases which are of low prevalence and/or of no significant human health threat.

Skovgaard (1981, cited by Blackmore 1983) has suggested that the majority of gross lesions detected today in individual carcases are not associated with public health hazards. Moreover, emphasis on individual carcase inspection may have little, if any effect in significantly detecting unsafe meat. The major diseases which are transmitted in meat are unlikely to be detected by traditional meat inspection techniques. As such, veterinarian involvement in inspection may be illogical unless a particular problem carcase is identified (Blackmore 1983).

Table 1.1
Total Cost of AQIS Meat Inspection Services 1985-86 ($'000)

Item	Export meat[a]	Domestic meat	Total meat
Base salary	39 345	4 811	44 156
Salary loadings	850	107	957
Overtime	4 530	390	4 920
Travel	6 957	582	7 539
Protective clothing	833	110	943
Consultants	104	29	133
Seals and testing	575		575
Operations development	321	297	618
Compensation	983	60	1 043
Trade description	128		128
Incidentals	762	46	808
Sub-total	55 388	6 432	61 820
Superannuation	7 745	495	8 240
Long Service Leave	984	120	1 104
Sub-total	64 117	7 047	71 164
Inflation factor	1 283	141	1 424
Total field costs	65 400	7 188	72 588
Regional offices	6 011	884	6 895
Head office	3 285	336	3 621
Management support	695	73	768
Total	75 391	8 481	83 872

Source: DPI (1986)
a. Includes all meat prepared on export registered premises.

The suggested over-investment of inspection resources to the detection of diseased carcases may be a result of the close subjective link between an aesthetic risk and a human health risk. Inspection procedures mainly detect aesthetically unacceptable lesions and contamination. However it is questionable whether this warrants veterinarian involvement, or highly trained inspectors (Blackmore 1983). Murray (1986) in addressing this problem in the Australian context, suggested that it may be possible to have meat workers remove defects under veterinary supervision. Inspection staff could then deal with areas of higher public health priority (e.g. chemical residue testing).

The problem of the demarcation between aesthetic acceptability and human health risk has similarly been addressed with reference to the New Zealand inspection system. It has been suggested that providing public health guarantees within a cost-effective framework is difficult when trying to satisfy importing country requirements which define public health objectives largely in terms of visible carcase pathology (Hathaway, McKenzie and Royal 1987).

At this stage, it should be acknowledged that there are other perceived benefits from meat inspection in addition to the protection of public health. For example, consumer confidence in the product and disease traceback information to producers are often viewed as additional benefits. While the accuracy of disease traceback information from meat inspection operations has been questioned in a number of countries, this and other benefits will not be addressed in the study. The main rationale for concentrating upon the human health benefits only is that it is the detection of zoonoses (and aesthetically displeasing conditions) which have the greatest bearing upon the procedures used and hence the cost of pigmeat inspection.

A more detailed discussion of inspection procedures for pig carcases and the significance of conditions detected is given in Chapter 3.

1.3 Objectives of the Study

Given this background, the objectives of the present study are:

(a) to review critically the scientific basis of the current pigmeat inspection procedures in Australia;

(b) to construct a conceptual economic framework which describes a theoretical 'optimal' pigmeat inspection intensity in terms of human health objectives; and

(c) to undertake an economic evaluation of possible alternative pigmeat inspection strategies with respect to human health objectives.

1.4 Hypothesis

1.4.1 General hypothesis

The general hypothesis under investigation in this study is that current pigmeat inspection procedures in Australia are not providing cost-effective human health benefits. Pigmeat inspection can be viewed as a production process; various inputs are combined to produce various outputs or benefits. One of these benefits can be described as 'the protection of human health'. This production process can be 'optimised' such that the maximum net benefit is achieved.

1.4.2 Operational hypothesis

A reduction in inspection intensity would represent a move towards an optimal intensity level, in the human health context. An optimal intensity level is defined as one which maximises net human health benefits.

1.5 Organisation of the Study

In this introductory chapter the problem to be investigated has been discussed, along with appropriate background information. The objectives and the hypothesis have also been developed.

In Chapter 2 a conceptual economic framework for the evaluation of pigmeat inspection procedures is discussed and the limitations of various evaluations which could be developed within this framework are outlined. The empirical investigations undertaken in the study are then reviewed.

The pigmeat inspection process and its relevance to the protection of human health are described in some detail in Chapter 3. In Chapter 4 the concept of inspection intensity and its relationship with human health hazards in meat is introduced. The alternative pigmeat inspection systems to be examined in the study are then described and justified.

Sources of data, data collection methods and explanations of the calculation of costs and benefits are given in Chapter 5. These data are then presented as results in Chapter 6, along with a discussion of the relevance of these findings. A summary and conclusions, together with an overview of the limitations of the study and the policy implications arising from the conclusions are provided in Chapter 7.

Chapter 2

THE DEVELOPMENT OF A CONCEPTUAL FRAMEWORK FOR THE ECONOMIC EVALUATION OF MEAT INSPECTION

2.1 Introduction

The purpose in this chapter is to develop a conceptual economic framework within which pigmeat inspection procedures can be analysed. Initially, the full range of costs and benefits occurring from meat inspection procedures are discussed. This discussion is then narrowed down to consider only the human health aspects of the inspection process. A number of alternative conceptual frameworks for determining the optimal level of inspection are presented and the problems with their empirical implementation are highlighted. The analytical procedure to be undertaken in this study is then discussed.

2.2 A General Framework for the Full Range of Benefits

Pigmeat inspection can be viewed as a production process, involving the use of inputs to provide a set of outputs. These outputs, rather than being physical in nature, consist of various services or benefits which are thought to accrue from the meat inspection process. The benefits most commonly cited are reduced human infection from contaminated meat, improved herd productivity through disease traceback information and stimulation of demand through increased consumer confidence in the product.

The situation described above is analagous to a production process involving multiple inputs to produce multiple outputs. The multiple input costs can be summed to derive total and marginal cost curves for meat inspection. Similarly, assuming the multiple outputs are independent and additive, these can be summed to produce a total product and marginal product curve for meat inspection. This 'product' will be expressed as the value of the benefits produced by the meat inspection process.

Given this framework, the meat inspection process can be subjected to the profit maximisation conditions which apply to multiple inputs and multiple outputs (see Dillon 1968, pp. 44-45). Three optimising relationships can be established. These are the well known factor-product, factor-factor and product-product relationships. The factor-product relationship specifies that for each output of the meat inspection process, there will be an optimal (or net benefit maximising) level of each input. The factor-factor relationship specifies that inputs used in the production of each output must be combined in a least-cost manner. Finally, the mix of products should be such that total net benefit is maximised as described by the product-product relationship.

Investigating these three optimising conditions for the meat inspection process in terms of an algebraic model would be impossible because of a lack of information about the underlying technical production relationships.

2.3 A Conceptual Economic Framework for the Human Health Benefits of Meat Inspection.

Arguably, the main objective of pigmeat inspection procedures is the removal of infected carcases/carcase parts which would cause human illness. A conceptual economic framework to evaluate this single output or benefit of the inspection process can be constructed, as in the previous section where the total 'package' of benefits was discussed.

A number of assumptions must be made:

(a) human health benefits are independent of other benefits of the inspection process;

(b) the 'total human health benefits' are the simple sum of the benefits occurring from the avoidance of individual diseases;

(c) the costs of inspection inputs cannot be partitioned between the individual diseases in the 'total human health benefits' term; and

(d) the inputs in the inspection process are inspection staff (X_1) and veterinary staff (X_2), and the cost of these inputs relate specifically to the human health output of the inspection process,.

This final assumption is somewhat of an oversimplification. First, it ignores fixed inputs such as structural requirements in abattoirs, associated with the inspection process (e.g. sterilising units for inspector's knives and elevated platforms at inspection points). However, if it is assumed these fixed inputs will remain unchanged as the level of inspection varies, then the major variable cost item to be considered is the cost of inspection and veterinary staff. This cost will include items such as base salaries, salary loadings, third party insurance, travel, protective clothing, superannuation and incidentals. Second, part of the cost of these staff should, theoretically, be contributed to benefits of the inspection process other than the protection of human health (e.g. disease traceback information). Problems of cost indivisibility arise here. To narrow down the allocation of costs to the human health output alone, only post-mortem inspection staff costs are considered in this study. This will overestimate the costs associated with providing that benefit. However, post-mortem inspection is crucial for the detection of zoonoses in carcases. Ante-mortem, boning/chilling room and transport container inspection are not as closely related to zoonosis detection hence, are not included in the cost analysis.

The profit (or net benefit) function to be optimised has the form;

(2.1) $$B = P_T Y_T - R_1 X_1 - R_2 X_2$$

where B = net benefit per annum;
P_T = the resource savings per person from avoiding illness;
Y_T = the number of persons avoiding illness per annum because of meat inspection procedures;
R_1 = the cost of input X_1
R_2 = the cost of input X_2
X_1 = level of use of input X_1 and
X_2 = level of use of input X_2.

Given the assumption that total human health benefits are the sum of the benefits occurring from the avoidance of individual diseases, then the total benefit term in equation (2.1), ($P_T Y_T$ = total benefit) can be written as;

(2.2) $$P_T Y_T = P_1 Y_1 + P_2 Y_2 +, \ldots\ldots, P_n Y_n$$

where P_i = the resource savings per person from not contracting disease i; and
Y_i = the number of persons not contracting disease i per annum because of meat inspection procedures.

The optimising (or net benefit maximising) conditions for equation (2.1) in terms of inputs X_1 and X_2 can be derived by taking the first partial derivatives, setting them equal to zero and solving simultaneously to find the input levels of X_1 and X_2 which will maximise net benefit.

However, such a process assumes that the functional form of the relationship between Y_T (the 'output') and the inputs X_1 and X_2, represeted by equation (2.3) is known.

(2.3) $$Y_T = f(X_1, X_2)$$

In practice, it is unlikely that equation (2.3) can be specified, since this would involve estimating the proportion of each input allocated to the detection of each disease found in pig carcases which is deemed important in terms of human health. Since the inputs considered are inspection and veterinary staff, it is not feasible to divide staff input between different diseases due to the practical difficulties involved in making such a distinction. Hence an algebraic solution to determine the optimal level of inputs for the provision of human health benefits appears infeasible.

An alternative method of analysis can be based upon a graphical approach to this problem. Roberts (1983) has depicted cost and benefit functions for the meat inspection process in a graphical form and has defined the 'optimal' level of meat inspection intensity as the point where marginal benefits (MB) equal marginal costs (MC). Inspection intensity in this context refers to the degree of 'sophistication'with which each carcase is examined. For example a low level of inspection intensity may simply involve observation for changes in colour or smell indicating decomposition. More intense procedures to detect chemical residues or microbial contamination would involve costly laboratory analysis. This situation is illustrated in Figure 2.1. Point q_0 represents the 'optimal' level of inspection intensity.

Figure 2.1 could represent the total 'package' of benefits occurring from meat inspection services, or a single output or benefit. If this approach is applied to the human health benefits arising from 'inspection', a suitable measure along the horizontal axis must be found upon which costs and benefits can be based. Roberts (1983) gave no indication of a method to measure inspection intensity.

