Diseases and pests

University of Reading
Department of Agriculture

AN ECONOMIC EVALUATION OF THE SWINE FEVER ERADICATION PROGRAMME IN GREAT BRITAIN

Using cost–benefit analysis techniques

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Study No. 11, 1972

Price £1·25

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This study was carried out under a research grant from:

THE WELLCOME TRUST

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FOREWORD

The author is deeply indebted to the Directors and staff of the Animal Health Division and the Central Veterinary Laboratory of the Ministry of Agriculture, Fisheries and Food, (MAFF) without whose help this study would not have been possible. In particular he wishes to thank Mr. E. Lowes for the many hours he devoted to securing information and providing technical guidance and Mr. W.G. Parkinson, Mr. A.D. Campbell, Mr. E.W. Russell, Mr. E.C. Hulse, Dr. J.T. Done, and Mr. P. Stuart who also gave so freely of their time and experience.

The author's grateful thanks are also due to Mr. K. E. Hunt, Director of the Agricultural Economics Institute, Oxford University, for encouragement and help throughout the study; to Mr. M.F. G. Scott of Nuffield College, Oxford for advice on project analysis techniques and to Dr. A. Power of the Food Economics Unit of MAFF for helpful criticism; to the staff of the Meat and Livestock Commission at Bletchley and in the field, for help in securing information, and to farmers in various parts of the country for reports on the effects of swine fever before eradication commenced.

Special mention must be made too of the help, and encouragement received from colleagues at Reading University, among them Professor J. C. Bowman, Mr. P. J. Charlton, Dr. J. Pearce and Mr. R. S. Morris. The help of Mr. J. O'Connor, student of Agricultural Economics, who assisted with data extraction and analysis, and Mrs. P. Lacey who painstakingly typed drafts of this report, was also much appreciated.

The list of other individuals and organisations that made valuable contributions to this study is too long to include in full. However, the author feels sure that they all know already how much their help was appreciated.

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SUMMARY

This study combines an economic assessment of the swine fever eradication programme in Great Britain, with an examination of techniques and information sources needed for such evaluations. It is hoped that readers overseas, as well as in Britain, will find it useful.

The author's approach was to define the characteristics and effects of the eradication programme (A), carried out between 1963 and 1966, and an alternative programme (B) based on the continuation of the control measures in force in 1962. The period for which benefits were determined was 1963 to 1975. Each programme was broken down into a series of components and a detailed analysis was made of each : field activities, laboratory work, head office supervision, miscellaneous expenses, vaccination and compensation for animals slaughtered.

The numbers of swine fever outbreaks that could have been expected in association with Programme B were projected on the basis of available epidemological evidence. Two assumptions were made. The first, and best supported, of these projected a further rise in incidence, beyond the 1962 peak, before a decline commenced. The second indicated a minimum level, based on decline in total numbers of outbreaks from 1962 onwards. Losses due to mortality were costed with the aid of statistical records, and simple mathematical models of pig herds were used to assess the effects of the disease, and Programme B, on farm income.

The costs of Programme A were subtotalled for each year, the corresponding year's prices having been used for all items. Programme B was costed as Programmes B/I and B/II, on the basis of the two assumed trends in disease incidence, and two series of subtotals were thus obtained. These included farm losses.

Cost/benefit analysis techniques were used to calculate and present the results. The total cost of carrying out the eradication programme, and maintaining surveillance until 1975, was assessed at £12.3 millions, at 1970 prices. The Net Present Value (net gain) of eradicating swine fever, the Average Rate of Return from the programme and cost/benefit ratios were determined by comparisons with Programmes B/I and B/II. Net gains and losses from 1963 to 1969 were adjusted to 1970 values and 5% compound interest was then added. Net gains from 1971 to 1975 were discounted back to 1970 values at the rate of 10%. The results are summarised in the following table:-

	Net gain (NPV)		Average Rate of Return	Cost/Benefit Ratio
Eradication compared with Programme B/I	1963-1970 £25.2m.	1963-1975 £37.5m.	80%	1:4.03
Eradiaction compared with Programme B/II	£ 9.9m.	£20.0m.	34%	1:2.62

The true return probably lies at or near the upper range of values but even at the extremely low levels of swine fever assumed for Programme B/II the investment in swine fever eradication showed an excellent return. Weaknesses in the analyses and assumptions are discussed but two sensitivity tests failed to invalidate the results.

Having scrutinised press reports, price records, pig census and production data and statistics of slaughterings due to swine fever, the author concludes that effects on pig supply, demand or prices were unlikely to have occurred, even during the peak period of slaughtering in 1963. Benefits may have accrued from improved exports but no effect on imports could be detected from trade figures. Important benefits undoubtedly resulted from reduced suffering in pigs, elimination of consequential losses due to quarantines and simplification of the diagnosis of other herd health problems, but no attempt was made to quantify them.

Although certain methodological problems were encountered it was evident that cost/benefit analysis and mathematical modelling could make valuable contributions to the assessment of animal health programmes. Systems Analysis and computer simulation should, also, prove useful additions. Epidemiological evidence on the disease and information on the characteristics of the pig industry were found to be the most important data components. It is suggested that, in relation to diseases requiring Government intervention, such information should now be recorded in a form which permits regular computer analysis.

CHAPTER 1

INTRODUCTION.

This report covers the first of a series of studies on the social and economic implications of animal health which is being conducted at Reading University with support from the Wellcome Trust. The study had three, equally important, objectives:-

a. To assess the value of the programme in economic terms;

b. To develop additional analytical techniques for assessing the economic value of animal health programmes, and

c. To identify the kinds of information needed for such evaluations.

As in all retrospective studies, delving into the rather distant past, there were serious information gaps with respect to swine fever which could only be filled by "educated" guesswork. Furthermore, the need to combine past and future benefits made the analytical procedure rather complicated. However, the swine fever programme offered a rare opportunity for attaining a good estimate of the real outcome from a well recorded investment and has provided a basis on which to plan the evaluation of new and more complex animal health programmes.

The author became concerned with the need for more efficient evaluation techniques in the course of his work with the World Health Organization (WHO) and the Food and Agriculture organization of the United Nations (FAO). He has, therefore, taken the liberty of including a substantial amount of detailed and explanatory information for the benefit of those not familiar with animal production and health in Britain. Some of this material will, certainly, seem tedious and oversimplied to specialist readers but it should also serve to draw attention to the complexities of animal health and to the problems which veterinarians and economists must face in preparing for policy decisions.

A great deal of effort has been expended over the past few decades on the collection of information on economic losses caused by animal disease. A large part of the resulting material was reviewed and discussed in the FAO/OIE/WHO Animal Health Yearbook (1962). Findings varied so widely from country to country that it was only possible to draw some very broad conclusions on the magnitude of losses and needs for veterinary services. Other more recent studies have demonstrated improved techniques and yielded more exact information. These include the work of Beynon (1970) in estimating morbidity and mortality losses in cattle and sheep production, Borland, Hammond and Helme (1970) on economic aspects of veterinary treatment and disease incidence in dairy herds, and Hardie (1969) on the economics of veterinary practice. Meanwhile Blood and Morris (1971), working for some years in Australia, and Barfoot and colleagues (1971) in Canada, have developed economic analysis techniques for veterinary preventive medicine programmes. Still more work has been undertaken by the U.S.Department of Agriculture (Macallon 1970) which routinely uses a project cost/benefit analysis system to evaluate potential veterinary programmes. In fact rapidly increasing numbers of individuals and organizations are making a practice of expressing their findings in economic terms. This list is, therefore, far from complete and is simply intended to illustrate the wide scope of current economic studies on animal health.

It should be emphasised that an economic approach does not exclude such fundamental considerations as animal welfare and human health implications. It is intended to complement and, where possible, incorporate them so that the veterinarian may present animal health programmes in clearer perspective to the farming community and Government authorities.

CHAPTER 2

METHODOLOGY.

2.1 The Analytical Approach

The measurement of disease losses and veterinary costs has always proved difficult because of the problems of collecting representative data. The physical effects of disease vary from farm to farm as do animal production systems and the ways in which farm records are kept. The economic evaluation of a disease control or eradication programme is even more complicated. It involves a comparison of the long term costs and results of what has been done with those of alternative programmes that might have been used. For each alternative, the effects of continuing interactions, over a number of years, between the disease, the production system and a combination of veterinary measures must be assessed. To the problems of collecting basic data, therefore, are added those of measuring or estimating these interactions, projecting the possible courses of events and then applying economic analysis technique.

The approach adopted was to define, analyse and compare the costs and effects of the eradication programme (A) and those that could have resulted from the continuation of the programme it replaced (B).

In the case of Programme A it was possible to extract almost all the statistical and financial information needed from records and publications. The way in which the different components were treated is described in Chapter 4 and Appendices I, II and IV. The costs for each year consisted of subtotals for head office supervision, field activities and laboratory and research activities. In a number of years application of vaccine, compensation to farmers for slaughtered stock and miscellaneous expenses were also components. No provision has been made in Programme A for operating losses on the farm, following the elimination of a herd. Using the same types of model as those described for Programme B losses in Appendix VIII, the author concluded that the levels of compensation permitted re-establishment of the enterprises without significant consequential loss.

The components of Programme B are described in Chapter 5. A substantial amount of information was available on each from records and publications but a number of gaps had to be filled from the recollections of participants. The epidemiological evidence that could be obtained was used in Appendix V for the very important task of estimating the size and number of swine fever outbreaks which would have occurred in succeeding years. A first assumption (I) projected the most likely trend in incidence and a second (II), the minimum levels that could reasonably have been expected. These two incidence trends were then linked with estimated component costs for Programme B and presented as alternatives B/I and B/II. The costing of field activities is explained in Appendix VI, and of laboratory activities and vaccination in Appendix I. Estimates of supervision and miscellaneous costs were made in consultation with MAFF.

The operators of various pig industry recording schemes were contacted but no one could supply financial records of SF losses experienced by herd owners prior to 1963. Summaries of the few case histories that could be obtained from individual owners are contained in Appendix VII. It was therefore necessary to deduce from statistical evidence what average loss would have been in typical herds. The simple mathematical modelling approach used is described in Appendix VIII. The results were linked with SF outbreak projections from Appendix V to provide estimates of the mortality and operating losses which represent a large part of the costs of Programmes B/I and B/II.

The subtotals for these programme components appear in tables C & D of Chapter 5 5. All the values given are at prices for the respective year, having been obtained from records or estimated with the aid of an appropriate index listed in Appendix IX.

2.2 Economic Methods

Project cost/benefit[1] analysis technique seemed an appropriate choice for this study and in applying it the author has drawn heavily on the OECD Manual Vol.I (1968) and the works of Little and Mirrlees (1968) and Walsh and Williams (1969) in this field.

Note: (1) Opinion is divided over the use of the terms cost/benefit and benefit/cost to describe this form of analysis. The author feels the latter is the more logical but has adopted the former because it is more commonly used in Britain.

As mentioned in the introduction, the analysis was complicated by the fact that both past and future values had to be taken into account. A compromise was, to try to make the assessment from the view point of the decision makers in 1963. This was done as an academic exercise, with future studies in mind, and the results are shown, together with relevant explanations and calculations, in Appendix XI. However, net benefits calculated in this way, even restated in 1970 values, could not be accepted as reflecting the present value of the programme some years after its completion.

It was, therefore, necessary to make a number of adjustments although the main features of cost/benefit analysis could still be retained. Three methods of presenting the results were examined : Net Present Value, Average Rate of Return and Cost/Benefit Ratio. A discussion of the merits and drawbacks of each will be found in the OECD Manual Vol.I and other texts. They can give different relative values for programme alternatives according to such factors as the discount rate used and the distribution of benefit values over the period studied.

2.2.1. The Net Present Value (NPV)

This is defined for the purposes of this study, as the net benefit (after recouping all costs) which had accrued by the end of 1970 and will have accrued by 1975; expressed in 1970 values. 1970 was chosen as the base year because it was the latest year for which the necessary factual information and published prices were available. The costs of Programmes B/I and B/II were regarded as the gross benefits because they were avoided by the adoption of Programme A. Two series of net gains or losses have been calculated for each year by subtracting the cost of Programme A from the benefits represented by Programmes B/I and B/II.