The functions shown in Figure 2.1 are similar to those used in the field of environmental policy and welfare economics to explain optimal pollution control strategies. For example Hjalte, Lidgren and Stahl (1977) have described marginal cost and marginal willingness to pay curves for the reduction of SO_2 emissions into the

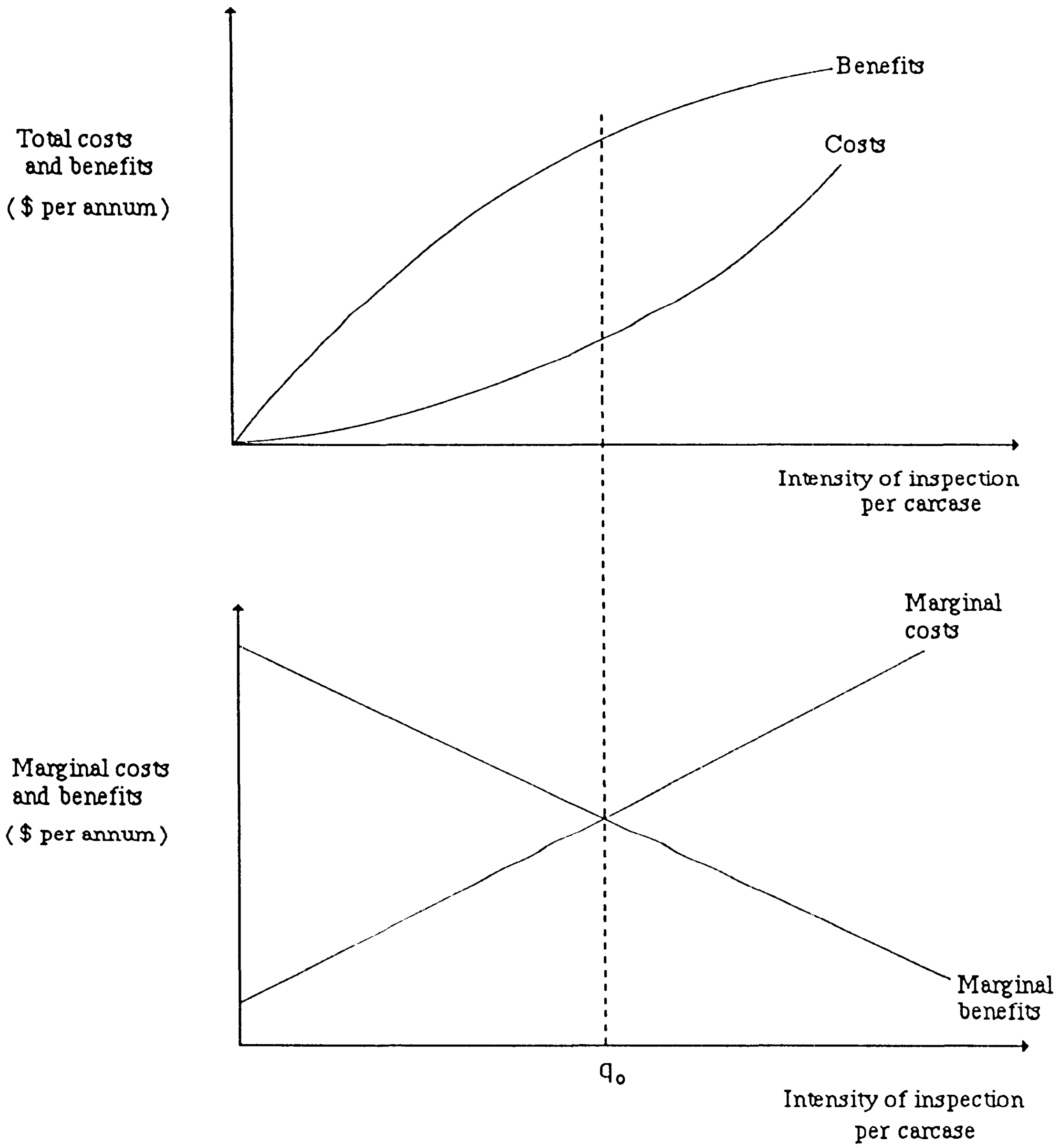


Figure 2.1. Meat Inspection Cost and Benefit Functions for a Given Number of Carcases Inspected

atmosphere. The scale of measurement along the horizontal axis was reduction of SO_2 emissions in thousands of tonnes (i.e., the output of the control process was measured on the horizontal axis). This raises the problem of what measure to use for the horizontal axis in the case of meat inspection. Inspection intensity could be measured in descriptive terms which relate to the intensity of observation of each carcase. Discussion with relevant persons in the industry have revealed two alternative meat inspection systems which represent progressively less detailed examinations of individual carcases. Marginal cost and benefit curves could be constructed on this basis as follows:

(a) four inspection systems are examined - the current system, two less intense systems and the no inspection situation;

(b) for representative abattoirs, the input requirements and associated costs of each system are calculated to provide total and marginal cost curves;

(c) the benefits in terms of the number of people who avoid illness under each inspection system are calculated - the information required for such a calculation would include;

- the probability of human infection with disease from an infected pig carcase;

- the probability of an infected pig carcase escaping detection under each alternative system;

- the total incidence of infected pig carcases, such that the number of carcases escaping detection under each system can be estimated;

- the human population exposed to infected pig carcases; and

- the resource cost saving associated with avoiding human infection with a particular disease.

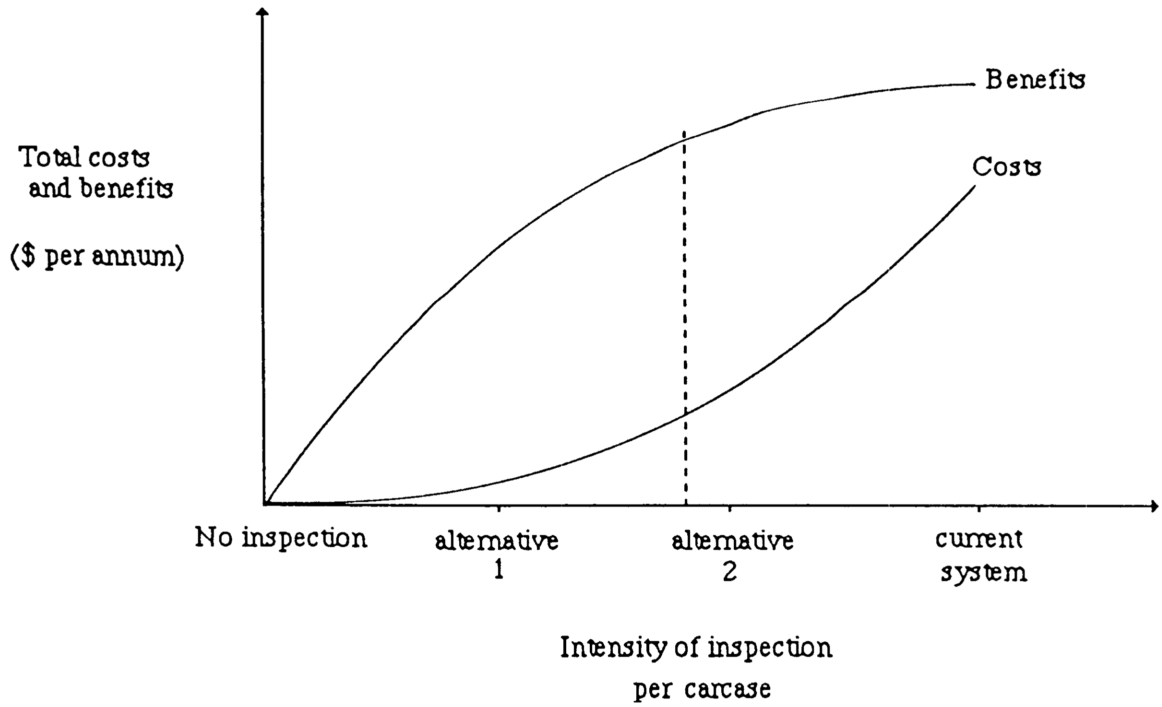


Figure 2.2. Total Costs and Benefits of Alternative Pigmeat Inspection Strategies

If the costs and benefits of the alternative systems were calculated for the inspection industry, the cost-benefit comparison shown in Figure 2.2 could be made. However, this approach has two flaws. First, it is difficult to define just how 'intense' each alternative system is and, hence, it is difficult to decide upon the graduation to be used on the horizontal axis. The relative position of the alternative systems on the intensity scale (horizontal axis) will affect the shape of the total benefit (TB) and total cost (TC) curves.

Second, there is no assurance that each of the alternative systems represents the least-cost way of providing that level of benefits. The alternative systems may represent the only technically feasible way of providing that level of benefits, in which case they do represent valid alternatives. However if there are technically feasible, lower-cost alternatives to provide a given level of benefits, then the above analysis is not strictly identifying an 'optimum' inspection intensity. Nevertheless, the analysis would provide some insight into alternative and possibly more cost-effective ways (in terms of total costs and total benefits) of providing the pigmeat inspection service.

A theoretically more acceptable approach within a graphical solution may be to use output as a measurement on the horizontal axis. Output could be measured in terms of the percentage of diseased carcases which escape detection, or the incidence of human disease resulting from such carcases (Figure 2.3).

This method is similar to that used in the analysis of optimal pollution control strategies. However the practical problem exists that for each point chosen on the horizontal axis, an inspection system and its associated costs must be identified which provides the specific level of disease detection. This would prove to be a difficult task, especially if the chosen system must represent a least-cost alternative. This situation is represented graphically in Figure 2.4. Each isoquant represents combinations of inputs X_1 and X_2 which provide a specific level of disease detection. The least-cost input combination for a particular isoquant must then be identified. If a range of detection probabilities are considered, a least-cost expansion path could be constructed. This would be an important feature in identifying a cost-effective inspection system over various levels of disease detection probability.

The probability of disease detection warrants consideration since this provides a basis upon which alternative inspection systems can be compared. Two scenarios can be