The net values for each year from 1963 to 1969 were adjusted to 1970 values with a series of factors derived from the retail price index (Appendix IX) to eliminate distortion due to inflation. It then appeared legitimate to add compound interest to allow for the normal earning capacity of the sums involved. A 5% rate was chosen after consideration of bank interest rates over the period.

Following normal NPV procedure, net benefits estimated as accruing from 1971 to 1975 were discounted back to base year (1970) values. A rate of 10% per annum was used, in accordance with current Government practice. In this way deductions were made from future benefits to allow for such factors as inflation, risk and the possible return from other uses of the money.

By summing the resulting series of values for each year, the Net Present Value of the eradication programme has been obtained.

2.2.2. The Average Rate of Return

The Average Rate of Return is closely analagous to the yield on a stock or bond. By definition it is the rate of interest at which the net gains must be discounted in order for their sum to equalise the initial net loss and bring the profit from the programme down to zero. The calculations for the Programme A/BI comparison are given in Appendix XI as an example. It is obvious that high average rates of return imply large benefits.

3.3.3. Cost/Benefit Ratio

This relates the NPV of gross benefits to the NPV of costs. An example of this calculation is given in Appendix XI and the ratios for the Programme A/BI and Programme A/BII comparisons, at 1970 values, are included in Chapter 6.

3.4 Underlying Issues

Under the heading of economic technique, reference must also be made to the questions of transfer payments, social costs and benefits, and recognition of future benefits.

No attempt has been made in this evaluation to deal with such problems as the differences in value to be assigned to Government (public) and private (farmer) costs, or

between public and private benefits. The question of transfer payments is almost certainly involved but, in the case of the pig industry in Britain, it raises issues which are too complex to cover at this stage of veterinary project analysis.

Since it was mainly a question of additional benefits the author did not feel justified in complicating the present study with adjustments to reflect social costs and benefits. The British public rightly attaches a high value to animal suffering, and so its relief could have been counted among the benefits. Similarly, any obvious influence that animal health activities might have had on size, structure or regional distribution of the animal industry could represent a significant cost or benefit to the community. Cost/benefit analysis offers the means, and it would seem appropriate to incorporate such factors into future programme evaluations where the purely economic justification is not clear cut.

With regard to crediting future benefits, it should be pointed out that the 13 years included in this study constitute an unusually short period. Major animal health programmes have such profound and lasting effects on animal production that from a technical point of view, benefits over periods of 20, 30 or even 40 years could legitimately be included. However, the choice of period is influenced by the rate at which future benefits have to be discounted. Rates may vary according to the type of project to be evaluated. A high discount rate reduces the present value of a benefit receivable in the distant future so dramatically, that it may have negligible impact in an evaluation. Even so a period of 20 or 30 years should prove justifiable in many instances.

These issues will have to be taken up as cost benefit analysis is brought into more extensive use in connection with animal health activities.

CHAPTER 3.

SWINE FEVER AND ITS CONTROL PRIOR TO 1963.

3.1 History of Swine Fever and its Control in the United Kingdom

A comprehensive history of swine fever can be found in the Animal Health: A Centenary (1965) and summaries in reviews such as those by Claxton (1954) and Campbell (1966). Figure 1 depicts the numbers of outbreaks confirmed from 1894 to 1967, and more detailed statistics on the period 1920 to 1970 will be found in Table Va. (Appendix V)

For purposes of brief description, control policy can be divided into three phases : the initial eradication programme, the long term control phase and the final eradication programme.

3.1.1. Initial Programme 1879-1916

Swine Fever was first recognised in the United Kingdom in 1862. Following the passage of the Contagious Diseases (of Animals) Act of 1878, the disease was made notifiable in 1879 and local authorities were empowered to apply control measures. However they failed to reduce the number of outbreaks. In 1894 the newly created Board of Agriculture assumed responsibility for control of the disease in accordance with a new Diseases of Animals Act. Movement controls and various forms of slaughter policy were applied without prolonged or marked effect. The variable character of disease and the possibilities of spread by swill, containing infected carcase meat, had not yet been fully appreciated.

3.1.2 Control Phase 1916-1963

In 1915 the slaughter policy was drastically curtailed, and abandoned completely in 1916 in favour of voluntary uncompensated slaughter, or enforced isolation of the affected farm until clinical evidence of the disease had disappeared. Between 1915 and 1922 free serum treatment was provided but proved to be of little value.

A complex system of scheduled areas frequently subject to outbreaks was gradually consolidated into a single area by 1922. This was subject to only minor changes until 1950. Licences to move pigs within this area could only be obtained if the pigs had been on the premises for 28 days. The aim was to reduce dealer trading. Elsewhere, pigs could be moved freely.

No obvious trend in incidence was recognised until 1941 (App.V). Strict controls of pig production, marketing and slaughter, and a sharp decline in the size of the industry brought about a marked reduction in outbreaks. The reduction in imports of pig meat from endemically infected countries was also an important factor. This decline continued with minor exceptions until 1950 when a transient withdrawal of scheduled area restrictions coincided with a sharp upsurge in the disease.

In 1954, when free marketing of livestock recommenced, a new Regulation of Movement of Swine Order removed the scheduled area scheme and substituted a system of licencing for markets and for pigs moving through them or through dealers' premises. This was complemented two years later by much more extensive and severe restrictions of movement, to be applied in particular areas where the disease had become widespread. In 1959 the Regulations of Movement of Swine Order consolidated all these measures into the system which is described in Chapter 5 as part of the alternative programme.

The isolation procedure on affected farms remained unchanged from 1915 to 1963 but the prophylactic use of crystal violet vaccine was permitted from 1947 onward and encouraged, under the Swine Fever Registered Vaccinated Herds Scheme, from the end of 1953. In an attempt to reduce the spread by swill, earlier orders, made in 1947, which required the boiling of certain animal foodstuffs, were strengthened by an additional order on waste foods in 1957. Further details of these procedures are also given in Chapter 5.

The third phase of final eradication is described in Chapter 4.

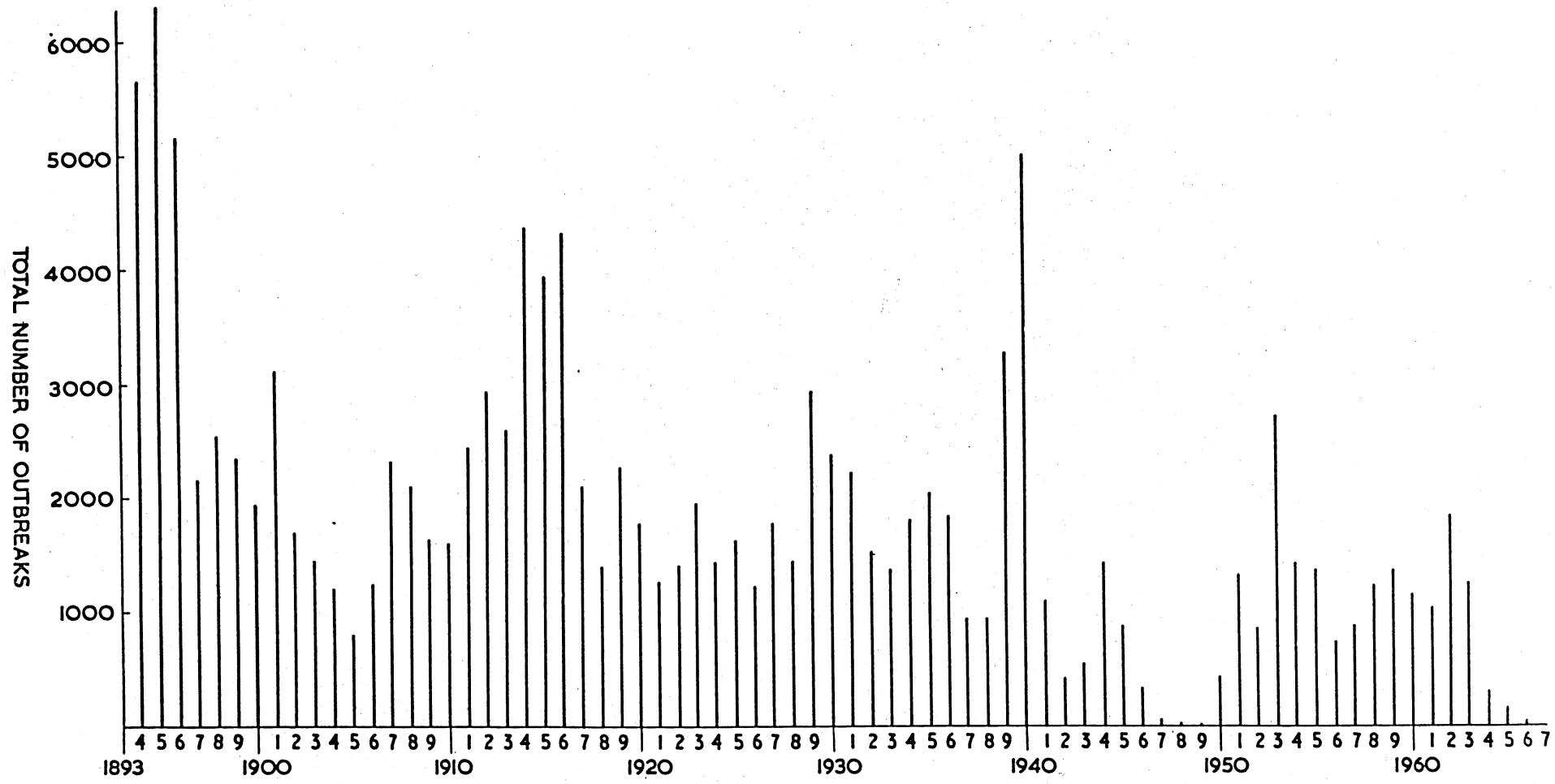


FIG. 1 ANNUAL TOTAL NUMBERS OF SWINE FEVER OUTBREAKS 1894-1967

3.2 Characteristics of the Disease and the Virus, of Significance for Control and Eradication

3.2.1. The classical concept of the disease comprised a normal incubation period of 5 to 35 days, high temperature at onset, loss of appetite, listlessness, reluctance to stand or move and a number of very rapid deaths. Less acute cases could develop nervous signs inco-ordination of movement, offensive smelling diarrhoea, nasal and eye discharge, pneumonia, pinpoint (petechial) haemorrhages under the skin and red to purple patches in the skin of the ears. Mild chronic disease, showing only unthriftiness, often proved to be swine fever. Abortion in affected sows, stillbirths and trembling piglets were also recorded.

Post mortem findings emphasised petechial haemorrhages in organs and on internal membranes, pneumonia and particularly characteristic was intestinal ulceration.

3.2.2. Variability

Diagnosis was always considered difficult. It was only when reliable laboratory tests came into routine use that the true range of clinical signs was recognised and difficult cases could be rapidly diagnosed. (See App.I Laboratory Involvement). Mild, almost sub-clinical, disease must often have escaped notice prior to that time.

3.2.3. The Carrier Sow

The role of the pregnant sow as a carrier of swine fever virus, although suspected as early as 1907, was not demonstrated until 1963 (Campbell 1965). Further details of this phenomenon will also be found in Appendix I.

From accumulated field and laboratory evidence it was concluded that a mild field strain in a susceptible sow, or a virulent strain in a vaccinated sow, might produce no signs of the disease but infect the piglets in her uterus. Weeks later the piglets could be born dead or defective and infect normal litter mates or other pigs on the farm. Indeed, parental antibody from a vaccinated sow appeared to delay the onset of the disease in such piglets for as much as six weeks.

3.2.4. Persistence and Spread of the Virus

Virus did not normally survive more than 1 to 2 days in outdoor pens (Blood & Henderson 1968) and could easily be destroyed by boiling, cleaning and disinfection. In dark, poorly ventilated buildings, however, it could persist for somewhat longer. The virus could also survive for several years in frozen pork and for several months in bone marrow of salted, chilled or smoked carcases, and for nearly a month in bacon (Animal Health Centenary 1965). Such powers of survival in pig carcases certainly aided in the perpetuation of the disease and particularly in spread through swill. However, once these characteristics were understood effective measures could be applied.

Direct pig to pig contact was always recognised as the principal method of spread but the ease with which it could occur was not appreciated until comprehensive market tracings were undertaken (Appendix II). Indeed such thorough tracing frequently revealed outbreaks before owners had observed signs. The fact that pigs incubating the disease could excrete virus in their urine 2 or 3 days before clinical signs appeared, as well as during undetected clinical disease, was certainly a contributing factor. Beynon and Campbell (1965) also drew attention to the considerable weight of circumstantial evidence implying spread by indirect means such as attendants, vehicles, contaminated materials and vermin.

3.3. Structure of Veterinary Services

Under the Diseases of Animals Act of 1950 the Minister of Agriculture and the Secretary of State for Scotland were given even wider powers than before to control diseases of animals and poultry. These legal powers were, indeed still are, used to make or amend the detailed orders concerned with combating existing disease in Great Britain and avoiding the introduction of exotic diseases. (Northern Ireland developed separate and different programmes). A list of the regulations and orders directly concerned with swine fever appears as Appendix III.

Since 1938 the administration of Government veterinary activities throughout the country had been undertaken by the Animal Health Division of the Ministry of Agriculture Fisheries and Food (MAFF). Headquarters at Tolworth on the outskirts of London coordinates the field programmes implemented by staff of 78 Divisional Offices through 11 Regional Offices. Each Division consists of one of the convenient Geographical areas into which the country has been divided and in almost all instances corresponds to a County. The role of full time staff is partly supervisory, since a large part of the work is assigned to experienced private practitioners who are appointed to serve as part-time Local Veterinary Inspectors (LVI). In addition the enforcement of many measures including control of markets, issuance of licences, and application of quarantine restrictions remains the responsibility of Local Authorities (County and City Government units responsible to elected Councils).

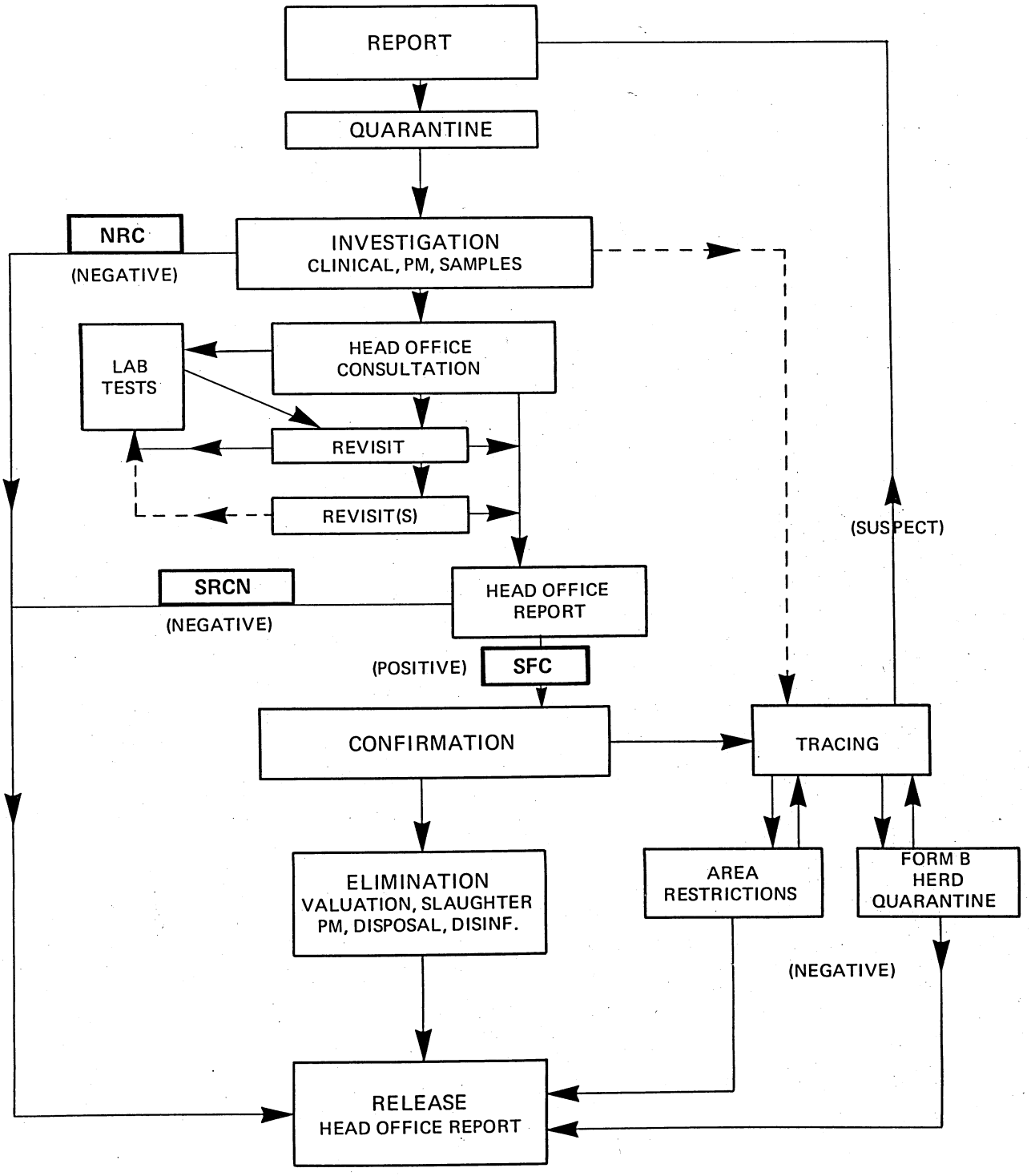
3.4 The Decision to Eradicate

As the pig industry expanded and became more intensive in the late 1950s producers and producer organisations, as well as the veterinary profession, became aware of the need for more effective control, and preferably the eradication of swine fever. Late in 1962 the Government announced plans to introduce a stamping out policy believing as Beynon (1962) stated, that the conditions for a successful eradication programme then existed.

Considerable encouragement was derived from the complete success achieved in Canada, Australia, Northern Ireland and the Irish Republic in eliminating swine fever.

No detailed estimates of the time or expense involved were published nor were current losses from swine fever quantified beyond a rough figure of £1,000,000 per year. The eradication programme commenced on 11th March 1963 and the last outbreak was recorded on 27th June 1966. Although no further disease occurred for some years, surveillance continued and eradication arrangements were kept ready to activate. They were again needed when swine fever was discovered in a herd of swill-fed pigs in Yorkshire in July 1971. It was quickly contained and eliminated as is described in Appendix X.

Had it not been possible to initiate an eradication programme in 1963 the effects of the disease would almost certainly have increased for the reasons outlined in Appendix V. Without a slaughter policy it would have been possible to do little more than continue the 1962 programme so this has been adopted as the alternative with which to compare the costs and benefits of eradication.



NRC = Negative Report Case
SRCN = Suspect Case
SFC = Confirmed Case

FIG. 2 PROGRAMME A. FLOW DIAGRAM

CHAPTER 4

THE ERADICATION OF SWINE FEVER (PROGRAMME A:)

The eradication programme has been well documented and the following is a summary of the steps it involved.

4.1 Procedures and Costs in the Eradication Programme

A report of suspected swine fever led to the series of actions shown in Fig.2 (Flow diagram). They fell into three groups according to outcome : a report case which proved negative at first investigation (NRC), a case which looked suspicious initially and merited further investigation but was later accepted as negative (SRCN) and a case which was confirmed as swine fever (SFC). These three categories provide the means for expressing the physical and financial inputs per case unit as recorded by MAFF. In addition provision has to be made for the very extensive tracing work, supplementary quarantines (Form B) and certain common services. A very large proportion of the tracings were associated with infection in markets. In fact, investigations relating to direct farm to farm movement and other contacts were so small that it was felt that they could be disregarded for costing purposes. The recorded data and grouped estimates of inputs are shown in Table IVc (Appendix IV) and Table B at the end of this chapter.

4.2 Report Procedure

The suspicion of an outbreak was reported by a farmer or other person, e.g. a veterinary surgeon or meat inspector, to the police or directly to a Government Veterinary Officer. The police issued a Form A (standstill) order and passed on the report to the Animal Health Office and the Local Authority, as did the Veterinary Officer if he was informed directly.

4.3 Investigation

The Divisional Veterinary Officer (D.V.O.) arranged for a Veterinary Officer (V.O.) or private veterinary surgeon holding a Local Veterinary Inspector (L.V.I.) appointment to investigate the outbreak. (If an LVI was used and he suspected SF a VO still had to visit the premises). Waterproof clothing and boots had to be worn and these, together with all equipment, were disinfected before the investigator left the premises. If the Inspector of the Local Authority had not already done so the VO issued a Form A (SF9) imposing restrictions on the premises but only to the parts where pigs were kept. When an owner's premises were separated by a road separate Form A's were served on each to avoid inter-site movement.

Inspection started with healthy pigs, then sick pigs were clinically examined, and post-mortems were carried out on dead pigs (including exhumed carcases. If necessary sick or suspect animals were valued and slaughtered for diagnostic purposes. (Indemnities were paid on the same basis as in Section 4.4.1.) Spleen and pancreas were removed at an early stage for possible laboratory examination). The VO could not give the owner a firm diagnosis. Carcases in negative or inconclusive cases were buried or incinerated as in confirmed outbreaks, charges being paid by the VO who was subsequently reimbursed. The indemnity for the animals' value was paid about 14 days later.

4.3.1. Negative Report Case (NRC):

If the VO considered that SF was not present he prepared the report form (SF1) for the DVO who, if satisfied, would withdraw Form A restrictions with Form SF10. The case report was sent to Head Office and no further action taken. Thus the NRC unit cost comprised reporting procedure costs, one investigatory visit by the VO, farm staff time and minimal indemnity and contractual service with respect to animals killed for diagnostic purposes. However it was not possible to average indemnity per case as this item was not differentiated in MAFF records.

4.3.2. Suspect Case (SRCN):

If the initial investigation was inconclusive. SFI was prepared for the DVO and form SF24 was sent to the owner. The DVO had to advise HO who issued an SR case number.

HO was also consulted if a laboratory examination was desired and if agreed, a selection of blood, brain, pancreas, tonsil and spleen specimens was sent by passenger train in containers and material from a kit provided, to the Central Veterinary Laboratory. Appendix I reviews the tests used and outlines how costs were apportioned. The nearest Veterinary Investigation (VI) Centre could be invited to help in differential diagnosis. The owner and his veterinary surgeon (VS) had to be kept informed of progress (Form SF11 for VS). If all findings were negative the DVO consulted HO and obtained permission to withdraw restrictions.

4.3.3. Confirmed Case (SFC):

If sufficient positive diagnostic evidence had been obtained the VO or DVO telephoned HO to obtain "Confirmation of Disease and authority to slaughter." The VO served Form D "Swine Fever Infected Place" notice and arranged disinfection at every entrance and exit. HO gave the case an SF register number and advised the DVO, RVO and Divisional Executive Officer by telegram or telex, and Local Authority by letter (Form SF16).

4.4 Eradication Procedure:

The VO was then responsible for implementing or supervising the eradication procedure. He would do much of this personally but could call in a Technical Assistant (TA) to supervise disposal and disinfection if necessary. The steps comprised:-

4.4.1. Valuation: Following the principles laid down in the Diseases of Animals Act, 1950, indemnities were paid to the owner on the basis of one half of an animal's value immediately before infection or, if unaffected, the full value immediately before slaughter. Two valuations were made for each ailing pig (i) current market value including subsidy and disregarding depreciation due to the current disease, to be used if SF was the cause of the animal's illness and (ii) market value of the animal in sick condition at the time of valuation, to be used if SF was not the cause of illness in the pig concerned. The VO valued small numbers and ordinary breeding stock where the total did not exceed £500. For larger values and special stock, a professional valuer was called in (form SF19) but a VO had to be present during the valuation. Valuations were recorded on form SF5 in quintuplicate: original for HO, one copy for the owner at the time of valuation and a second, verified copy after slaughter; the remaining copies were retained by the Animal Health Office and Valuer. Ailing pigs were marked and identification numbers shown on the form. The owner was invited to sign the form agreeing to the amount of valuation. If a specialist valuer was to be used for valuable animals, valuation had to be approved by HO before being submitted for signature by the owner. Where the valuation was unacceptable to the owner he could call in his own valuer. Whether or not the owner agreed to valuation he had 14 days in which to appeal whereupon the case was submitted to arbitration. A scale of fees and expenses was prescribed for professional valuations.