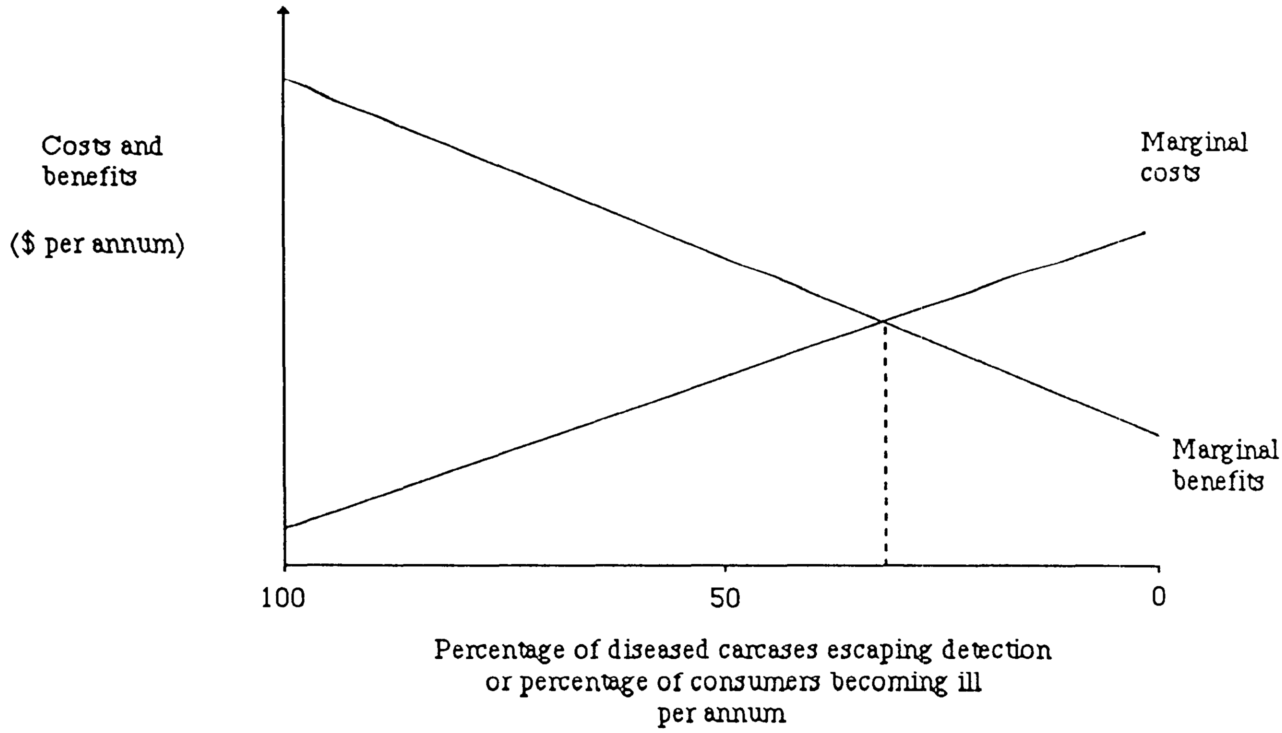


Figure 2.3. Marginal Costs and Benefits for Meat Inspection

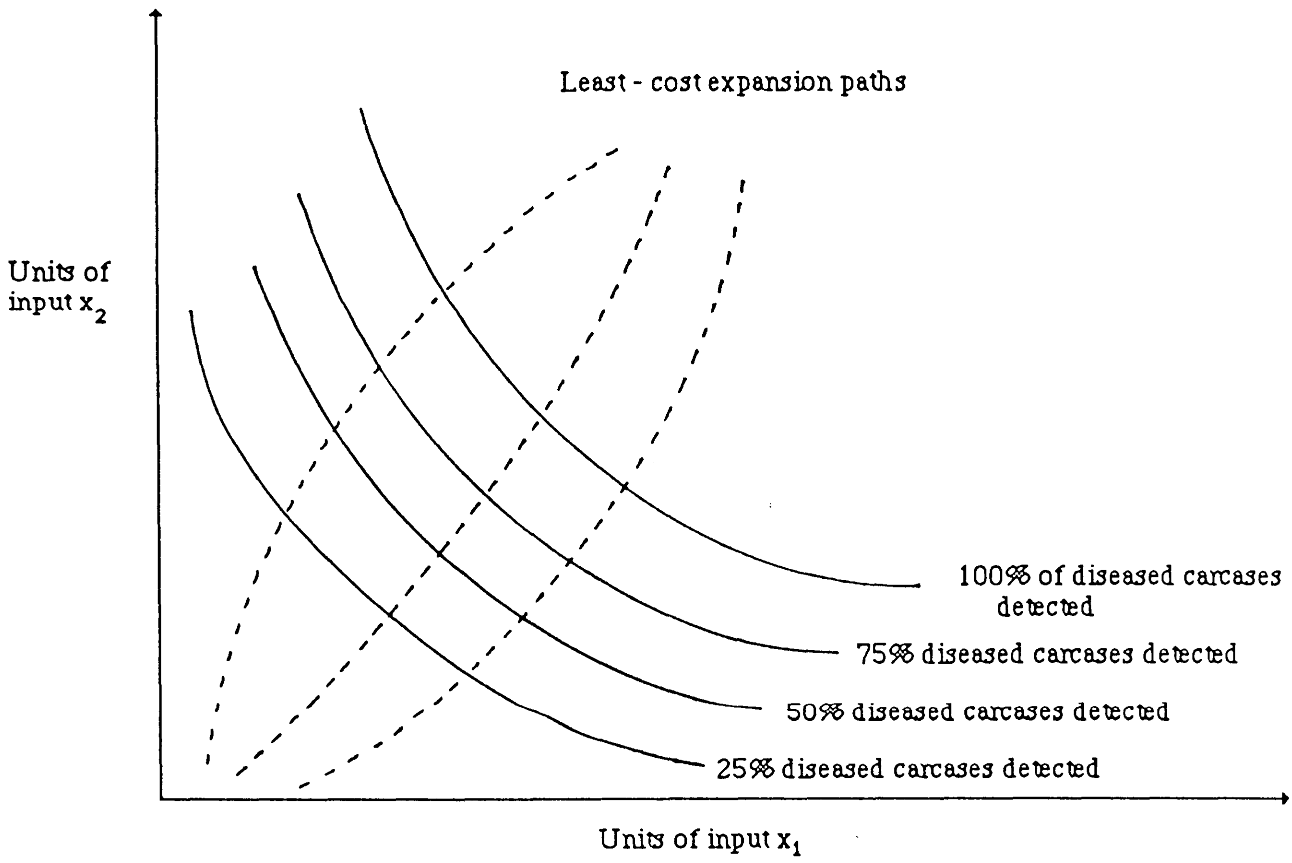


Figure 2.4. Inspection Intensity Isoquants

considered. First, alternative inspection systems which give the same detection probability for the relevant diseases as the current system could be investigated. This basically involves the question of efficient resource allocation. For example, if veterinary and inspection staff are considered as the two substitutable inputs in the inspection process, combinations of these inputs can be identified which provide a constant detection probability for a given disease. This is analogous to movement along an isoquant in factor-factor space, where the isoquant represents a constant level of disease detection probability (as shown in Figure 2.4). This approach would be complicated by the problem of disease disaggregation. A series of isoquants would be required for each disease considered.

The second approach would be to design alternative systems with different detection probabilities to the current system, these detection probabilities being based upon the human health significance of the disease in question. Hence, where a condition is judged to have no human health significance, it would not be specifically inspected for, so its detection probability would theoretically be zero. The alternative inspection systems could then be devised by eliminating procedures from the current system which are specifically targeted to diseases of little or no human health significance. This could be done sequentially by first removing procedures related to diseases which clearly have no human health impact and then removing procedures related to diseases which have only minor human health implications. This method may eventually lead to a reduced inspection system which investigates a smaller number of conditions, those conditions representing a definite health threat to humans.

The probability component of the analysis may be easier to define as a pre-determined parameter, rather than as an independent variable. This can be achieved by measuring inspection output as the number of carcases inspected on the horizontal axis and examining the costs and benefits for a range of disease detection probabilities. This approach is described graphically in Figure 2.5. A number of assumptions are involved. First, the curves labelled A,B,C,D and a,b,c,d in Figures 2.5a and 2.5b, respectively, represent corresponding levels of disease detection (e.g. curves A and a may be a 10 per cent disease detection probability for disease z while curves D and d may represent an 80 per cent detection probability for the same disease). This is similar to the first scenario described above, however, instead of examining alternative systems with the same detection probability as the current system, a range of detection probabilities are examined. Hence, each curve in Figures 2.5a and 2.5b essentially relates to alternative inspection systems, each with different detection probabilities for the disease in question.

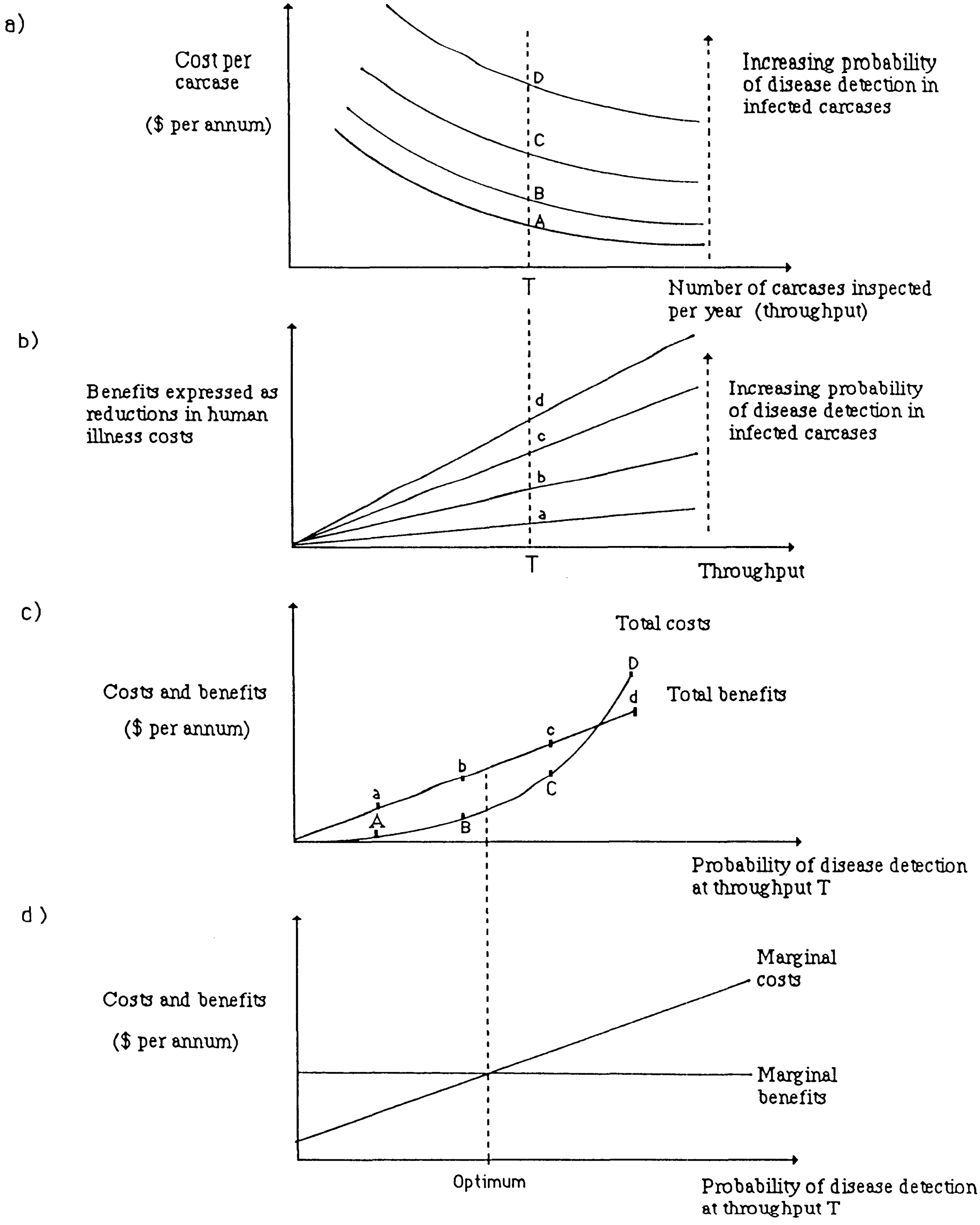


Figure 2.5 The Optimum Inspection Intensity Concept

Second, the cost curves in Figure 2.5a are drawn progressively further apart as the detection probability increases, yet the benefit curves in Figure 2.5b increase at a constant rate with increasing detection probability. This assumes that inspection costs increase at an increasing rate, as the probability of detecting a particular disease condition becomes large. This assumption is probably valid, because very specialised and costly techniques may be required to achieve higher detection rates. It should be noted that the forms of the functions shown in Figures 2.5a and 2.5b are hypothetical.

Benefit functions which increase at a constant rate as detection probability increases (at any given throughput level), indicate that the benefits are a simple linear function of the reductions in human illness from disease z, that arise from meat inspection. The cost of human illness at any given level of disease non-detection probability can be calculated as;

(2.4) $$C = [P_{HIz} (P_{NDz} \cdot N_{Iz})E]K_z$$

where C = annual cost of human illness from disease z;
P_{HIz} = probability of human infection from a carcase infected with disease z;
P_{NDz} = probability of <u>not</u> detecting a carcase infected with disease z;
NI_z = number of carcases infected with disease z per annum;
E = number of human exposures per infected carcase per annum; and
K_z = cost per case of human infection with disease z.

The benefits at various levels of disease non-detection probability are then calculated as the savings in human health costs in moving from a higher to a lower non-detection level.

From the above discussion, it becomes evident that there will be a set of diagrams similar to those in Figure 2.5 for each disease in pigs which is considered transmissible to humans. Again this raises the problem of cost and benefit aggregation. As previously mentioned, it is not possible to segregate the costs of the inspection process among these various disease conditions. Hence, the benefits from avoiding a range of diseases must be aggregated in order to identify an overall optimum probability of detection for any chosen throughput level. The problem with this approach is that the cost of an inspection system which gives say a 50 per cent detection probability for disease z may be very different from the cost of a system which gives a 50 per cent detection probability for disease y.

Figure 2.5c shows total cost and total benefit curves at a given throughput level. The total benefit curve is linear, since increases in benefit level are assumed constant with a constant increase in the detection probability. As discussed previously, cost increases are not assumed constant, hence the total cost curve is a non-linear function. Figure 2.5d shows marginal cost and marginal benefit curves derived from the respective total cost and total benefit curves. Again, the optimal detection probability level is determined by equating marginal cost and marginal benefit. However, it must be re-emphasised that this method identifies the optimal detection probability for an individual disease, rather than identifying an optimal inspection system.

2.4 The Significance of Diseases Detected During Meat Inspection

If, as preliminary evidence suggests, (e.g. Blackmore 1983), a number of diseases currently inspected for do not represent a human health threat, then an important distinction can be made between:

(a) examining the scope for improving the cost-effectiveness of meeting the current specifications in terms of disease detection; and

(b) examining the scope for improving the cost-effectiveness of meeting specifications which are based upon the significance of diseases in terms of human health. This will involve the generation of a new set of specifications.

This second analysis would appear to have the greatest potential for reducing input costs, yet targeting those inputs used to areas where the greatest benefit can be derived. By concentrating upon devising a least-cost way of inspecting for diseases of pigs which represent a true human health threat, the inspection system could be significantly improved. To date however, no studies have been undertaken which investigate empirically the human health significance of disease conditions detected in pigs at slaughter.

2.5 The Scope of Empirical Investigations in this Study

The conceptual framework developed in Figure 2.5 represents a rigorous investigation of the costs and benefits of alternative pigmeat inspection procedures. However practical problems and a variety of resource restrictions prevent this approach from being strictly followed. In particular, identifying the inspection costs associated with individual diseases is very difficult. Also, the specification of inspection systems which provide a particular detection probability level for each disease is beyond the scope of the study.

The approach adopted in this study is to devise alternative inspection systems based upon the human health significance of the diseases inspected for. As discussed in Section 2.3, the inspection system can be progressively streamlined by discarding those procedures specifically related to diseases of little or no human health significance. Hence, a number of alternative inspection procedures can be constructed. This process could be continued such that the eventual inspection system produced involves only a small number of procedures related to those diseases deemed to pose a significant human health threat. For each inspection system, the costs and benefits (in terms of changes in human illness costs) can be estimated. If these costs and benefits are compared with the current inspection situation, total cost and benefit comparisons can be made. This method uses the current inspection system as a base level against which changes in costs and human health benefits are measured. An examination of the net benefits will indicate whether the current system lies to the left or right of the optimum point as defined in Figure 2.1. In addition to analysing these alternative systems, a further alternative suggested by R. Meischke which represents a technically feasible pigmeat inspection system will be examined. This alternative is judged to be the least intense of those investigated.

Given this approach, it is not necessary to specify detection probabilities for each disease prior to designing the alternative procedure. However once a procedure has been defined, it will be necessary to estimate the detection probabilities of all diseases of human health significance. This will allow the human health benefits to be estimated, based upon the calculation described in equation (2.4) in Section 2.3. The estimation of these probabilities will inevitably rely upon expert opinion. As shown in Figure 2.5, the level of costs and benefits will vary with throughput. Cost and benefit calculations in this analysis will be based upon 1987 throughput levels in AQIS staffed pig slaughtering establishments.

The important feature of the approach described above is that it examines meeting inspection specifications based upon the human health significance of disease conditions found in pigs. There would appear to be greatest potential for cost savings with this approach, in contrast to examining alternatives to meet the current specifications.

Clearly, such an analysis will not identify the 'optimal' level of inspection intensity as postulated by Roberts (1983). However, if an alternative system can be shown to improve the level of net benefits (in a human health context), then this suggests that the current level of inspection lies to the right of the optimum as defined in Figure 2.1. Furthermore, if it can be demonstrated that the current pigmeat inspection procedures are not removing significant health threats, this implies that consumers are under some misconception as to the benefits of meat inspection.

It is important to clarify the direction taken using this approach. The analysis will not reach a conclusion about the overall benefit-cost ratio of the current pigmeat inspection system. Rather, it will gauge the impact (in terms of benefits and costs) of making adjustments at the margin to the current procedures. This is based upon the premise that some procedures may not be providing human health benefits and, hence, can be discarded or modified without having an adverse effect on the overall human health benefits of the inspection system. If this is the case, it suggests that the current inspection system lies to the right of the theoretical optimum intensity level. This indicates an inefficient allocation of resources and the opportunity to redirect some resources to areas of meat inspection where more tangible benefit will be derived. It does not imply that the inspection system is producing no human health benefits, but rather that there is scope for increasing the net health benefits derived from meat inspection.

Moreover, this approach does not indicate the position of the current inspection system relative to the theoretical optimum in terms of total costs and benefits. Rather, it represents a partial analysis and only examines the desirability of the current inspection system in terms of the human health benefits which it provides. Benefits such as disease traceback information to producers and consumer confidence in the product are not examined. Inclusion of these benefits could alter the total cost and benefit functions such that the theoretical optimum inspection intensity is different than that based upon human health aspects alone.

The following chapter will review the pigmeat inspection process and discuss the human health hazards posed by diseases detected during meat inspection at the abattoir.

Chapter 3

PIGMEAT INSPECTION: DISEASES AND HUMAN HEALTH HAZARDS

3.1 Introduction

Prior to examining alternative pigmeat inspection procedures, it is important to obtain an understanding of the current inspection procedures, how they detect various disease conditions and the significance of those conditions.

Inspection of all livestock presented at the abattoir involves both ante-mortem and post-mortem inspection. Ante-mortem or pre-slaughter inspection is carried out by a veterinary officer or experienced meat inspector in the abattoir holding yards. The immediate purpose of ante-mortem inspection is to separate normal and abnormal stock. Normal animals are passed on to slaughter, while abnormal animals are classified as either unfit for slaughter, or affected with a local condition, or one which will be obvious at post-mortem inspection (Gracey 1981). Ante-mortem inspection of pigs usually detects conditions such as fever, damaged limbs, pigs unable to stand, or coughing indicative of severe pneumonia. Generally, very few pigs are rejected as a result of ante-mortem inspection (DPI Meat Inspector, pers. comm., 1986).

3.2 Post-mortem Inspection

The inspection procedures analysed in this study will concentrate on post-mortem pigmeat inspection, rather than ante-mortem inspection, since post-mortem inspection incurs far greater resource costs in terms of inspection staff requirements.

According to Gracey (1981), post-mortem examination detects and eliminates abnormalities, including contamination, ensuring that only meat fit for human consumption reaches the consumer. The process also allows checks to be made concerning the suitability of the slaughter and dressing procedure and provides information for disease control purposes. It is important to note that many conditions not evident at ante-mortem inspection are detected during post-mortem inspection. However, as will become evident later in the chapter, the human health hazard posed by most conditions in pigs is minimal. The removal of aesthetically displeasing lesions from the carcase has become a major role of the meat inspection services in Australia. Murray

(1985, p.7) has described this role as "one of ensuring wholesomeness measured in terms of acceptance of a particular product".

Post-mortem examination of pigs is carried out by inspectors placed at various positions along the slaughter chain. The slaughter chain refers to a rail from which pig carcases are suspended. Depending upon the sophistication of the abattoir, carcases move along the slaughter chain either through a mechanical (automated) movement of the chain, or by a gravity-fed system. Both slaughtermen and inspectors are placed at designated positions along the chain to carry out carcase evisceration and trimming and inspection of the carcase. A flow-diagram of a typical pig slaughter floor is shown in Figure 3.1.

Following stunning, bleeding and evisceration, the viscera are placed in separate pans on the viscera table, while the carcase (and usually the head) remain suspended from the slaughter chain. Each carcase and its viscera move in synchronisation such that symptoms of disease found in one area of the body may be cross-checked with other regions of the carcase. Inspection begins with an examination of the lymph nodes of the head by inspectors placed at the head inspection station. All carcase lymph nodes represent important sites in the immune system where disease symptoms often become localised. Lesions in the head can indicate conditions which may be found elsewhere in the carcase.

At the viscera station, inspectors examine the heart, liver, lungs and intestines, together with designated lymph nodes. Similarly at the carcase inspection station, designated carcase parts and lymph nodes are examined. A final general carcase hygiene check is then carried out towards the end of the slaughter chain. A detailed list of the particular inspection procedures performed routinely at each station is given in Table 3.1. Inspection staff loading standards are based upon chain speed and are given in Appendix C.

Where a carcase displays disease symptoms which are judged to be significant (either from an aesthetic or human health viewpoint), it is segregated from the main slaughter chain and placed on a retain rail for more detailed examination (often referred to as 'railing out' a carcase). Depending upon the severity of the disease lesions, the entire carcase, or part of the carcase may be condemned. This decision is generally made by the supervising veterinary officer, or a senior meat inspector. Often, the carcase will only require minor trimming to remove localised lesions. This is carried out by abattoir employees under veterinary or meat inspector supervision.

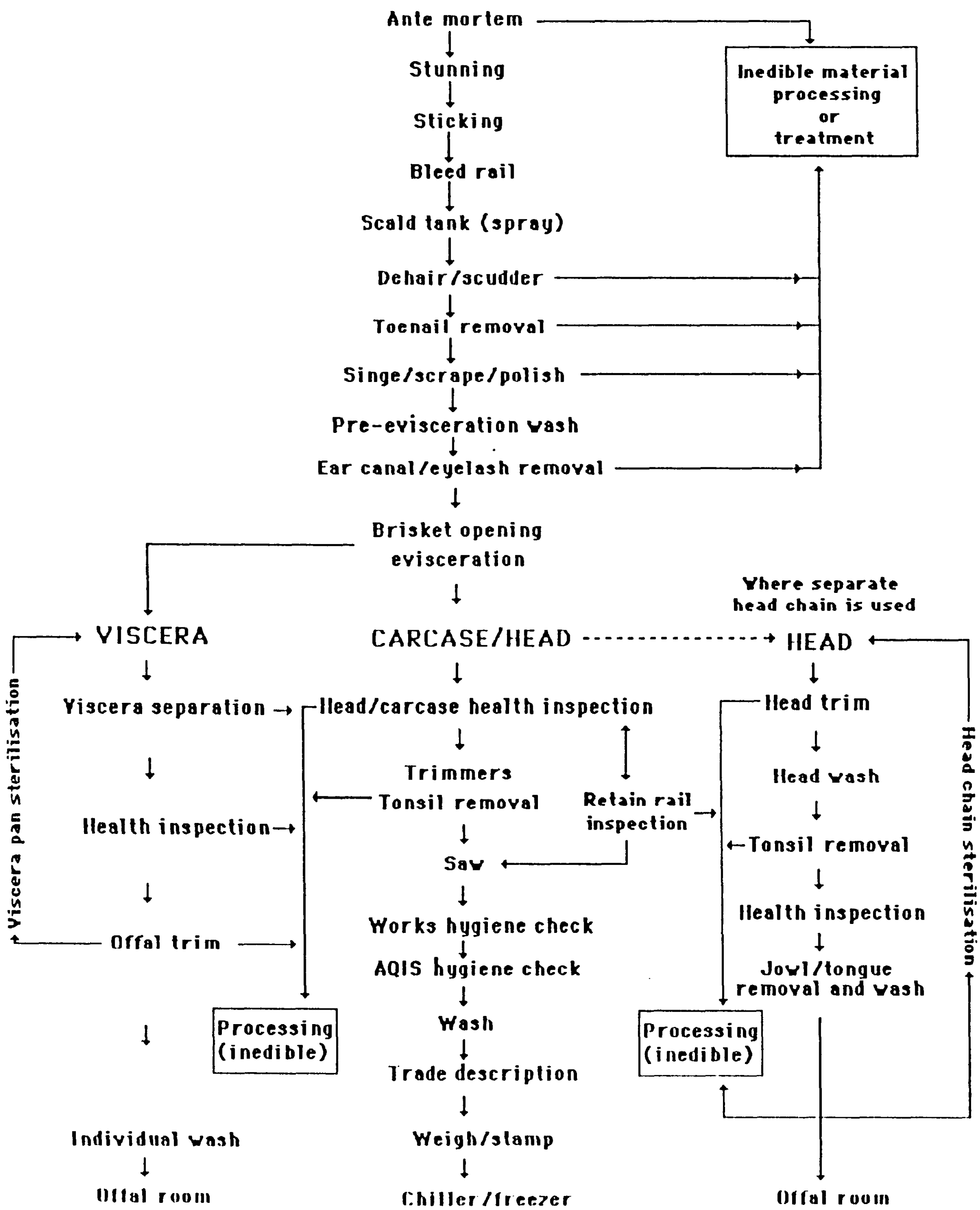


Figure 3.1. The Pig Slaughter Floor Process
Source: EIS (1985)

Table 3.1.

Minimum Procedures for Post-mortem Inspection of Pigs

Head
Observe head surfaces
Incise cervical and mandibular lymph nodes
Viscera
Observe and palpate lungs
Observe and palpate bronchial and mediastinal lymph nodes
Observe and palpate heart
Palpate liver
Observe portal lymph nodes, palpate and incise if necessary
Observe spleen, stomach and intestines
Observe and palpate kidneys
Carcase
Observe external and internal surfaces, including joints
Incise superficial inguinal lymph nodes and palpate iliac and lumbar lymph nodes.

Source : Murray (1985)

It is also standard procedure to obtain liver and fat samples from randomly selected carcases, to analyse in the laboratory for antibiotic and chemical residues. The Commonwealth sampling system tests for antibiotics, sulphonamides, chloramphanicol, heavy metals and pesticides. If a residue threshold is exceeded, the relevant State Department of Agriculture is notified who in turn initiates traceback to the property in question. State authorities may also conduct sampling programs though the procedures vary between the states (I. Stephens, pers. comm., 1986). Current residue sampling procedures are likely to undergo significant change following the recent residue problems in beef exported to the U.S. and Japan.