4.4.2. Slaughter was carried out by "competent slaughterer or knacker" using humane methods prescribed by The Slaughter of Animals Act 1958. The VO could do this if no competent person was available, and in all cases in young pigs for which an intra cardiac injection of pento barbitol sodium was required. At slaughter, all ailing pigs were examined post-mortem to check for SF lesions so that the appropriate valuation could be applied.

4.4.3 Disposal of carcases:

Carcases were disposed of by cremation or burial, whichever was speedier and most effective.

1. Burial was preferred but water supply contamination had to be avoided and local byelaws respected. The pit had to be deep enough to allow coverage of carcases by six feet of earth. In this case all costs including labour charges were born by MAFF.

2. Cremation was done on site in some instances and in others, local authority or private destructor plants approved and supervised by a Ministry Officer processed the carcases into meat and bone meal. Transport in watertight vehicles and careful disinfection of all people and equipment were required. MAFF bore any costs in each case. Obviously, processing was preferred to cremation. On completion a comprehensive report (SF21) was sent to Head Office.

4.4.4 Cleansing and Disinfection was carried out at MAFF expense with MAFF disinfectant except where a slaughterhouse, market or other holding or transit place for pigs was involved. In the case of these exceptions the work had to be done at the operators expense. The procedure comprised spraying with an approved disinfectant or one containing not less than 2% available chlorine. Protective clothing, footwear and hands had to be disinfected. Feedstuffs in troughs were destroyed without compensation, but stored items were not, unless considered contaminated.

Employment of labour and equipment and provision of supplies were covered and invoices were submitted with form SF18. Labour available on the farm could be used and was claimed for on SF17.

4.4.5. Special Situations:

If a market was the site of the outbreak detailed measures had to be agreed with HO.

In the case of a slaughterhouse, affected pigs were moved to an isolated section on which Form A could be served so that normal slaughtering could continue after disinfection. The affected group was slaughtered, and the carcases destroyed at Government expense, but the cost of disinfection was charged to the owner or occupier.

No compensation was paid for diseased carcases but carcases considered affected (e.g. from incubating cases), although showing no signs of disease, could be paid for if HO agreed.

4.4.6. Epizootiological investigation and Tracing

Whenever an outbreak was confirmed the Divisional Veterinary Office was responsible for a thorough investigation to determine whether it was connected with other focuses of SF. The following Table A summarises the conclusions reached.

TABLE A : Primary and Secondary SFC cases

Year	Total SFC	SFC Primary	%	SFC Secondary	%
1963	1,243	630	50.7	613	49.3
1964	402	166	41.3	236	58.7
1965	113	28	24.2	85	75.2
1966	25	7	28.0	18	72.0

Primary cases were those in which no connection could be established with another outbreak. As the programme progressed the proportion of primary cases declined, probably for the reasons suggested in section 3.2.4. The destruction of all pigs in confirmed outbreaks certainly removed almost all the risk of swill contamination. A large majority of secondary cases were shown to be due to movement of infected animals, although a small proportion was obviously due to local spread from farm to farm and others could be attributed to contaminated people, vehicles, equipment and materials.

Tracing of pig movements became an increasingly important and time consuming activity. The source and contacts of any pigs that might have brought the disease to the infected farm were checked. Any other exposed pigs from the same source were traced to their respective destinations and similar steps were taken to examine any pigs which had left the infected farm during the incubation period of the disease. Where animals had been exposed to infection by one of these means the whole endangered herd was subjected to Form B movement restrictions for 28 days, with a possible extension to 42 days. If a possible "carrier sow" was involved these restrictions were maintained until at least 14 days after farrowing. While such restrictions were in force no pigs could be moved on to the premises and pigs were only allowed off under licence for immediate slaughter, and after health inspection. Considerable hardship resulted particularly to owners of fattening establishments where normal quotas of young stock could not be brought in. Even harder hit was the breeder who could not dispose of weaned piglets as stores. This

problem was overcome, to some extent, with "Infected Area Restrictions" which were applied to all pig holdings in a heavily exposed area e.g. following the involvement of a market. Store pig sales in markets were prohibited and all movements were subject to licence by LA. However, holdings could receive stock from premises not under individual restriction and despatch of fat pigs to normal slaughter was unaffected.

4.4.7. Release

In NRCs the DVO withdrew restrictions at his own discretion; with SRCN cases HO had to agree to their withdrawal. In SF cases form A restrictions were withdrawn 14 days after completion of disinfection, except where pigs remained on contiguous form B premises. In this case form A could not be withdrawn without HO approval. Form B was withdrawn 28 days from the date of last contact, except where the premises were contiguous with form A premises, in which case 42 days were required to elapse from completion of slaughter before withdrawal of restrictions. LA, Police and HO were advised by copies of forms SF10 and SF4.

4.4.8. Post Eradication Activities

The legal requirements and operating procedure have remained unchanged. NRC and SRCN cases were, and are still, handled in the manner described. Tracing continues as part of the investigational procedure and Form B restrictions can be applied if there is evidence of contact with a suspicious case.

The volume of SF activity declined steeply as will be seen in Table IVc of Appendix IV. NRC and SRCN cases 1967-70 are the numbers which were in fact dealt with. No records of the numbers of tracings and instances of Form B restriction are available, but no market infection arose so the estimates are token in character. All other activities listed were correspondingly reduced.

For the period 1971 to 1975 estimates have been based on the averages for the years 1968 to 1970. The costs of the 1971 outbreak, the only outbreak since June 1966, have not been included but are referred to in the final discussion and in Appendix X.

4.5 Costings

The total costs for Programme A and the main sub totals are given in Table B at the end of this chapter. All values are those for the respective year except where indicated.

4.5.1 Field Activities. The numbers of working hours and travel costs for Veterinary Officers, Technical Assistants, Local Authority Staff and Farm Personnel are listed in Table a of Appendix IV. These were agreed with a group of Ministry staff, each of whom was involved in the field work of the eradication programme in a different area. The rates prevailing in each year were used to cost the services of each type of participant in order to obtain a unit cost for each NRC, SRCN, SFC and Tracing. (Appendix IV, Table b) The numbers of NRC, SRCN and SFC cases were obtained from official reports. Numbers of tracings and consequent restrictions were estimated from data on affected markets (Appendix II). Other tracing activity was very small in extent and probably well within the limits of error of these estimates; no provision has, therefore, been made for this item. The way in which the total cost of field work has been calculated for each year is shown in Appendix IV, Table IVc.

4.5.2 Laboratory Diagnosis and Research. The scope and detailed costs of this work are reviewed in Appendix I and the annual totals appear in Table B.

4.5.3 Crystal Violet Vaccine. Appendix I also contains the number of doses, value and cost of application of this vaccine before it was withdrawn in August 1964.

4.5.4 Compensation. The numbers of pigs slaughtered and the amounts disbursed by MAFF in payment for stock slaughtered, are shown in Table 8. No compensation was paid for consequential losses such as loss of future income and no provision has been made for them in these calculations for reasons which have been discussed in Chapter 2.

4.5.5 Miscellaneous Expenses. These included such items as valuations, slaughter, carcase disposal and disinfection expenses. They could not be costed individually but

were mentioned in the text in order to complete the list of procedures. The sums shown in Table B were obtained from MAFF records.

4.5.6 Coordination and Supervision. The cost of HO unit operations, printing communications, payment of slaughter compensation and general services could not be apportioned to the different types of case. Total sums were therefore calculated with the help of MAFF staff and the totals appear in Table B.

TABLE B.

PROGRAMME A COSTS OF ERADICATION AND SUBSEQUENT SURVEILLANCE

(IN THOUSANDS OF POUNDS STERLING,)

AT CURRENT PRICES FOR EACH YEAR 1963 - 70.

ACTIVITY	1963	1964	1965	1966	1967	1968	1969	1970	1971(3) to 1975
FIELD WORK (TABLE IVc)	158.1	123.4	90.0	39.9	14.7	5.1	3.2	2.1	-
LABORATORY SERVICE (APPENDIX I)	18.9	20.2	19.9	12.2	5.6	2.6	2.5	2.5	-
HEAD OFFICE SUPERVISION (1)	38.5	32.9	22.3	7.5	2.0	1.1	0.6	0.6	-
CRYSTAL VIOLET VACCINATION (APPENDIX I)	185.7	50.0	-	-	-	-	-	-	-
COMPENSATION(2) (NUMBER OF (PIGS SLAUGHTERED)	3,476,7 (254,786)	1,517.1 (110,922)	578.6 (42,141)	109.3 (8,098)	-	-	-	-	-
MISCELLANEOUS COSTS (2)	142.0	68.1	20.2	4.6	0.3	-	-	-	-
TOTALS (£000s)	4,019.9	1,811.7	731.0	173.5	22.6	8.8	6.3	5.2	7.9(3)

(1) Figures supplied by MAFF

(2) From official reports

(3) Average of 1968 - 70 costs at 1970 prices.

CHAPTER 5.

THE ALTERNATIVE PROGRAMME - PROGRAMME B

For purposes of comparison it was assumed that the control programme operated in 1962, as described by Beynon (1962), would have continued without fundamental change. The level of activity would, of course, have depended on the amount of disease suspected and confirmed. Only the differences from the eradication programme and their implications will be discussed.

5.1 Basic Assumptions

In Appendix V, past evidence and factors likely to have influenced the subsequent course of the disease have been examined and two assumptions are presented. The first,and most probable,trend projects absolute numbers of outbreaks rising until 1965 and a steady decline thereafter to the pre 1963 average level of 1200 outbreaks (Beynon) by 1970 and to very much lower numbers by1975 (Fig.Vd).

The second assumption,regarded as very conservative in the light of industry trends and experience in other countries, projects a sharp reduction in 1963 and a steady but slower annual decline.(Fig.Vd).

5.2 Procedures and Bases for Costing

The series of actions resulting from a report of suspected swine fever is depicted in Fig.3. Investigation procedures would have been the same as in Programme A and cases would have fallen into the same three groups, according to outcome. These are NRC (negative at first visit), SRCN (negative after further investigation and observation) and SFC (confirmed swine fever case).

In the five pre-eradication years SFCs represented 1/3rd of total reports but with the change of diagnostic procedure in 1962 this proportion decreased. No breakdown of negative cases into NRCs and SRCNs was obtainable for the years 1958 to 1961 but it was obvious that with improving laboratory diagnostic aids a higher proportion was falling into the SRCN category. For the alternative programme the proportions of 2 SFC: 2 SRCN: 1 NRC were, therefore, assumed. Estimates of the time involved in each type of case and the resulting costs are given in Appendix VI, Tables Vld and Vle.

5.3 Procedures following Confirmation

5.3.1 Quarantine of Outbreaks

If a member of the whole-time veterinary staff of MAFF had not made the initial investigation, one had to visit the affected premises before an outbreak could be confirmed. He prepared a comprehensive report which the DVO had to submit to HO within 6 days. This included an inventory of all pigs on the premises and a summary of actions taken to reduce the risk of further spread of disease. The local authority representative put up warning notices prohibiting unauthorised entry and visited the premises every 28 days to prepare a return covering pigs brought in, deaths and movement of pigs to slaughter. Movement off had to be licenced by MAFF field staff and could only be authorised for apparently healthy pigs destined for slaughter (apart from certain rare exceptions which have been disregarded in this study). These checks insured that no unauthorised movement of pigs could take place. Deaths within 28 days after confirmation were assumed to have been due to SF. Thereafter the VO conducted post mortems on all dead pigs and restrictions could not be withdrawn until 56 days after the last SF, or undiagnosed, death. All remaining pigs had also to be free of clinical evidence of SF. The quarantine period was, therefore, a minimum of 3 months.