3.3 Diseases of the Pig Detected at Post-mortem Inspection

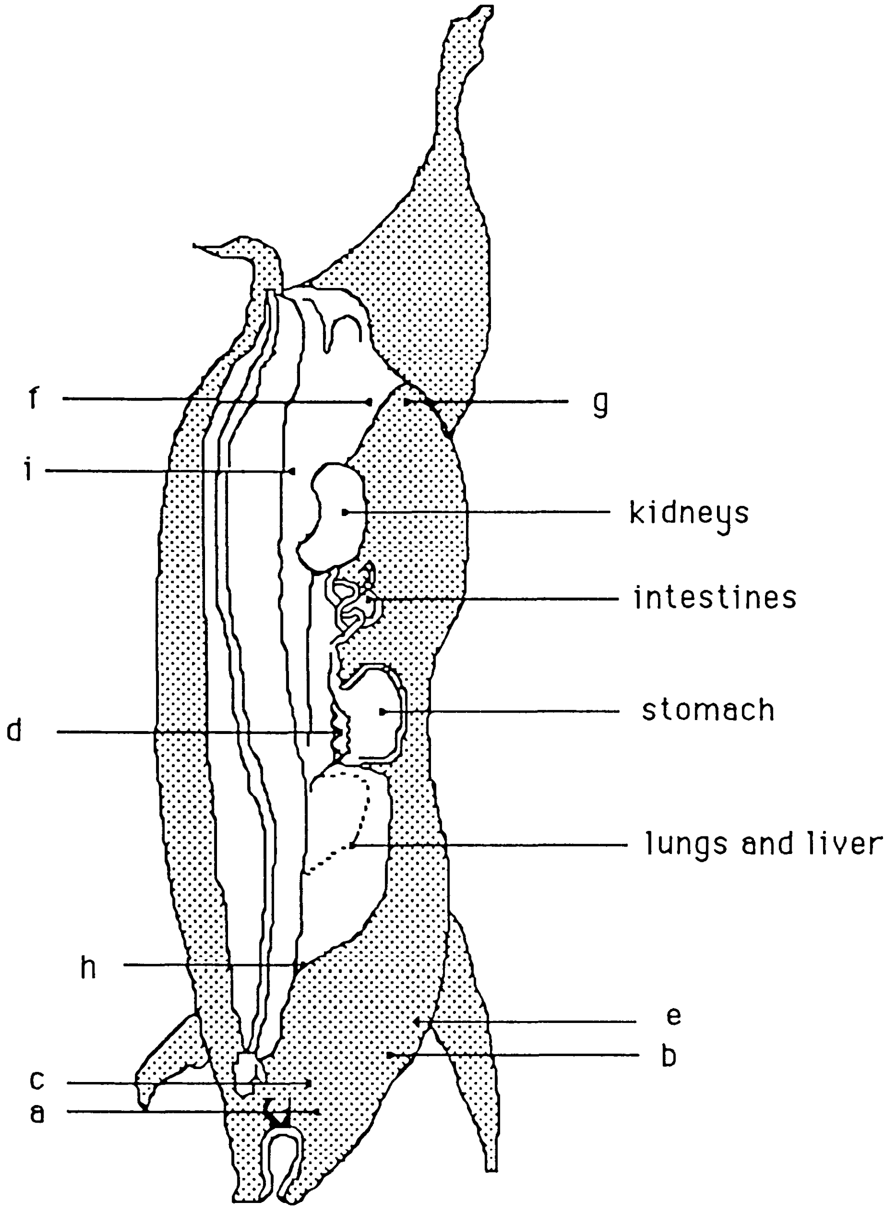
There are numerous disease conditions which may affect the pig. The following discussion reviews those diseases or conditions considered to be important by meat inspection authorities. Figure 3.2 illustrates the position of the various carcase regions mentioned in the following sections.

3.3.1 Tuberculosis (TB)

Scientifically, tuberculosis in mammals is now considered relevant to the causative organisms Mycobacterium bovis and M. tuberculosis only. The TB eradication scheme in cattle and improved public health schemes, means that the incidence of TB from these two sources is very low (Murray 1985).

A third category of organisms relevant to tuberculosis are classified as members of the Mycobacterium avium - intracellular scrofulaceum complex (MAIS complex). This group, referred to as the atypical mycobacteria's, is of particular significance to TB in pigs (G. Eamens, pers. comm. 1986).

Meat inspection literature often refers to tuberculosis in pigs, however, since the MAIS complex (in particular M. avium) is responsible for essentially all tubercular-type lesions in pigs (McMahon, Kahn, Batey, Murray, Moo and Sloan 1987), mycobacteriosis is a more accurate term. Lesions of mycobacteriosis seen at the abattoir are usually limited to lymph nodes of the pharyngeal and cervical regions and the mesentery, though lesions can be found in the bronchial, mediastinal and iliac lymph nodes. Disease identification through visual appraisal of lesions is further complicated by the existence of



a) Submaxillary (= mandibular) lymph nodes.
b) Cervical lymph nodes (ventral,dorsal and middle).
c) Pharangeal lymph nodes.
d) Mesenteric lymph nodes.
e) Mediastinal lymph nodes.
f) Iliac lymph nodes.
g) Superficial inguinal lymph node.
h) Bronchial lymph nodes.
i) Lumbar lymph nodes.

Figure 3.2. Significant Meat Inspection Sites in the Pig Carcase

Corynebacterium (= Rhodococcus) equi, which causes pseudo-tuberculosis and produces lesions similar to those caused by the mycobacterium organisms (Collins 1981).

3.3.2 Arthritis

This condition is usually recognised by the meat inspector as an enlargement of a leg joint. Cross and Edwards (1981) have also indicated that abnormality within the internal iliac lymph node may be a reliable indicator of arthritis in hindlimb joints, while incision and inspection of the ventral superficial cervical lymph nodes would give a good indication of forelimb arthritis. Occasionally, a generalised arthritic state (polyarthritis) may exist. The Victorian Animal Health Committee (1982) has defined stringent standards for dealing with porcine arthritis. Close inspection of suspected arthritic joints should be carried out on the retain rail. Total carcase condemnation should only occur where there are signs of septicaemia or emaciation. Where arthritic lesions are detected, the affected joint is condemned under appropriate supervision such that uncontaminated muscle can be saved.

The bacterial agent most frequently isolated from arthritic joints is Erysipelothrix rhusiopathiae, the organism responsible for the disease erysipelas in pigs (Archer and Gardner 1981). However, further arthriogenic agents in pigs cannot be ignored and these include Corynebacterium (= Streptococcus) pyogenes, Staphylococcus aureus, Haemophilus spp., Escherichia coli, Streptococcus spp., Salmonella spp. and Mycoplasma spp. (Turner 1982). In particular, Streptococcus suis should be regarded as a major causative organism. S. suis Type II may cause up to 50 per cent of polyarthritis in pigs in Australia (A. Pointon, pers. comm. 1986).

3.3.3. Abscesses/pyaemia

An abscess refers to a localised collection of pus circumscribed by fibrous tissue. Inflammation is chiefly caused by pyogenic organisms including Streptococcus spp., Staphylococcus aureus and S. albus, Corynebacterium (= Streptococcus) pyogenes, Pseudomonas aeruginosa and members of the E. coli group (Gracey 1981). Abscesses may occur at many sites on the carcase, or in lymph nodes, especially lymph nodes in the head. Partial carcase condemnations due to abscessation are common, though the condition rarely warrants total carcase condemnation (N.S.W. Department of Agriculture 1985).

Pyaemia refers to pyogenic organisms entering the bloodstream and dissipating to form numerous small lesions throughout the body. Pyaemia may manifest in the live animal as a high fever and constitutional disturbance (Gracey 1981). These pigs are noticably sick and are not presented for slaughter, or at least are detected at ante-mortem inspection. Hence, pyaemia is rarely seen at post-mortem inspection (T. Shannon, pers. comm. 1986).

One significant type of abscess which deserves mention is that indicative of the disease melioidosis, caused by the organism Pseudomonas pseudomallei. The disease is thought to be restricted to Queensland (Stevenson and Hughes 1980) and causes abscesses in the bronchial and mandibular lymph nodes, spleen and lungs. Infected pigs are often detected during post-mortem inspection (Ketterer, Webster, Shield, Arthur, Blackall and Thomas 1986).

3.3.4 Leptospirosis

In Australia, Leptospira interrogans serovar pomona and L. interrogans serovar tarrasovii are the most important leptospires causing leptospirosis in pigs (Cutler 1981). The condition is detected by meat inspectors via the presence of macroscopically visible grey-white spots in the kidneys which usually results in kidney condemnation (Jones, Millar, Chappel and Adler 1987).

3.3.5 Enzootic pneumonia and pleurisy/pericarditis/peritonitis (PPP)

Enzootic pneumonia is a mycoplasmal infection, caused by the organism Mycoplasma hyopneumoniae. Symptoms of the disease may be detected at ante-mortem inspection since the principal clinical sign is a chronic non-productive cough. Post-mortem examination may reveal the typical purple to grey lesions found in various lobes in the lungs (Ross 1981).

Pleurisy is evidence of bacterial infection within the thoracic cavity and causes adhesions (and lesions) between lobes of the lungs, or between lobes and the rib wall. Pleurisy commonly occurs as a secondary infection to pneumonia, but may also be found as a primary infection due to agents such as Haemophilus spp. or S. suis (Pointon, Farrell, Cargill and Heap 1987). Peritonitis results from the entry of organisms into the peritoneal cavity. Similarly pericarditis is an inflammation of the pericardium or heart sac (Collins 1981).

All four conditions often exist in association with one another and may lead to condemnation. PPP may cause septicaemia, observed by the meat inspector as widespread infection. However old chronic non-septic lesions may be trimmed and the remainder of the carcase passed for human consumption (Collins 1981).

3.3.6 Salmonellosis

There are numerous serotypes of Salmonella spp. which can be isolated from pig carcases. Gillespie and Timoney (1981) have suggested that S. choleraesuis and S. typhimurium are the most important serotypes causing disease in pigs. Disease symptoms are diverse, but pneumonia and diarrhoea are common. A recent Australian study has isolated S. derby, S. give, S. virchow, S. ohio, S. infantis and S. meleagridis from pig carcases at two abattoirs (Morgan, Krautil and Craven, 1987).

The important point to make however is that most healthy pigs harbour the organism and contamination cannot generally be detected by visual appraisal at the abattoir. Ante-mortem inspection may detect acute salmonellosis, but neither ante- nor post-mortem inspection will detect salmonellae carriers (Blackmore 1983).

3.3.7 Internal parasites

The two most common internal parasites found in pigs in Australia are the kidney worm (Stephanurus dentatus) and the large roundworm (Ascaris suum). Post-mortem symptoms associated with the kidney worm include adhesions of the peritoneum and mesentery to the abdominal walls due to burrowing larvae and extensive liver changes. Liver abscesses are common. The larvae mature in the fat surrounding the kidneys (Hungerford 1975). Even moderate infections may lead to rejection of carcases for export (Collins 1981).

Larvae of the roundworm penetrate the intestinal wall and are conveyed by the portal vein to the liver. Many larvae force their way through liver capillaries, giving rise to lesions on the liver surface seen at post-mortem inspection. Larvae passing through the liver enter the posterior vena cava to reach the heart and lungs. The passage of larvae through the lungs gives rise to symptoms of pneumonia. Affected livers are rejected as food, but may be used as by-products, or for pharmaceutical purposes (Gracey 1981).

3.4 Potential Human Health Hazard from Diseases of the Pig Detected During Meat Inspection Operations

It has been suggested that meat inspection procedures in many developed countries are out of touch with present day disease status and that the majority of gross lesions in individual carcases are not associated with public health hazards (Skovgaard 1981, cited by Blackmore 1983). In this section the current evidence concerning the human health threat posed by the diseases/conditions mentioned in Section 3.3. will be reviewed.

3.4.1 Tuberculosis

Available figures indicate that the incidence of TB in pigs in Australia is extremely low. A recent South Australian survey of 106 herds failed to detect the disease (Pointon et al. 1987), while the disease accounted for 0.04 per cent of partial condemnations and no total condemnations in N.S.W. abattoirs in 1985 (N.S.W. Department of Agriculture 1985). In spite of its low incidence, meat inspectors place heavy emphasis upon the incision of lymph nodes to search for tubercular lesions.

The MAIS complex is effectively responsible for all TB (or more correctly mycobacteriosis) in pigs in Australia. The human health threat from M. avium infection in pigs is highly questionable. Kleeburg (1975) has noted that M. avium infected pigs constitute no human health hazard, whether by contact with live pigs, or by eating infected meat. Similarly, Murray (1986) has stated that M. avium infection in pigs is not transmissible to humans. In N.S.W. in 1985, there were 60 human cases of bacteriologically positive atypical TB and of these some 42 were thought to be due to M. avium (N.S.W. Department of Health 1986). However, the likelihood of human gastrointestional infection through the ingestion of infected pigmeat is extremely low. Indeed, most of the cases in N.S.W. were glandular infections in children (R. Thomson, pers. comm. 1986).

3.4.2 Arthritis

The human health threat from porcine arthritis is difficult to gauge due to the array of organisms involved. As previously mentioned, E. rhusiopathiae is frequently isolated from arthritic joints. In Australia, 90 per cent of arthritis in pigs may be due to E. rhusiopathiae (G. Eamens, pers. comm. 1986). Cross and Edwards (1981) have found that inspectors miss a considerable number of arthritic joints in the forelimbs and since E.

rhusiopathiae resists curing and moderate heating, it seems probable that viable organisms reach the consumer. However no ill-effects of this have been documented.