5.3.2. Voluntary Depopulation

When SF was confirmed some farmers chose to destock completely by killing infected animals and sending healthy groups for slaughter. Repopulation was allowed 14 days after satisfactory disinfection had been carried out and sometimes earlier.

Owners only received compensation for the value and burial cost of the few pigs slaughtered for diagnostic purposes. These amounts were very small and have been

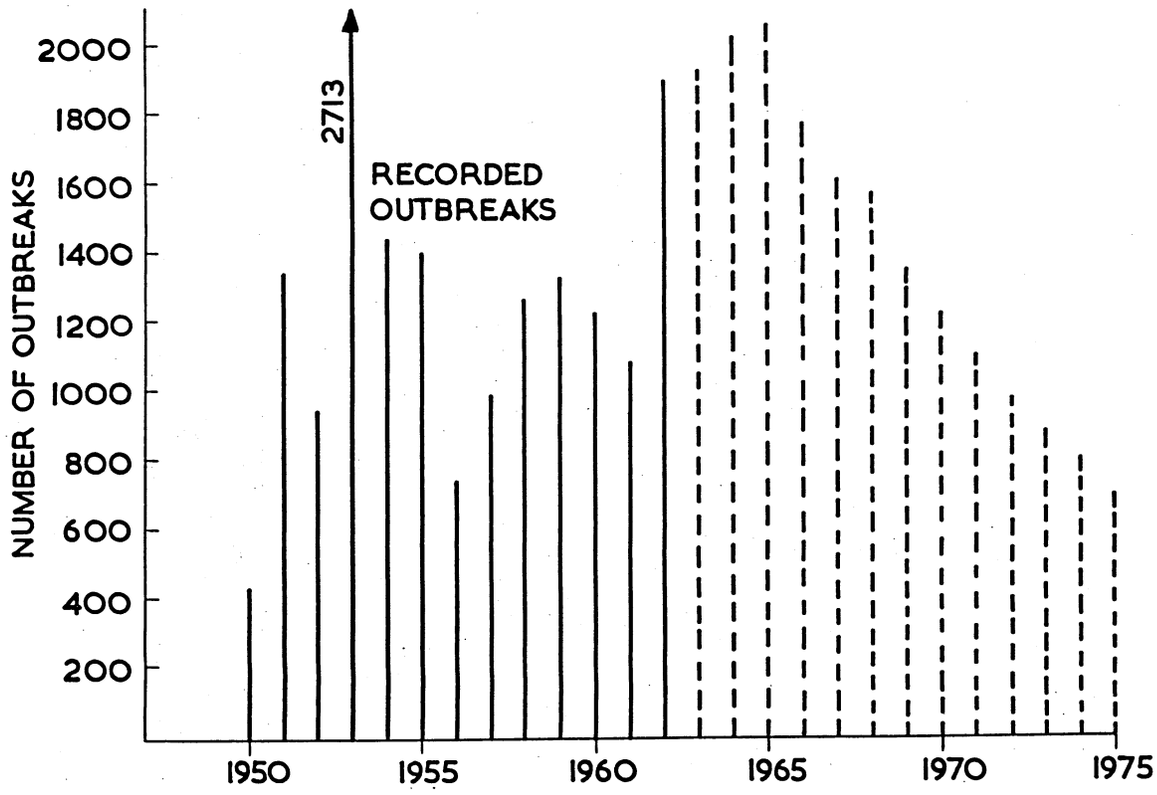


FIG. Vd ASSUMPTION I PROJECTED SFCs

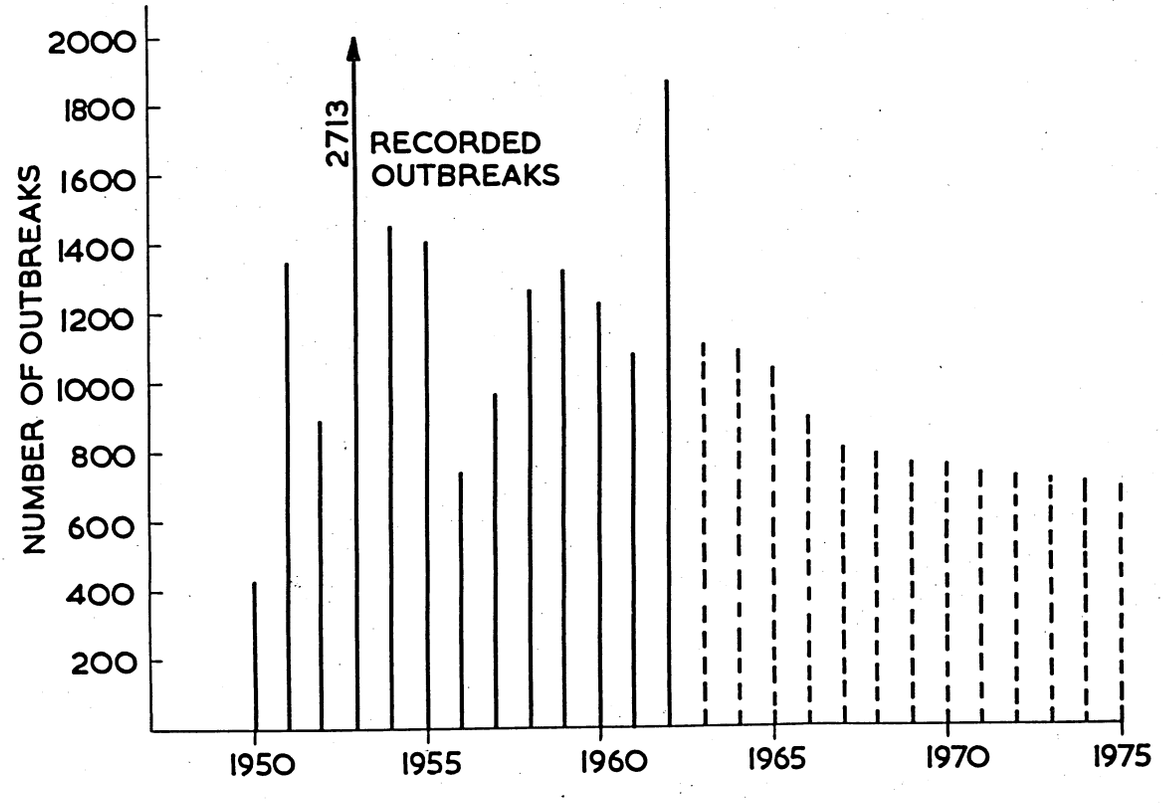


FIG. Vd ASSUMPTION II PROJECTED SFCs

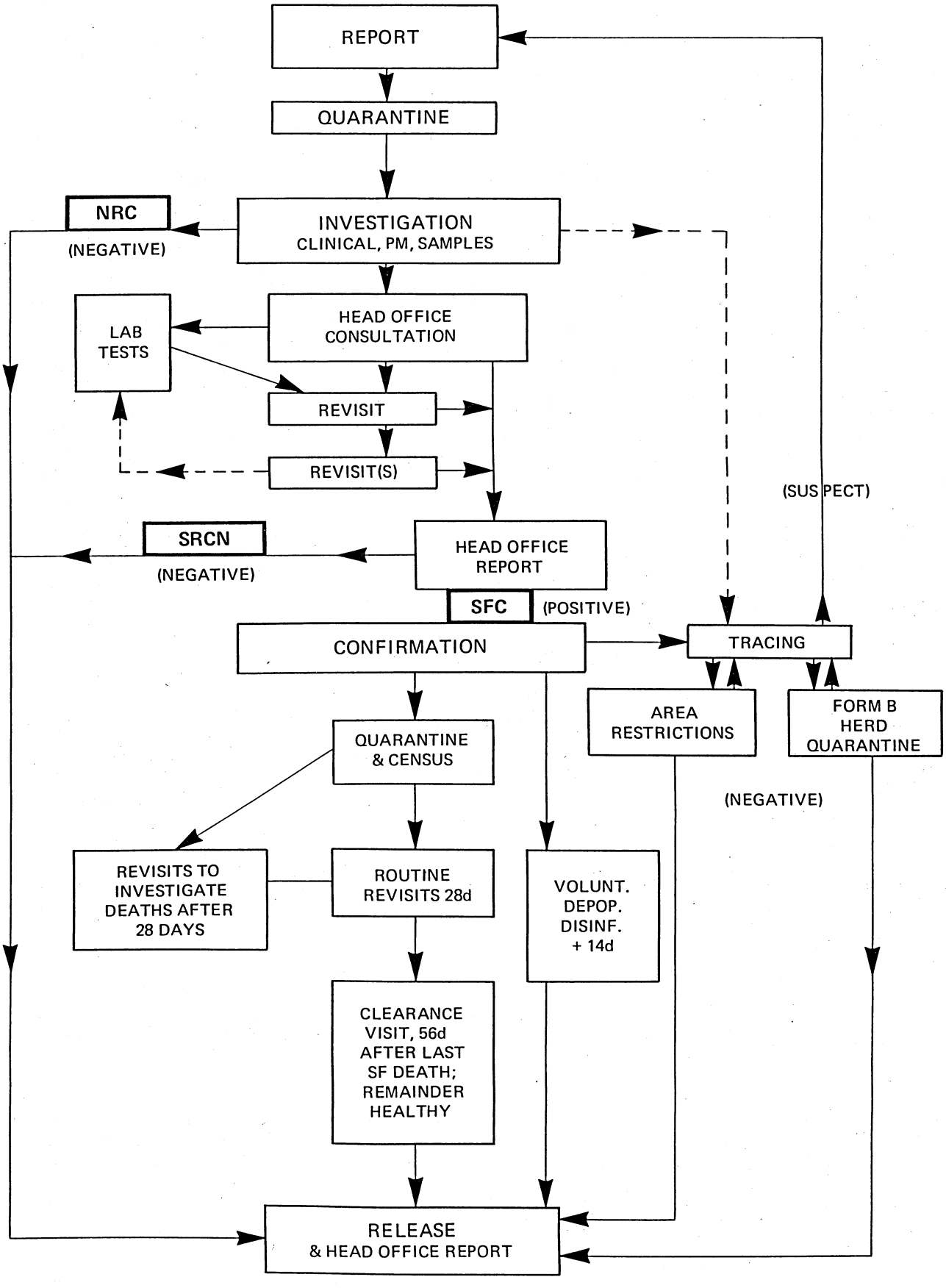


FIG. 3 PROGRAMME B. FLOW DIAGRAM

included in the miscellaneous cost estimates. The brunt of the heavy losses were, therefore, borne by owners.

5.3 Nature of Losses

Such losses would, of course, have continued under Programme B and would have consisted of:-

1. Mortality;
2. Reduced value of exposed animals sent prematurely to slaughter;
3. Loss of production in pigs which recovered; and,
4. Loss of income until normal production levels were again attained.

Various methods of assessing these losses were attempted. It proved impossible to secure any detailed examples of the financial loss experienced by individual farms but a number of case histories, included as Appendix VII, provided evidence of the physical effects of the disease. This was complemented by detailed statistical data published by Wilsdon (1958), part of which is reproduced in table VIIIa (Appendix VIII). Unfortunately similarly detailed statistics for later years, although recorded at the time, were no longer available. Summaries published in the annual reports of the Animal Health Division indicated somewhat lower mortality rates (17 to 19%) but farmers and veterinary surgeons who had records, or recalled details, of outbreaks shortly before eradication commenced, revealed no evidence of significant change. It was therefore felt that the differences did not justify additional complication of the assessment methods described in Appendix VIII. In tables VIIIb and VIIId, mortality losses have been quantified as a proportion of the numbers of pigs (table Vg) likely to have been involved at a weighted average prices (table VIIIa) for each year for each assumption.

Similarly, in tables VIIIk and VIIIL of Appendix VIII other losses listed in items 2 to 4 above are quantified according to each of the projected levels of incidence and on the assumption that half the animals affected would have been in "integrated" breeding and fattening herds while the other half would have been in "fattening" herds without breeding stock.

5.4. Epizootiological Investigation and Tracing

Prior to eradication it was customary to trace pigs which had been in contact with known or suspect cases in a lorry going to or from a market, or in the same pen at the market. Other pigs which travelled in the same lorry before it could be disinfected were also checked as well as those subject to any other obvious exposure. At this stage the amount of tracing activity was, therefore, quite small. From Table Vb it appears that approximately 50% of SFCs were classed as "Primary". About half of the "Secondaries" in 1961 and 1962 were connected with movement of pigs through markets. Since the same tracing could connect two or more outbreaks it was felt that 5 tracing visits per market linked SFC, and one tracing for other secondaries, would be a fair representation of this activity.

5.5 Crystal Violet Vaccination

Any major change in vaccination policy would have had a profound effect on the behaviour of SF and the character of programme B. The implications of such changes will be discussed later in this study but for purposes of programme assessment it is assumed that numbers of vaccinations would have continued to approximate 0.22 times annual census figures for pigs, as indicated in Appendix I.

5.5.1 Supervisory and Administrative activities have been quantified and priced with guidance from MAFF. It was assumed that time equivalent to the full employment of two senior veterinary officers and a number of administrative staff similar to that of 1962 would have been needed.

5.5.2 Laboratory Service costs are extrapolations from 1963 levels of activity explained in Appendix I.

5.5.3 Miscellaneous Expenses, including compensation for the few animals slaughtered for diagnosis, were estimated from pre-eradication figures at £1.5 per SFC.

5.6 The amounts corresponding to each item, and the total, for each year are given in tables C & D and at the end of this chapter.

5.7 It should be noted that possible effects of SF on imports, exports, marketing and market prices were considered but excluded from the main assessment for the reasons given in chapter 6.

TABLE C. PROGRAMME B, ASSUMPTION I: COSTS OF CONTROL MEASURES + ESTIMATED FARM LOSSES
(IN THOUSANDS OF POUNDS STERLING AT CURRENT PRICES FOR EACH YEAR).

ACTIVITY	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
FIELD WORK (TABLE)	190.6	204.0	231.4	209.6	203.3	191.1	186.3	183.1	164.9	148.3	133.8	119.7	104.4
LABORATORY SERVICE (APPENDIX I)	19.0	20.0	21.7	22.8	23.8	25.0	26.8	29.0	29.0	29.0	29.0	29.0	29.0
HEAD OFFICE SUPERVISION (3)	14.8	14.8	17.2	17.4	17.5	20.4	21.4	23.0	23.0	23.0	23.0	23.0	23.0
CRYSTAL VIOLET VACCINATION (1)	312.0	340.0	382.0	375.0	361.0	394.0	420.0	456.0	468.0	489.0	507.0	528.0	540.0
MORTALITY (FARM) (TABLE VIIIc)	465.0	564.0	604.0	605.0	651.0	664.0	636.0	665.0	632.0	603.0	570.0	534.0	486.0
OPERATING LOSSES (FARM) (TABLE VIIIh.)	1,606.0	1,957.0	2,099.0	2,115.0	2,251.0	2302.0	2207.0	2301.0	2188.0	2090.0	1976.0	1848.0	1682.0
MISCELLANEOUS (2)	2.9	3.0	3.1	2.7	2.4	2.2	2.0	1.8	1.6	1.5	1.3	1.2	1.0
TOTALS	2,610.3	3102.8	3358.4	3347.5	3510.0	3598.7	3499.5	3658.9	3506.5	3383.8	3240.1	3082.9	2865.4

(1) ESTIMATED VACCINATION COSTS = ANNUAL PIG CENSUS TOTAL X 0.22 X UNIT COST (APPENDIX I)

(2) BASED ON £1.5 PER SFC.

(3) ESTIMATED IN CONSULTATION WITH MAFF.

TABLE D. PROGRAMME B, ASSUMPTION II: COSTS OF CONTROL MEASURES + ESTIMATED FARM LOSSES

(IN THOUSANDS OF POUNDS STERLING AT CURRENT PRICES FOR EACH YEAR)

ACTIVITY	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
FIELD WORK (TABLE)	107.7	108.3	112.6	104.8	96.7	103.3	106.6	112.6	109.9	107.8	107.1	106.3	104.4
LABORATORY SERVICE (APPENDIX I)	12.0	12.4	13.7	14.4	14.8	15.8	16.9	18.4	18.4	18.4	18.4	18.4	18.4
HEAD OFFICE SUPERVISION (1)	14.8	14.8	17.2	17.4	17.5	20.4	21.4	23.0	23.0	23.0	23.0	23.0	23.0
CRYSTAL VIOLET VACCINATION (2)	312.0	340.0	382.0	375.0	361.0	394.0	420.0	456.0	468.0	489.0	507.0	528.0	540.0
MORTALITY (FARM) (TABLE VIII)	266.0	300.0	302.0	303.0	326.0	354.0	364.0	409.0	421.0	438.0	456.0	474.0	486.0
OPERATING LOSSES (FARM) (TABLE VIII)	918.0	1,045.0	1,052.0	1,056.0	1,126.0	1,225.0	1,261.0	1,419.0	1,458.0	1,491.0	1,585.0	1,641.0	1,682.0
MISCELLANEOUS (3)	1.7	1.6	1.5	1.3	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.0
TOTALS	1,632.2	1.822.1	1,881.0	1,871.9	1,943.2	2,113.7	2,191.1	2,438.0	2,499.0	2,568.3	2,697.6	2,791.8	2,854.8

(1) ESTIMATED IN CONSULTATION WITH MAFF

(2) ESTIMATED VACCINATION COSTS = ANNUAL PIG CENSUS TOTAL X 0.22 X UNIT COST (APPENDIX I)

(3) BASED ON £1.5 PER SFC.

CHAPTER 6

RESULTS, DISCUSSION & CONCLUSIONS

6.1 Results

The estimated total cost of Programme A, at 1970 prices was £12.3 million. This figure was obtained by treating the annual totals in Table B in exactly the same way as the net gains and losses from the programme comparisons. (Tables E & F)

6.1.1. Net Present Values

By comparison with Programme B/I, which anticipated initial high levels of disease, a net gain of nearly £25.2 million had accumulated by 1970 and a further £12.3 million has to be added for benefits which will accrue by 1975. Thus the NPV in this case was over £37.4 million.

Even with the very low levels of disease incidence for Programme B/II, eradication gave a net gain of £9.9 million by 1970 and an NPV of nearly £20.0 million when the discounted value of benefits from 1971-75 were included.

6.1.2. Average Rate of Return

The average or internal rate of return from the eradication programme was estimated at 80% per annum on the basis of Programme B/I and 34% per annum on the basis of Programme B/II.

6.1.3. Cost/Benefit Ratios

These were:-

For the Programme A/BI comparison = $\frac{£49,801,000}{£12,345,000}$ = 1:4.03

For the Programme A/BII comparison = $\frac{£32,304,000}{£12,345,000}$ = 1:2.62

6.2 Discussion

The difference between the two sets of findings is wide due to the initial increased incidence projected in Assumption I but, even with the very conservative Assumption II, is more than satisfactory and the economic value of eradicating swine fever to Britain is unquestionable.

Sub-totalling various elements draws attention to their relative importance.

a. A saving of between £1 million and £2 million in Government veterinary service costs accrues by 1975 (excluding compensation paid to farmers).

b. If an increased rate of vaccination had been included in Programme B the additional cost could easily have exceeded the amounts actually paid in compensation.

c. Laboratory investigation costs represented a surprisingly small part of the total eradication cost and major increases could easily have been justified if eradication had not ensued.

6.2.1. Sensitivity Tests

Since the results depended on a series of assumptions, it was essential to check their sensitivity to possible errors of assumption.

By far the most important factors in Programme B costs (Tables C & D) were farm losses but even at the levels of Assumption I they do not appear unrealistically high. The peak incidence of 1965 implies that 469,000 pigs would have been on premises

TABLE E: PROGRAMME A COMPARED WITH B/I (VALUES IN £'000s)

	1963	1964	1965	1966	1967	1968	1969	1970(5)	1971(5)	1972(5)	1973(5)	1974(5)	1975(5)
(1) PROGRAMME B/I COSTS	2,610	3,103	3,358	3,348	3,510	3,599	3,500	3,659	3,507	3,384	3,240	3,083	2,865
(2) PROGRAMME A COSTS	4,020	1,812	731	174	23	9	6	5	8	8	8	8	8
(3) NET GAIN OR (LOSS)	(1,410)	1,291	2,627	3,174	3,487	3,590	3,494	3,654	-	-	-	-	-
(3) NET GAIN OR (LOSS)AT 1970 VALUES	(1,905)	1,698	3,283	3,824	4,102	4,033	3,717	3,654	3,499	3,376	3,232	3,075	2,857
(4) 1970 VALUES	← PLUS 5% COMPOUND INTEREST →								← DISCOUNTED AT 10% p.a. →				
	(2,681)	2,275	4,190	4,648	4,748	4,446	3,903	3,654	3,181	2,789	2,427	2,100	1,774
SUB TOTALS						1963-70:		25,183				1971-75:	12,271
GRAND TOTAL												1963-75:	37,454

(1) From Table C

(2) From Table B

(3) Adjusted by Retail Price Index factor (Appendix IX)

(4) Compound interest at 5%, 1963-70; 1971-75 Values discounted at 10% /annum.

(5) At 1970 values

NET PRESENT VALUE (1970) = £37,454,000

AVERAGE RATE OF RETURN = 80%

TABLE F: PROGRAMME A COMPARED WITH B/II (VALUES IN £'000s)

	1963	1964	1965	1966	1967	1968	1969	1970	1971(5)	1972(5)	1973(5)	1974(5)	1975(5)
(1) PROGRAMME B/II COSTS	1,632	1,822	1,881	1,871	1,943	2,114	2,191	2,438	2,499	2,568	2,698	2,792	2,855
(2) PROGRAMME A COSTS	4,020	1,812	731	174	23	9	6	5	8	8	8	8	8
NET GAIN OR (LOSS)	(2,388)	10	1,150	1,697	1,920	2,105	2,185	2,433	-	-	-	-	-
(3) NET GAIN OR (LOSS) AT 1970 VALUES	(3,227)	13	1,438	2,044	2,259	2,365	2,324	2,433	2,491	2,560	2,690	2,784	2,847
(4) 1970 VALUES	(4,540)	17	1,835	2,484	2,615	2,607	2,440	2,433	2,264	2,115	2,020	1,901	1,768
SUB TOTALS							1963-70:	9,891				1971-75:	10,068
GRAND TOTAL												1963-75:	19,959

(4) ← PLUS 5% COMPOUND INTEREST → DISCOUNT RATE - 10% →

(1) From Table D

(2) From Table B

(3) Adjusted by Retail Price Index factor (Appendix IX)

(4) Compound Interest at 5% 1963 - 1970; 1971-75 Values Discounted at 10%/Yr.

(5) At 1970 values

NET PRESENT VALUE (1970) = £19,959,000

AVERAGE RATE OF RETURN 34%

where swine fever occurred. This amounts to 7% of the June census total for pigs (GB) and compares with a recorded 6.34% level in 1962 and 4.48% in 1953, the next two highest peaks. In terms of annual throughput, as measured by 14.3 million total slaughterings, the 469,000 represents less than 3.3%. One, therefore, concludes that these comparisons do not suggest over estimation of animals involved from a projection which assumes a rising incidence trend from 1962.