E. rhusiopathiae infection in humans is known as erysipeloid and is typified by local skin lesions. Recent reports of human erysipeloid are rare in Australia, though this may not accurately reflect the true incidence. Ewing (1957) has suggested that man is resistant to the organism when it enters the alimentary tract. Nevertheless, meat inspectors, abattoir workers and butchers are at risk of infection through skin penetration.

Other organisms causing arthritis should not be overlooked. Streptococcus and Mycoplasma spp. may be found in arthritic joints, though the pathogenicity to humans of the serotypes involved is generally very low and they are susceptible to cooking (G. Eamens, pers. comm. 1986). The importance of S. suis as a zoonosis has been emphasised, however Pointon et al. (1987) were unable to culture the organism consistently from swollen joints sampled from a S.A. abattoir. They found that the majority of swollen joints were sterile. Robertson (1988) has reported that S. suis Type II can cause serious human disease, though cases are rare in western countries. Nevertheless, the high level of infection in apparently normal pigs is a health threat to meatworkers, though the risk of infection is small. The risk to consumers is considered to be even less.

3.4.3 Abscesses/pyaemia

Many organisms isolated from abscesses can cause foodborne infection in man following ingestion, or infection by inhalation or entry into open wounds in the case of organisms such as S. pyogenes (Starke 1985). The likelihood of infection is, however, signficantly influenced by cooking and preparation methods where viable organisms are present in the meat. Abscesses caused by P. pseudomallei (the organism responsible for melioidosis) do represent a human health risk. Ketterer et al. (1986) have indicated that those most susceptible to infection are meatworkers and inspectors. However, since most infections are localised in abscesses, inadvertent contact or aerosol transmission is much less likely than is the case with other human pathogens.

3.4.4 Leptospirosis

Leptospiral infection in pigs poses a signficant human health threat. Infection in humans occurs when leptospires penetrate small cuts or abrasions in the skin, mucosal surfaces or conjuntivae, following contact with infected urine (Swart, Wilks, Jackson and Hayman 1983). Wilks and Milner (1979) reported 22 confirmed cases of human leptospirosis in Victoria during 1978-79 caused by L. interrogans serovar pomona and L. interrogans serovar hardjo. In particular, in August 1978, three slaughterhouse workers at the Castle Bacon factory, Castlemaine contracted L. interrogans serovar pomona infections. Faine (1983) has estimated that one in four meat inspectors are likely to acquire leptospirosis as an occupational infection during a working lifetime of 30 years. Furthermore, only 10-20 per cent of laboratory diagnosed cases are notified, hence the true human incidence in Australia is considerably higher. In 1986 there were 179 notified cases of leptospirosis (Commonwealth Department of Health 1987).

It appears that abattoir workers/meat inspectors are at most risk of contracting leptospiral infections from pigs or pigs carcases. The risk to consumers is somewhat less, since the organism is destroyed by adequate cooking. Furthermore, many kidney lesions are thought to be non-infective (R. Chappel, pers. comm. 1986; Millar, Chappel and Adler 1988).

3.4.5 Enzootic pneumonia and PPP

As previously discussed, these conditions involve a variety of organisms. S. suis is considered to be the only significant zoonotic organism. Many of the lesions indicative of PPP which are detected by inspectors are sterile and represent healed tissue which is evidence of infection in early life. Unless these lesions are septicaemic, they do not represent a human health threat. Removal of such lesions is largely to enhance the aesthetic appeal of the carcase (A. Pointon, pers. comm. 1987).

3.4.6 Salmonellosis

Salmonella contamination represents an important human health hazard. Salmonella food poisoning is caused by the ingestion of a sufficient number of living Salmonella organisms (Curtin 1984). Inadequate meat preparation is the most important contributing factor in Salmonella poisoning outbreaks (Beckers 1982, cited by van

Schothorst 1986). During the period 1974-1984, Salmonella was responsible for ten incidents, representing more than 283 separate cases of food poisoning in Australia. However only one incident recorded was attributable to pork (Downer 1985). The Commonwealth Department of Health (1987) reported 2494 notified cases of Salmonella infection during 1986. However the true incidence is thought to be in the vicinity of 200 000 cases per year, though the number attributable to pig meat is unknown (J. Craven, pers. comm. 1987).

3.4.7 Internal parasites

Kidney worm infestation represents no human health threat (assuming no secondary infections are also present) and hence condemnation is largely for aesthetic reasons (J. Gardner, pers. comm. 1986). Although A. suum is anatomically and serologically indistinguishable from Ascaris in man, cross infection from pig to man or man to pig does not occur (Gracey 1981).

3.5 Conclusions

First, it is evident that a number of diseases found in pigs during slaughter represent a human health threat. The preceding discussion indicates that often the abattoir worker or meat inspector faces a greater risk of infection than the consumer. It is also evident that a number of conditions inspected for (e.g. TB, arthritis and internal parasites) may not represent a significant human health hazard. This fact has led to considerable questioning and criticism of the current inspection procedures, both in Australia and overseas (e.g. Blackmore 1983; Hathaway, McKenzie and Royal 1987; Murray 1985). It has been suggested that stringent inspection routines for individual carcases may be an inefficient method of providing safe meat. Moreover, reference to Appendix A indicates that Australian inspection procedures are often more intense than those in overseas countries. Second, the general hygiene of production systems is more likely to influence the safety and wholesomeness of the final product (Blackmore 1983). This indicates the possibility of transferring greater responsibility for meat hygiene to abattoir management and reducing the role of the Commonwealth (and State) inspection services in direct carcase inspection.

Chapter 4

RISK ASSESSMENT, INSPECTION INTENSITY AND THE DEVELOPMENT OF ALTERNATIVE PIGMEAT INSPECTION SYSTEMS

4.1 Introduction

The description of inspection intensity given in Chapter 2 can be augmented by including the probability of human infection from a diseased carcase. Inspection intensity can then be defined as the ability of a given procedure, or set of procedures, to detect and remove a potential human health hazard. As such, a direct link between inspection intensity and human health risk is established. Given such a definition, it is evident that the level of inspection intensity which applies to current pigmeat inspection procedures within Australia has not been identified, since no quantitative risk assessment has been applied to the current procedures. However, the Australian meat inspection system is not the only system facing this inadequacy. Starke (1985) has revealed that the U.S. Federal meat and poultry inspection system suffers from a similar lack of quantitative risk analysis.

In this chapter the concept of inspection intensity and its relationship with risk assessment is examined. A critical analysis of the U.S. and Australian inspection systems in relation to risk assessment will be undertaken. Following this, alternative levels of 'inspection intensity', will be developed for pigmeat inspection within Australia.

4.2 Risk Assessment in Meat Inspection

4.2.1 A definition of risk assessment

Although subject to debate, it can be argued that the perceived role of meat inspection services is to remove diseased carcases or carcase parts which may cause human infection. However, Australian inspection authorities have suggested that the removal of sources of human infection is indeed a minor role and the removal of aesthetically displeasing lesions now assumes a more important role for the meat inspector (Murray 1985; J. McMahon, pers. comm. 1987). Cost-benefit analysis represents an attempt to quantify elements of the decision-making process and, in the context of the present study, health risk assessment would appear to be a necessary element when considering the human health benefits of alternative pigmeat inspection procedures.

Estimation of risk assessment for meat inspection procedures involves four steps, as discussed by Starke (1985);

(a) Hazard identification. This is perceived as the first and most important step in risk assessment. With reference to pigmeat inspection, it is vital to know which diseases are important and which are trivial in terms of human health. It has been suggested in Chapter 3 that the hazard identification step may have been neglected under the Australian pigmeat inspection system (and indeed under the inspection systems of other nations). Disease conditions of little human health significance are investigated and there has been a tendency to define health objectives in terms of visible pathology, rather than in terms of the hazards represented by that pathology.

(b) Exposure assessment. This step involves the determination of the likely magnitudes of the hazards identified in step (a). This involves estimating how many people will be exposed to infective doses of pathogens found in pigmeat. This process is very complicated. Some of the factors which must be considered include the number of people consuming pigmeat, the sensitivity to infection of that population, the level of contamination present in the meat and meat preparation methods which may enhance or reduce the level of exposure. A statistical distribution of exposures must be estimated, since average exposures do not take into account members of the population who are very sensitive or highly exposed (Starke 1985).

(c) Hazard assessment. The third step involves estimating the outcomes of various exposure levels. This will involve conditional probabilities: if a human population receives a given statistical distribution of exposures, what is the probability of a certain human health outcome? This process implies a dose-response relationship. It defines the effects of exposing a human population to various levels of an identified risk, taking into consideration the distribution of exposure levels and the distribution of sensitivities to infection amongst the human population.

(d) Quantitative health risk assessment. This final step involves the integration and interpretation of the preceding three steps to estimate the consequences of exposure to a particular hazard under a given set of circumstances. Such a procedure would give a best estimate of risk, within statistical confidence limits and could be used to make decisions concerning alternative meat inspection procedures.

4.2.2 Risk assessment and the U.S. Meat and Poultry Inspection System

The study of the U.S. inspection system undertaken by Starke aimed to evaluate the usefulness of proposed new inspection systems. However, this was not possible, since there was no "comprehensive quantitative technical analyses of the hazards to human health of specific agents or of the benefits that would follow the adoption of new techniques" (Starke 1985, p.154). In essence, there was no basis upon which to judge the new procedures. No formal assessment of the risks existing before and the residual risks remaining after, the implementation of inspection procedures were available. Hence, it was not feasible to evaluate whether the new procedures would be beneficial to the public, or whether sufficient resources had been allocated to the new programs.

As a result, the study strongly recommended that a formal quantitative risk assessment be undertaken so that it could be revealed whether the public health risks justified the inspection effort and the resource cost. Although the assessment would require considerable time and resources, it appeared to be a worthwhile investment that may substantially improve the cost effectiveness of the inspection system.

4.2.3 Risk assessment and the Australian meat inspection procedures for pigmeat

Discussion in this section will be confined to the activities of the Commonwealth inspection system coordinated by the AQIS. Pigmeat inspection undertaken by the various State authorities is very similar to the Commonwealth system.

As with the U.S. system described above, the Australian meat inspection system suffers from a lack of quantitative risk assessment in terms of human health. The AQIS have tested new procedures, with the aim of eliminating inspection tasks which are not effective in detecting pathological conditions within the carcase. This has involved a statistical comparison of the ability of the current and revised procedures to detect pathological lesions within specified regions of the carcase. Where there was no significant difference between the current and revised procedures in the detection of lesions, the revised procedures may be viewed as a feasible alternative (see McMahon et al. 1987). In terms of quantitative risk assessment, this procedure may be inadequate. The statistical analysis examined conditions which were missed by the new procedures, but neglected to evaluate the human health risk associated with the missed pathology. This would appear to be the fundamental question which must be addressed.

The AQIS have argued that the removal of aesthetically displeasing lesions by meat inspectors is an important task and maintains consumer confidence in the product. While this is certainly true, the validity of this procedure being a function of meat inspectors is questionable. Blackmore (1983) has pointed out that this process could easily be undertaken by abattoir employees under veterinary supervision, since it represents a commercial concern for the processing company.

Murray (1985) has addressed the problem of aesthetics versus the human health threat and has posed the question as to where priorities should lie between those areas. Furthermore, he has acknowledged that there exists no absolute standard of acceptable levels for lesion removal and as such, the standard becomes the current procedure (i.e., lesion removal at the discretion of the supervising veterinary officer or senior meat inspector). This again implies a lack of any quantitative risk assessment. Moreover, Murray agreed that a major role of the inspection services has become one of enhancing the aesthetic appeal of the carcase and suggested that individual carcase inspection be reviewed. Meat workers could remove defects under veterinary supervision given that conditions conducive to such a practice can be defined, the likely effectiveness of such a process can be gauged and a satisfactory level of inspection staff supervision can be established.

Hathaway and McKenzie (1987) have investigated quantitative risk assessment as it applies to the New Zealand meat inspection service. However, their perception of 'risk' was extended beyond risk to human health, to include the risk of losing market access. As such, elements including public health risks, animal health risks and aesthetic risks were mentioned. The study developed a method to model a quantitative risk assessment for ovine liver fluke (Fasciola hepatica) which represents an aesthetic rather than a health risk to consumers.

The important finding in the Hathaway and McKenzie study was that, unless accuracy data in terms of sensitivity and specificity are produced, quantitative risk assessments which compare alternative inspection procedures are statistically invalid.