Errors could also have arisen in the valuation of farm losses. Mortality rates did appear to have declined from 20% to around 17% in some years just prior to the commencement of eradication. However, the average value placed on each pig appears conservative so the national cost of the mortality rate is unlikely to have been over-estimated. Operating losses could have been over-estimated by allowing too much time for restocking and too great a price reduction on the pigs scheduled for premature slaughter. However, a change in the former would have had negligible effect since only fixed costs and a narrow profit margin were involved. The latter was an arbitrary estimate of a component which was more variable than the rest, being dependent on the proximity of slaughtering facilities, the speed with which sale could be arranged and the extent of infection. A 50% higher average price for such pigs(£13.05 in 1970) would have reduced the loss per sow in integrated herds from £64.2 to £47.97, and per pig place in fattening herds from £5.9 to £3.49. The effect of these changes on the Programme A/BII comparison are shown below:-

	Net Present Value (1970)
Programme A/BII	£19,959,000
Programme A/BII at higher premature slaughter price	£13,199,000

In the present case the duration of the programme was known and a large majority of the costs could be determined accurately from records. Consequently there would seem to be no reason to question individual components of Programme A. However, in the evaluation of such a programme at the planning stage, a large measure of uncertainly would have existed. As an academic exercise, therefore, it was assumed that eradication took six years instead of four to complete. Programme costs for the additional years were interpolated from those recorded to give the following totals 1963 : £4,020,000 1964 : £1,822,000, 1965 : £1,270,000, 1966 : £731,000, 1967 : £450,000 and 1968 : £174,000.The remaining totals were deferred by two years in each case. These changes were introduced into the NPV calculation based on Programme B/II with the result shown in the following table:-

	Net Present Value (1970)
Programme A/BII	£19,959,000
Programme A/BII with delayed completion	£16,914,000

If both these changes were applied together the NPV was further reduced to £11,305,000.

Thus none of these tests succeeded in invalidating the end results.

6.2.2 Unquantified Economic Implications

The possibility of an effect on the supply/demand pattern, and consequently on prices for pigs was considered. The author could find no reference in market reports, PIDA/MLC publications or the farming press to any such effects during the eradication period. Careful scrutiny of a complete weekly price series, kindly supplied by MLC, failed to reveal any unusual pattern in volume of pigs certified for slaughter under the guarantee system, or in prices, around the peak of swine fever confirmations in 1963. In fact "weekly average returns" for all pigs were generally lower in 1963 and the early months of 1964, than they had been in 1962.

Correlation of the numbers of pigs involved with census and throughput data also casts doubt on the likelihood of market effects:-

	BREEDING SOWS AND GILTS	FATTENING PIGS (MORE THAN 14 WKS)
June 1963 Census total (MAFF):	876,410	-
Total slaughter 1963 (MLC):	-	12,200,000
Total destroyed due to SF	23,736	145,300
Monthly totals destroyed:-		
March 1963	6,786	30,921
April "	2,880	19,449
May "	2,523	22,675

Numbers of SFCs and the numbers of pigs that had to be destroyed declined steeply after the first three months of the eradication programme. Even in the peak month of March 1963 less than 0.8% of the breeding herd and 3% of the throughput of fatstock to slaughter, were eliminated. Further efforts to discern a supply - demand effect during eradication did not, therefore, seem justified.

No attempt was made to deduce any market effects due to the levels of disease projected for Programme B. Those that might have occurred would have tended to add to the cost of that programme.

The implications of further restriction of imports from SF infected countries were also considered. These imports represented such a small fraction ($< 1\%$) of total domestic pig production that further reductions were unlikely to have affected market prices. In addition there would seem to have been a measure of substitution by supplies from SF free sources when similar steps were taken in earlier years.

Exports probably benefited from SF eradication. Exports of pigs and pig products rose from £6 million for the 1960-1964 period to £15.2 million for 1965-1969. There was no striking trend with respect to live pigs or cured meats but there was increased volume of movement of fresh chilled and frozen pork. However, no assessment was made because of the difficulty of determining the proportion of net benefit attributable to SF eradication.

6.2.3 Social and Other Considerations

This discussion would be incomplete without further reference to less easily quantifiable but none the less important factors. Principal among these are animal welfare and effects on industry structure. The amount of suffering that could be avoided by SF eradication would have given this factor a high rating if non-economic evidence had been required. Far fewer animals were slaughtered, (quickly and humanely) during eradication than would have died a painful death from the disease by 1970 if Assumption I had materialised. The inconvenience and consequential loss of quarantines applied to farms (Form B) or areas (Area Restrictions) has been mentioned but not quantified. A fairly high rating might also have been attached to pig industry flexibility. Continuance of SF would have accelerated the concentration of pig production into fewer and larger units and opportunities for independent fatteners to purchase stores in markets would have dwindled.

In retrospect, substantial benefit has certainly accrued from the ease with which other herd health problems can now be diagnosed and treated.

6.3. Conclusions

It would appear that swine fever eradication yielded far greater economic benefits than were anticipated when the programme was planned.

Because of its retrospective character this study presented a number of methodological problems. Nevertheless it has provided a basis on which to plan further work, identified certain key data components and indicated a number of factors for which suitable handling techniques must be devised.

With respect to data, excellent information was available on the nature and costs of disease control procedures from MAFF, on pig production costs from MLC (1971) and Ridgeon & Sturrock (1969), and on pig marketing from MLC. The gaps in data related mainly to epidemiology and the assessment of swine fever losses on farms. Much of this material would have been available from official records but for the normal Government practice of destroying files more than seven years old. Thus it was no longer possible to extract factual evidence on the distribution of outbreaks according to type or size of pig herd, prior to 1963. Nor was it possible to identify and do sample surveys of herds that had been affected to check actual farm losses against those assessed by modelling. MAFF census data has provided a steadily broadening basis on which to assess national levels of disease and loss, but lacked essential information on industry structure prior to 1957.

Although it was not feasible until recently, data processing systems are now well enough developed for Governments to consider the routine recording of information on diseases requiring their intervention in a form which can be routinely analysed by a computer. In this way, information for the projection of incidence and the assessment of control strategies would be immediately available.

With respect to methods, the systematic consideration of problems and programmes as a series of units appears to be a satisfactory approach and could be improved by the adoption of Systems Analysis techniques. These offer ways in which the interaction of biological and operational aspects of animal health programmes can be expressed in diagrammatic models and then quantified. This establishes the relative importance of contributing factors and identifies those that require examination in greatest detail.

Cost/Benefit analysis provides a convenient means of expressing the findings thus obtained in economic terms, and of comparing the merits of alternative programmes. Its application in other fields has led to the development of ways in which such factors as animal welfare and inconvenience to farmers may be incorporated into the assessment. Thus, while cost/benefit analysis can be used to evaluate past work, it should be even more valuable as an aid to planning, selecting, and monitoring progress of new animal health activities.

APPENDIX 1

LABORATORY INVOLVEMENT

Development of Diagnostic Techniques

The diagnosis of swine fever was hampered for many years by the fact that the virus would not cause disease in laboratory animals, indeed in any species other than the pig, and could not be reliably detected or ruled out by direct or indirect laboratory tests. The presence of microscopic changes in blood and brain tissue proved useful aids to diagnosis but, until, the middle nineteen fifties, confirmation that SF existed depended on the findings of clinical and post mortem examinations on affected pigs. Biological tests, using susceptible and immunised pigs, were occasionally used but were too expensive and impractical as a routine. Dunn (1970) has made a comprehensive review of the development of diagnostic techniques throughout the world.

As far as the U.K. was concerned important new developments came from the work of Done (1957) who identified specific inflammatory lesions in the brains of pigs which had died of SF and Mansi (1957) who found that an Agar Gel diffusion precipitin test (GDPT) with pancreatic tisue from affected pigs and SF antiserum, gave reliable results. From March 1958, the routine examination, at the Central Veterinary Laboratory at Weybridge (CVL) of viscera from all suspect cases was complemented by the GDPT and by brain and biological tests in selected instances.

From the experience thus gained it become evident that SF could present much more widely varying characteristics than had hitherto been suspected. As a result, it was decided that from January 1962, the CVL would concentrate on GDPT and brain tests on doubtful cases, while field officers confirmed the more obvious cases by clinical and post mortem examination.

It was felt that this new procedure improved the rate of diagnosis and strengthened the prospects of control by reducing spread of SF from a typical case, but both laboratory tests had the drawback that they could not be relied upon, absolutely, to detect early cases or latent disease. However, in conjunction with the slaughter policy and a broader view of the clinical disease picture, they made an important contribution to the systematic elimination of the disease.

As incidence declined the role of the pregnant sow in spreading SF was recognised. Huck and Aston (1964) isolated infective virus from new-born piglets from sows exposed, but not obviously infected, during pregnancy, while Harding, Done, O'Neill & McLeod (1964) linked congenital tremor with specific lesions of the cerebellum in young piglets thus affected by SF. Once this syndrome was defined, the GDPT was brought into use to detect antibodies in the serum of suspected carrier sows.

A further laboratory contribution came from the introduction of the fluorescent antibody technique developed by Mengeling, Pirtle and Torrey (1963). It gave a high level of efficiency (King, 1971) in tests to identify virus in spleen tisue from suspect cases in the field and helped in the detection of early and a typical outbreak. As the numbers of positive pancreases from field outbreaks dwindled, thus removing the source of antigen for GDPT, the FA test was increasingly used.

In addition to this very extensive routine diagnostic work, tests on other tissues as well as other forms of the test were also explored. However, progress toward eradication in 1965 and completion in 1966 reduced opportunities for further research work. In fact the areas of experimental vaccines and immunity were omitted from research plans since eradication by a slaughter policy was the agreed objective from about 1960 onward.

Vaccine Production and Application

Live virus vaccine was considered unsafe and was not in use prior to the eradication programme; it's use was prohibited from the outset of the programme.

Since 1947 the application of crystal violet vaccine had been encouraged and from 1953 to 1964 a "Registered Vaccinated Herd Scheme" was operated. Almost all the vaccine used was produced at the CVL and supplied, at cost, through private veterinary surgeons who also charged an agreed fee per dose for its application. Beynon (1962) reported that only

about 1¼ million pigs were vaccinated each year, out of a total throughput of approximately 11 million. The numbers of doses actually issued are shown in Table Id along with estimated costs for 1963 and 1964. The total cost per dose was the main factor which dissuaded farmers from adopting vaccination on a larger scale, and the initiation of the eradication programme resulted in a sharp decline in usage. In August 1964 the distribution of crystal violet vaccine was stopped because the disease was extremely difficult to recognise in the vaccinated herd which became infected. There was a risk that such herds could serve as inapparent reservoirs of infection (Campbell 1965).

Costings

Programme A - Diagnosis (Tables Ib, and Ic)

The work of the Pathology Department has been costed to reflect the use of the laboratory facilities, equipment, staff and general costs of the Pig Pathology Section for swine fever diagnosis and investigation in the years 1963, 1964 and 1965. For 1966, 1967 and 1968 a reducing proportion of the Department's efforts was required and the costs were reduced accordingly. To these basic costs was added an appropriate amount for each block of tissue processed.

From 1969 onward the cost was further reduced but included a token allowance for surveillance and maintenance of a diagnostic service.

The work of the Virology Department was costed by the Department in a similar manner. New techniques reduced the effort involved and it reached the surveillance and maintenance level by 1968.

Crystal violet vaccine (Table Id) was produced by the Central Veterinary Laboratory (CVL) and distributed at cost in two sizes of dose through the veterinary profession. A dose rate of 5cc was used for young and medium sized pigs and was priced in 1963 and 1964 at 10p and that of 10cc for adults, at 20p. Application costs were calculated as follows from the then prevailing recommended rates on the assumption that 50 pigs would be vaccinated per visit:-

Travel - estimated 10 miles at 3 p	=	30p
Basic fee for 6 pigs	=	60p
24 pigs at 10p	=	240p
20 pigs at 7½p	=	150p
Total Cost 50 pigs	=	480p
Average cost per pig	=	480/50 or 10p (rounded)

Based on Beynon's observation that approximately 1.8 million doses of vaccine were used to vaccinate 1¼ million pigs in 1962 it was assumed that half the vaccine was used in the form of a 10cc dose and that numbers of pigs vaccinated therefore corresponded to 2/3rds the number of doses distributed in 1963 and 1964.

The corresponding figures are incorporated into Table Id.