Sensitivity refers to the probability of an infected carcase being detected and is calculated as:

$$\text{Sensitivity} = \frac{\text{Number of infected carcases detected}}{\text{Total number of infected carcases}}$$

Specificity refers to the probability of non-infected carcases being classified as non-infected and is calculated as:

$$\text{Specificity} = \frac{\text{Number of carcases classified as non-infected}}{\text{Total number of non-infected carcases}}$$

Two inspection methods (designated A and B) were investigated. It was evident that superficial analysis of the raw data suggested that (although not statistically significant, $P > 0.05$) inspection method A was better than method B in terms of the apparent prevalence of liver fluke in the sheep livers. However this superficial analysis was misleading and the use of accuracy data revealed that method B was more sensitive than method A, since method A had a lower sensitivity and thus detected less truly-infected livers. Method A also had lower specificity and thus produced more false positives. This can lead to unnecessary wastage of acceptable carcase parts (see Appendix B for detailed results of this trial).

Comparative trials carried out by the AQIS to examine current and revised post-mortem inspection procedures (e.g. McMahon et al. 1987) show no evidence of the collation of accuracy data and as such, given the definition described by Hathaway and McKenzie (1987) do not represent true quantitative risk assessments. In addition, no mention has been made of the human health risk status of alternative inspection procedures examined by the AQIS. As detailed by Starke (1985), only after a thorough quantitative health risk assessment will it be possible to know whether the relative allocation of resources to pigmeat inspection is reasonable in comparison to resources devoted to areas such as chemical residue monitoring and disease traceback procedures.

4.3 The Rationale for Examining Alternative Inspection Intensity Levels for Australian Pigmeat

Given the evidence in Chapter 3 and in the preceding sections, that the human health benefits of some pigmeat inspection procedures may be low, it appears feasible to examine alternative inspection systems which represent a lower resource cost in terms of their contribution to the protection of public health. For the purpose of this study, these lower cost alternative systems may be described as 'less intense' inspection systems in as much as they will involve a more superficial examination of the bulk of 'normal' pig carcases encountered on the slaughter chain. However, in terms of the definition of inspection intensity given in Section 4.1 (the ability of an inspection procedure to remove a potential human health hazard), this is not strictly correct. Since no quantitative risk assessment of the current, or any alternative procedures has been undertaken, it is difficult to gauge the impact of the proposed new 'lower intensity' procedures upon human health. Hence, the less intense procedures outlined later in this chapter describe the intensity of carcase examination, rather than the intensity of hazard removal. It is envisaged that the intensity of human health hazard detection under each system will be revealed through the estimates of a panel of experts via the Delphi technique (see Chapter 5). The methods used in this study however will not follow the rigorous approach of Starke (1985) outlined in Section 4.2.1. In particular, Starke's definition of quantitative risk assessment involved the preparation of statistical distributions for hazard exposure levels and human health outcomes. In this study a simpler approach based upon average human exposure levels and average probabilities of human infection from such exposures will be adopted. It is acknowledged that this represents a 'second-best' method.

As mentioned previously, 'inspection intensity' in the context of this study refers to the ability of the inspection system to detect a diseased carcase at post-mortem inspection. As explained in Chapter 2, the probability of a diseased carcase escaping detection can be linked with the probability of a diseased carcase causing human infection to give an estimate of the human health risk associated with each inspection system. It is important to note that the alternative systems examined only refer to post-mortem inspection. Ante-mortem inspection procedures will remain as is.

Defect (or lesion) removal is perceived as an important function of inspection staff, which will be taken into consideration when devising the alternative inspection procedures to be investigated in the study. Nevertheless, it should be noted that some members of the pig industry are of the opinion that enhancing the aesthetic appeal of the carcase could be carried out by meatworks' employees, or even by butchers, resulting in considerable inspection staff cost savings. Clearly, if inspection staff did not remove such defects, it would be in the interest of butchers to do so to ensure customer satisfaction. Butchers, especially those working for large supermarket networks, already carry out substantial trimming of meat in addition to that which occurs at the abattoir.

Furthermore, the AQIS has defended the current procedure of incising the cervical lymph nodes in pig heads with the assertion that large pus-filled abscesses, which would cause gross contamination of head-meats, are discovered through this process. However there is some doubt concerning the number of pig heads used for human consumption. Moreover, it is not clear that carcase lymph nodes are present in the normal cuts of pork sold to consumers in Australia.

Discussion with the Product Description Manager of the Australian Meat and Livestock Corporation (AMLC) has revealed that the cervical and mandibular lymph nodes will not appear in cuts of pork, but rather may be included in pigmeat sold as smallgoods or as a canned product. These lymph nodes may appear in jowl meat which is salvaged from pig heads, however, the use of jowl meat in smallgoods is limited for a number of reasons. First, not all pig heads are used to manufacture edible products. Many are put in a digester and rendered down to produce meat meal. Second, jowl meat often has a high fat content which is unacceptable for smallgoods. As a result, any jowl meat used is likely to come from younger, leaner pigs (P. Connell, pers. comm. 1987). The incidence of carcase pathology, such as lymph node abscesses, is lower in younger pigs.

The incision of other lymph nodes may also be questionable. The superficial inguinal lymph node may appear in ham or leg cuts of pigmeat, depending upon the trimming process used. However, in general, these lymph nodes are trimmed out since they are located in a fat depot in the crotch region of the carcase. Similarly, the iliac and lumbar lymph nodes are generally removed as they are taken out of the carcase in conjunction with the 'tender loin' (psoas muscle).

Based upon this information, it is apparent that the possibility of lymph node material reaching the consumer is substantially reduced by the various trimming processes which occur. Lymph node material from the head region is most likely to reach the consumer via smallgoods or canned products.

4.4 Alternative Pigmeat Inspection Systems

Three alternative inspection systems will be examined in this study. In coherence with the original hypothesis that too many resources are being devoted to the detection of zoonotic conditions in pigs, these alternatives will represent reduced levels of inspection intensity. Two of the alternative systems involve the omission of various procedures from the current inspection system which relate to the detection of conditions no longer considered a human health threat. The third alternative is based upon a suggestion by Roger Meischke and involves the replacement of on-line meat inspectors with suitably qualified veterinary officers. Marginal net benefit changes associated with each alternative will be calculated, using the current system as a base level of costs and benefits. Estimates of the human health threat posed by various diseases which are required to derive benefit values will be elicited from expert opinion via the Delphi method as explained in Chapter 5. These estimates will also be used to give an indication of which diseases are relevant in terms of human health and, hence which procedures can be omitted to provide the first two alternative procedures mentioned above.

The following sections outline the current and proposed alternative pigmeat inspection systems in detail. Comments will be made concerning the method and likely effectiveness of disease detection under each system and the implications for human health. A detailed analysis of important disease conditions in pigs was given in Chapter 3. This will be re-emphasised in terms of the specific inspection procedures used to detect these conditions. Table 4.1 has also been constructed to provide a brief summary of the important zoonoses found in pigs, including their potential threat to human health and the effectiveness of their detection under the current inspection procedures.

It is important to keep in perspective any comparison between the current and proposed alternative inspection systems. Although the alternative proposals represent a reduced level in inspection intensity, discussion in Chapter 3 and the information in Table 4.1 indicate that the current procedures do not identify positively all disease conditions in a pig carcase. Indeed, positive identification of all conditions would require detailed and costly laboratory analysis (see Table 4.1). The greatest difference between the current and proposed alternative systems is likely to be in their ability to detect visible pathology and the impact of this pathology upon human health.

4.4.1 Description and analysis of the current procedures for pigmeat inspection

Basic current procedures for pigmeat inspection are given in Table 3.1. Additional inspection procedures may also be required by various importing countries, however these are not examined in the present study. The rationale for the basic current procedures is as follows;

(a) Head Inspection:

(i) Observation of head surfaces - this procedure may detect external abscesses, or possibly dirt or faecal contamination of the head. Severe

Table 4.1

Zoonoses in Pigs - Human Health Significance and Detection Procedures

Zoonosis	Causal Agent	Mode of Infection to Humans	Method of Detection Under Current Pigmeat Inspection Procedures	Requirements for Positive Diagnosis of Infection in Pigs	Human Health Hazard
Leptospirosis	Leptospira interrogans serovar pomona and L. interrogans serovar tarrasovii	Leptospires penetrate cuts or abrasions in the skin, mucosal surfaces or conjunctivae, following contact with infected urine.	Detected via the presence of numerous grey-white foci in the kidneys (nephritis). Evidence suggests this method is not entirely accurate. Some lesions may be evidence of past infection, while some infected pigs do not show kidney lesions.	Serum agglutination test.	Important occupational disease in Australia. Meat inspectors and abattoir workers are very susceptible to infection. It is estimated one in four meat inspectors will acquire the disease as an occupational infection during a working lifetime of 30 years.
Erysipeloid	Erysipelothrix rhusiopathiae	Contact with organism which infects via cuts and abrasions. The organism is found in infected pig carcase joints, tonsils or intestines. Faeces and urine may also be infectious.	Infection in pigs may present as : i) Swollen joints (arthritis) - other organisms can also produce this symptom e.g. Streptococcus, Mycoplasma and Salmonella spp. ii) Skin lesions (Diamond skin disease) - usually detected and segregated at ante-mortem inspection. iii) Vegetative endocarditis (chronic form) - seen as degeneration of heart valves, but unlikely to be detected via heart palpation alone. iv) Lymph nodes may be enlarged and discoloured around infection site in acute cases. Detection very subjective. Swollen joints often missed or infected joints may not exhibit swelling.	Bacteriological culture is the most reliable method.	Infection through the skin causes local skin lesions, however documented cases are rare. Man is resistant to the organism through the alimentary route.
Salmonellosis	Salmonella spp. in particular S. choleraesuis, S. typhimurium and S. derby	Ingestion or contact with an infective dose of Salmonella organisms.	Chronic cases may show enlargement of the mesenteric lymph nodes, cervical and bronchial lymph nodes and/or ulceration of the stomach and intestines. Many healthy pigs harbour the organism and show no symptoms that will be detected macroscopically. Most cases of Salmonella contamination are not detected by current procedures.	Bacteriological culture.	Important disease in humans, commonly causing acute gastro-enteritis. Abattoir hygiene and meat preparation and cooking procedures greatly influence the number of organisms found in pigmeat.

Table 4.1 continued

Streptococcal infection	Streptococcus spp. in particular S. suis Type II	Ingestion or contact with an infective dose of Streptococcus organisms.	Can cause arthritic symptoms or septicaemia, but most infections are subclinical and cannot be detected via macroscopic examination at the abattoir.	Bacteriological culture.	S. suis Type II can cause serious infection in humans, however human disease is rarely reported in western countries. Risk of infection in meatworkers is small, and in consumers even smaller.
Tuberculosis	Organisms belong to the Mycobacterium avium-intracellulare-scrofulaceum (MAIS) complex, especially M. avium	Inhalation possibly. Pigs are not generally considered to be a source of human infection. Most human infections are considered to be environmental in origin.	Detected via lesions in the head/neck and digestive tract. M. avium lesions are usually local and confined to the lymph nodes of the digestive tract, particularly the mesenteric lymph nodes.	Bacteriological culture or pathogenesis for experimental animals.	Risk of human gastrointestinal infection through the ingestion of infected pigmeat is thought to be zero. Mycobacterial infection in pigs represents a minimal human health hazard.
Melioidosis	Pseudomanas pseudomallei	Infection through skin cuts and abrasions is the most likely mode of transmission from pigs to man.	Generally seen as abscesses containing thick green pus in tonsils, submaxillary lymph nodes, liver, spleen and lungs. The lungs, bronchial lymph nodes and spleen appear to be the most common sites of abscesses.	Serum agglutination, complement fixation tests and bacteriological cultures.	Can cause serious, sometimes fatal disease in humans. Infections are almost always localised in abscesses in pigs hence risk of infection through inadvertent contact or aerosol transmission is very low. Most human infections are via contaminated soil/water rather than contact with infected pigs.

snout distortion or obvious nasal discharge will provide evidence of atrophic rhinitis infection, however this condition has no zoonotic significance (A. Pointon, per. comm. 1986).

(ii) Incision of cervical and mandibular (= sub-maxillary) lymph nodes - these procedures are most important for the detection of abscesses. Arthur (1981) has reported that 97 per cent of lesions found in porcine lymph nodes were abscesses, many of these being found in the cervical and sub-maxillary lymph nodes. As discussed in Chapter 3, the human health significance of these abscesses is open to question, although definite health threats do exist.

Other factors warrant mention when examining these procedures. First, discussion with some veterinarians who have a knowledge of meat inspection (e.g. R. Meischke, per. comm. 1987) suggests that incision of these lymph nodes may actually spread pus contamination to other areas of the carcase, unless great care is taken with knife sterilisation. However this risk may be countered by the argument that unless such incisions are made, abscesses in the lymph nodes may be missed. Again, this poses the questions of whether these lymph nodes appear in cuts of meat sold to consumers? What proportion of heads are actually used for human consumption? (it appears many are rendered down for meat meal) and would butchers trim out any undetected abscesses?

Lesions indicative of porcine tuberculosis may also be found in these lymph nodes, however the negligible health significance of such lesions was outlined in Chapter 3.

(b) Viscera Inspection

(i) Observation and palpation of the lungs - principally detects the lesions of pneumonia in pigs, together with the associated condition pleurisy. These conditions may initially begin as enzootic pneumonia, caused by the organism Mycoplasma hyopneumoniae and be followed by secondary pneumonial infections. These secondary infections can be caused by a variety of organisms including Salmonella spp, Pasteurella suiseptica, Haemophilus spp., Bordetella bronchiseptica and various streptococci and staphylococci organisms (Hungerford 1975). Pneumonic lesions are readily detected by visual observation of the lungs (Ross 1981).

Pleurisy as a secondary infection to pneumonia is commonly caused by Pasteurella multocida. Where pleurisy is present as a primary infection, it is generally caused by Streptococus suis, Haemophilus parasuis or Mycoplasma hyorhinis. S. suis is the only significant zoonotic organism amongst the group, however any obvious septicaemic condition will be trimmed out largely from an aesthetic viewpoint.

Lesions indicative of melioidosis or parasite infestation may also be seen in the lungs. The human health significance of these conditions has been discussed previously in Chapter 3.

(ii) Observation and palpation of the bronchial and mediastinal lymph nodes - these nodes are primarily examined to check for the lesions of tuberculosis, the low human health significance of which has been mentioned.

(iii) Observation and palpation of the heart - may detect pericarditis (inflammation of the pericardium), however the condition usually occurs in conjunction with pleurisy and pneumonia (MacFarlane 1984). Endocarditis (damage to the heart valves) as a symptom of erysipelas may also be seen, however this form of the disease is uncommon (Archer and Gardner 1981). Other than visibly obvious septicaemia of the pericardium, the chances of significant human pathology in this region of the carcase are minimal.

(iv) Palpation of the liver - may reveal parasite infestations by Stephanurus dentatus or Ascaris suum leading to liver condemnations on aesthetic grounds. These parasites are not a human health threat. The procedure may also detect lesions of melioidosis, the significance of which has been mentioned.

(v) Observe portal lymph nodes, palpate and incise if necessary - gives an indication of liver infections, such as secondary infection following parasite damage. It is unlikely to give any information additional to liver palpation.

(vi) Observe spleen, stomach, intestines - generally reveals parasitic infestation or damage, resulting in condemnations on aesthetic grounds. Abscesses indicative of melioidosis may also be found in the spleen.

(vii) Observe mesenteric lymph node - a common site of tuberculosis lesions, especially M. avium infection. This lymph node was incised under the old procedures, however the practice was discontinued due to the risk of spreading Salmonella.

(viii) Observe and palpate kidneys - an important visual check for lesions indicative of Leptospirosis infection. In terms of human health threat, it is abattoir workers and meat inspectors who are at risk of infection through contact with urine containing leptospires (L. interrogans serovar pomana in particular). The significance of this disease as an occupational hazard was discussed in Chapter 3 and is further detailed in Table 4.1. Leptospirosis probably represents the most significant human health threat from pig carcases. Further, it should be noted that the presence of 'white spotting' on kidneys does not necessarily indicate current leptospiral infection. Millar, Chappel and Adler (1987) have suggested that pigs displaying such lesions may be over the infection, while pigs without these lesions may still be carriers of the disease.

(c) Carcase Inspection

(i) Observe external and internal surfaces including joints - Observation of the external surfaces of the carcase will reveal obvious defects such as external wounds/abscesses and dirt or faecal contamination. Observation of the internal surfaces may also reveal abscesses and, in the case of the thoracic and abdominal cavity, is likely to reveal lesions associated with pleurisy, peritonitis and pneumonia.

Examination of the joints is primarily to detect arthritis. The doubtful human health threat posed by E. rhusiopathiae infection was discussed in Chapter 3, however other organisms which cause arthritis were also mentioned (Corynebacterium pyogenes, Staphylococcus aureus, Haemophilus spp., E. coli, Salmonella spp. and Mycoplasma spp.). In particular, Streptococcus suis Type II may be responsible for up to 50 per cent of polyarthritis in pigs in Australia (A. Pointon, pers. comm. 1986).

(ii) Incise superficial inguinal lymph nodes and palpate iliac and lumbar lymph nodes - examination of these lymph nodes may reveal lesions indicative of a wide range of conditions including tuberculosis, arthritis and abscesses due to a variety of causes.

4.4.2 Alternative pigmeat inspection systems A and B

Table 4.2 gives the procedures for the current system and for alternative systems A and B. In the following section , alternative systems A and B will be described and any problems with their effectiveness discussed.

(a) Inspection system A

Based upon the results of the Delphi (see Chapter 5), it is apparent that tuberculosis, streptococcal infection and melioidosis in pigmeat or live pigs represent a minimal human health threat. As such, the following procedures have been deleted from the current inspection routine;

Procedures relating to TB:

- incise cervical and mandibular lymph nodes;
- observe and palpate bronchial and mediastinal lymph nodes;
- observe mesenteric lymph nodes;
- incise superficial inguinal lymph nodes; and
- palpate iliac and lumbar lymph nodes.

Procedures relating to streptococcal infection:

- incise cervical and mandibular lymph nodes; and
- incise superficial inguinal lymph nodes.

Procedures relating to melioidosis:

- incise cervical and mandibular lymph nodes;
- observe and palpate lungs;
- observe and palpate bronchial and mediastinal lymph nodes;
- observe spleen, stomach and intestines; and

Table 4.2

Current and Alternative Pigmeat Inspection Systems

Current System	Alternative System A	Alternative System B
Head	Head	Head
Observe head surfaces Incise cervical and mandibular lymph nodes	Observe head surfaces	Observe head surfaces
Viscera	Viscera	Viscera
Observe and palpate lungs Observe and palpate bronchial and mediastinal lymph nodes Observe and palpate heart Palpate liver Observe portal lymph nodes, palpate and incise if necessary Observe mesenteric lymph nodes Observe and palpate kidneys	Observe and palpate heart Observe and palpate kidneys	Observe and palpate kidneys
Carcase	Carcase	Carcase
Observe external and internal surfaces including joints Incise superficial inguinal lymph nodes and palpate iliac and lumbar lymph nodes	Observe external and internal surfaces including joints Incise superficial inguinal lymph nodes and palpate iliac and lumbar lymph nodes	Observe internal and external surfaces including joints

- palpate liver, obsėrve portal lymph node and incise if necessary.

The main problem perceived under this system is the increased chance of non-detection of abscesses in lymph nodes that are not incised or palpated. As discussed in Chapter 3, this is probably more of an aesthetic risk rather than a health risk to the consumer. Moreover, as discussed in Section 4.3, many of these abscesses may not appear in cuts sold to consumers and those that would are likely to be trimmed out by butchers.

(b) Inspection system B

The results of the Delphi also indicate that the human health threat posed by erysipelas in pigs is minimal. System B therefore consists of the current procedures, minus the procedures outlined above for system A and minus procedures specifically related to the detection of erysipelas which are:

- observation and palpation of the heart; and
- incision of the superficial inguinal lymph node.

The observation of carcase leg joints is also a procedure designated to detect erysipelas which appears in the arthritic form. This procedure will remain since the external and internal surfaces of the carcase must still be examined and joint observation can readily be carried out during this operation. As with system A, the main problem posed by system B is the possibly of abscess non-detection in lymph nodes.

4.4.3 Alternative pigmeat inspection system C

System C involves a quite radical alternative to the current system and systems A and B. It involves the replacement of meat inspectors with a suitably trained veterinary officer. The system has been based upon a proposal by Roger Meischke, a veterinary surgeon who has had experience working in the meat inspection services. The rationale for the system is as follows.

Changes in the pig industry over past decades have led to an emphasis on intensive production, accompanied by a greater concentration on animal health. This has included a greater awareness of disease conditions found in pigs, the use of closed herds and quarantine procedures to restrict disease spread and the introduction of pig health monitoring schemes to notify producers of disease problems in their herds. Preventative medicine has become a feature of most intensive piggeries. Substantial amounts are invested in the control of diseases via vaccination and treatment of infections/infestations (for example erysipelas and leptospirosis vaccination). In addition, many resources have been devoted to the eradication of diseases endemic in food animals (tuberculosis and brucellosis are examples).

Given this background, Meischke has suggested that it should be possible to provide a streamlined inspection service which utilises on-farm disease information. System C is based on this premise. The on-farm disease information is provided as a health certificate, signed by a veterinary practitioner or company veterinarian testifying to the health of the pigs (clearly, there would be the need for a procedure to check the validity of these certificates). This system would mean that consignments of pigs arriving at the abattoir would be of three possible classes; known health status - good health, known health status - poor health or some specific problem, or unknown health status.

Runs of pigs with a known good health status would require little more than an oversight, allowing the veterinarian at the abattoir to concentrate upon those consignments with unknown or poor health histories. Charging for inspection could then be set to reflect the amount of effort required for inspection. Those segments of the industry with good veterinary input at the farm level would thus benefit from reduced meat inspection charges, while those whose pigs have a suspect or unknown health status would pay higher charges.

Rather than following a routine of incisions, palpations and observations, the level of inspection for each group of pigs is decided upon by the veterinarian, based upon the animals' health status. Pigs of unknown health status would require a level of investigation based upon the judgment of the veterinarian, taking into account local disease histories and local disease problems. Hence, inspection for these pigs may be a general examination of all major organ systems (urogenital, respiratory, gastrointestinal systems and the internal and external surfaces of the carcase), or concentration on a particular organ system when pigs are deemed to be at risk from a particular condition. When necessary, full inspection is carried out on the retain rail in the case of individual animals and on the chain for groups of animals.

Pigs with a known health problem would undergo the necessary inspection procedures to detect that condition, yet otherwise would simply receive an overall visual appraisal. Pigs with a certificate indicating no specific health problems would receive simply an overall visual appraisal by the veterinarian.

It is envisaged that the system would require two tags. A 'suspect' tag which is applied to individual carcases on the slaughter chain by the veterinarian, indicating the carcase must be railed out for detailed examination. A 'condemned' tag would then be used for carcases unsuitable for human consumption.

The veterinarian would be responsible for checking carcases on the retain rail, as well as on the slaughter chain. In works where a large proportion of the kill was from small producers with lower levels of veterinary input on-farm, one or two meat inspectors would be required to assist checking carcases on the retain rail. Visible pathology would be removed by plant employees who are experienced in this task. Where there are doubts, these trimmers would consult the veterinarian or meat inspector. Inspection of viscera in the viscera trays would be undertaken by veterinarians/meat inspectors only where there was an indication for it. It is important to realise that although the viscera may provide important disease traceback information to the producer, in terms of conditions which are of human health significance, the viscera is unimportant. The obvious exception is leptospirosis in the kidneys, however, with the current slaughtering method, the kidneys remain in the carcase.

Given the above procedures, it is estimated that 75 per cent of meat inspectors would be replaced. One veterinarian could cope with a chainspeed of 120 pigs per hour, given that animals were largely of a good health status (R.Meischke, pers. comm. 1988).

System C involves a considerable reduction in inspection intensity, based upon the minimal public health threat posed by the bulk of pathology seen in pigs and the low incidence of recognised zoonoses in pigs. The system leaves the task of enhancing the aesthetic appeal of the carcase to trimmers and butchers. It is assumed that a trained veterinary officer can recognise an obvious human health threat and act to remove it with the same efficiency as a group of inspectors performing a set of routine procedures. It is argued that this system could make better use of the veterinarians skills than is currently the case. In particular 'professional judgement' is a skill which could be drawn upon - epidemiology, pathology, microbiology and parisitology all contribute, but so does local knowledge and good relations with private practitioners and local and state authorities. Combining these factors, a veterinarian using professional judgement will decide upon the level of intensity with which to inspect each carcase or group of carcases.

The development of the above alternative inspection systems does not adhere strictly to the principal of quantitative risk assessment, since a detailed risk assessment has not been performed. The analysis does, however, take into account the the probability of human infection from pig zoonoses, based upon expert opinion. The alternative systems are aimed at removing or streamlining procedures which are no longer deemed to contribute to public health protection. Each alternative still embodies basic inspection procedures which are judjed to have a significant impact upon the elimination of human health hazards from pigmeat.