TABLE Ia. PROGRAMME A. PATHOLOGY

	1963	1964	1965	1966	1967	1968	1969	1970	1971-1975 (annual estimate)
Number of blocks examined:	12,700	15,300	10,300	3,700	850	412	171	185	
Total Cost (£s).	12,900	13,700	13,400	7.200	4,100	1,600	1,500*(2)	1,500*(2)	1,500*(2)

(1) Includes basic costs & costs per block.

(2)* Includes provision for surveillance and emergencies.

TABLE Ib. PROGRAMME A. SEROLOGY - VIROLOGY

	1963	1964	1965	1966	1967	1968	1969	1970	1971-1975 (annual estimate)
Numbers of Tests:									
Gel Diffusion Precipitin	6,500	7,717	6,819	3,082	1,077	284	112[3]	81	
Fluorescent Antibody	-	-	336	2,471	548		111	108	
Total	6,500	7,717	7,155	5,553	1,625	284	223	189	250
Cost	£6,000	£6,500	£6,500	£5,000	£1,500	£1,000[2]	£1,000[2]	£1,000[2]	£1,000[2]

(1) Annual total cost estimated by Virology Dept. CVL.

(2) Includes a provision for maintenance of diagnostic equipment and materials and for refresher training.

(3) 2,451 serums also examined in a special survey for anti-bodies

TABLE Ic. PROGRAMME A. DIAGNOSIS SUBTOTALS

	1963	1964	1965	1966	1967	1968	1969	1970	1971-1975 (annual estimate)
Pathology Cost (£s).	12,900	13,700	13,400	7.200	4,100	1,600	1,500	1,500	1,500
Serology-Virology Costs (£s)	6,000	6,500	6,500	5,000	1,500	1,000	1,000	1,000	1,000
Sub totals (£s)	18,900	20,200	19,900	12,200	5,600	2,600	2,500	2,500	2,500

TABLE Id. DISTRIBUTION OF CRYSTAL VIOLET VACCINE

Year	No Doses ('000s)
1954	1,060
1955	1,056
1956	1,112
1957	1,187
1958	1,333
1959	1,395

Year	No Doses ('000s)	Vaccine Cost (1) £s.	Application Cost (2) £s.	Total Cost £
1960	1,619	-	-	-
1961	1,614	-	-	-
1962	1,814	-	-	-
1963	1,114	111,400	74,300	185,700
1964	300	30,000	20,000	50,000

(1) 10p/dose sale price

(2) Assuming that half the animals vaccinated received the 10cc dose, the remainder 5cc.

TABLE Ie. PROGRAMME B. LABORATORY INVESTIGATIONS

	1963	1964	1965	1966	1967	1968	1969	1970	1971-1975 (annual cost)
(1) Assumption I (£s)	19,000	20,000	21,700	22,800	23,800	25,000	26,800	29,000	29,000
(1) Assumption II (£s)	12,000	12,400	13,700	14,400	14,800	15,800	16,900	18,400	18,400

(1) Constant levels of activity, costed and adjusted by an index of field service unit costs.

Laboratory Involvement Costings (Cont'd)

Programme B - Investigations and Vaccination

Had the alternative programme continued, levels of laboratory work could have varied widely according to how much investigational work would have been done on diagnosis and methods of immunisation. However, detailed projections did not appear justified as the cost seemed unlikely to represent a major portion of costs avoided. It was therefore estimated that under Assumption I a level of activity comparable to that in fact experienced in 1963 would have been maintained indefinitely while for Assumption II laboratory activity would have been at a much lower average level, based on appromately 2/3rds the numbers of tests done in 1963.

A large majority of these costs related to staff. To obtain the corresponding costs for 1964 to 1970 of these constant levels of activity, the 1963 costs were adjusted by an index derived from the field service unit costs for each year (Appendix IX) since these involved staff on similar salary scales.

It was equally difficult to predict the usage of Crystal Violet Vaccination in the alternative programme. However, with either assumption the minimum level would not have been less than that of 1962, which represented 0.22 times the June census figure. When this factor was applied to the census figures or projections for succeeding years it gave probable numbers to be vaccinated which roughly correlated with those obtained by taking 10% of recorded slaughterings (equivalent to Beynon's throughput). The census data was used rather than the latter because adult stock constituted a substantial proportion of the total vaccinated.

The cost of each vaccination (Table If) was estimated by allowing $1\frac{1}{2}$ doses of vaccine per animal vaccinated at a cost of 10p per dose. Over the previous ten years there had been one reduction from the equivalent of 11p to 10p per dose. Net economies resulting from increased volume of production were minimal because correspondingly increased numbers of pigs were required. Nor were economies likely to have accrued from projected increases in vaccine application under Programme B because additional facilities would have been needed at the CVL. Consequently, no change in the price to 1970 seemed justified. Application cost per animal was calculated by applying the field service index (Appendix IX) for each year to the 1963 cost of 10p.

The anticipated numbers of vaccinations and the unit costs for each year are shown in Tables C & D.

TABLE If. PROGRAMME B. COST OF VACCINATION

	(new pence) Vaccine (1)	Application (2)	Total
1963	15	10	25
1964	15	10	25
1965	15	11	26
1966	15	12	27
1967	15	12	27
1968	15	13	28
1969	15	14	29
1970	15	15	30
1971 to 1975	15	15	30

(1) Cost of $1\frac{1}{2}$ doses at 10p.

(2) 1963 application cost times field service index.

APPENDIX II

EXAMPLES OF MARKET TRACING

Leicester Markets, 1964

The series of tracings which resulted from the connection of two confirmed outbreaks with the movement of stock through a market, serves as an illustration of this painstaking and expensive, but vital, part of a disease eradication programme. Figure IIa outlines the links between the original two cases (SF1364 and SF1436), a third (SF1361) which was also considered to be an important factor in the spread of the disease, and a total of 26 more cases.

As soon as there was evidence that infected pigs could have been present in a market, the origins and destinations of all pigs at that market were checked. The frequency of movement was such that before the disease was discovered in the contact animals, other pigs to which they had been exposed had been sent to another market. Thus two outbreaks led to the complete tracing of ten markets held in Leicester between September and November.

Tracings required 366 visits to 223 premises, i.e. 1.64 visits per tracing. Form B restrictions were applied to 101 of these premises, 13 were SR negatives and 15 were confirmed as SF cases.

The original outbreaks also involved two markets at Melton Mowbray, one at Market Bosworth and one at Rugby which led in turn to the discovery of a further eleven outbreaks. All these markets had to be traced in a similar manner.

Bury St. Edmunds Markets, 1965

Although the Leicester tracings were very extensive they were not exceptional. In another series resulting from three cases connected with nine Bury St.Edmunds market sessions in April and May 1965, 1001 premises had to be visited. As a result at least one further case was discovered.

Leicester and Melton Mowbray, 1965

In May and June 1965 another tracing arising from infection on a dealer's farm required 349 visits and revisits to 214 premises. Each of these had either supplied or received pigs at 5 different markets, thus giving an average of 43 tracings per market. Form B restrictions were applied to 74 of the 214 premises i.e. approximately one third.

Monmouthshire, 1966

In the following year, 1966, pigs responsible for a confirmed case in Herefordshire were found to have come through Hereford market from a farm in Monmouthshire. The disease on this latter farm had been introduced via Abergavenny market and led to a very complex investigation in which pigs at nine market sessions had to be traced. Of the eighteen confirmed SF cases, only two were reported by the owners. Six were recognised by practising veterinary surgeons called in to deal with an unspecified disease problem. The remaining ten were not suspected until they were discovered by veterinary officers engaged in the tracing activity. The original source of the outbreak appeared to have been improperly cooked swill containing imported bacon scraps and its extensive spread was mainly due to an owner failing to recognise and report the disease. His pigs had gone to several farms, markets and slaughtermen before the disease was discovered.

This last instance highlights the significance of epidemiological investigation. While the exercise in each case was very expensive and time consuming, it was possible to:-

a. detect cases which might have gone unreported and have been disseminating the disease for days or even weeks and

b. identify new potential sources of infection arising from direct or indirect contact, and either eliminate them immediately, because of heavy exposure, or prevent contact with other herds until freedom from the disease was assured.

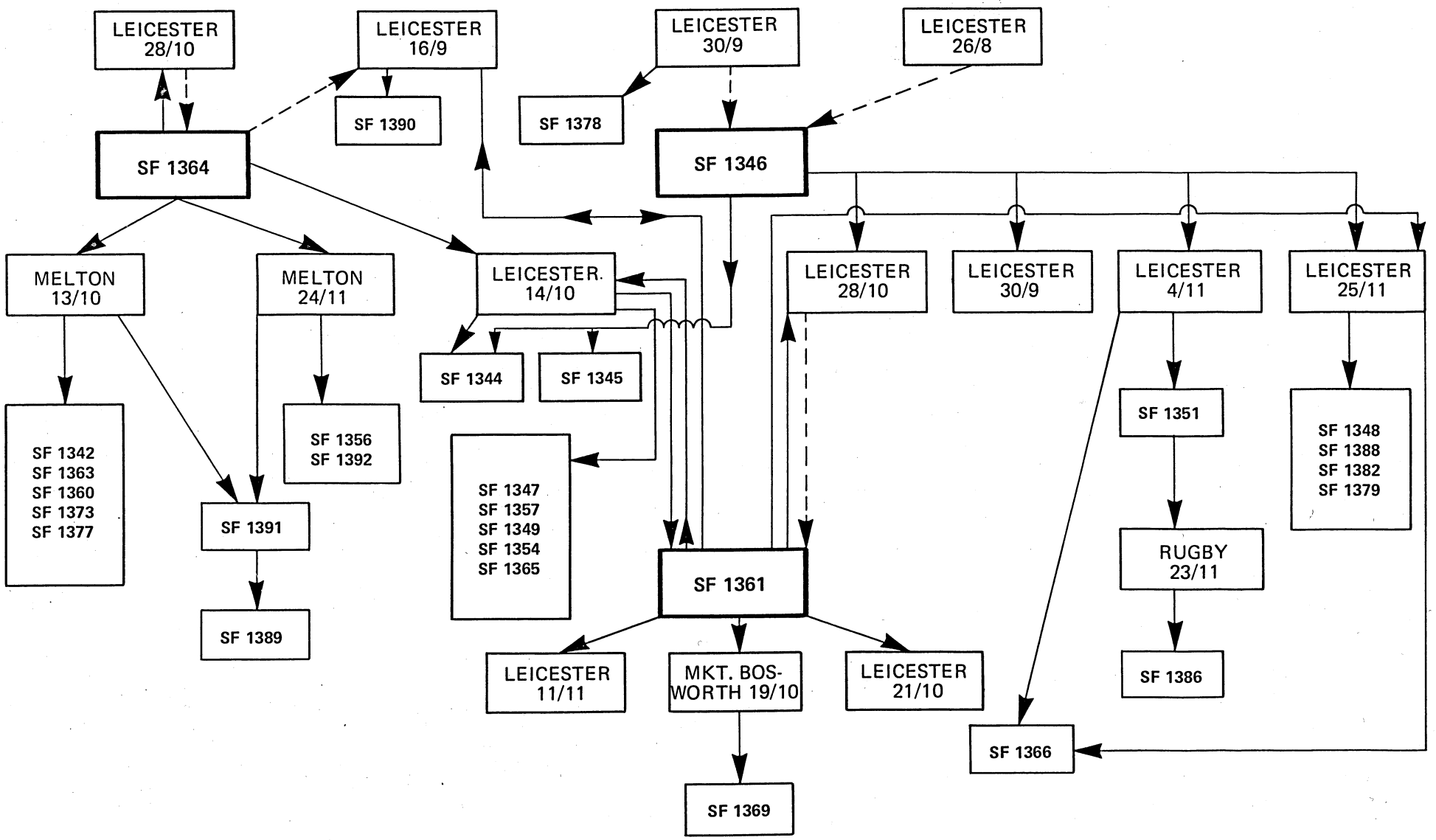


FIG. IIa LEICESTER MARKET SEPT/DEC. 1964

Costs of Tracing and Form B Restrictions

As indicated in the text a large proportion of tracing was the result of market infection and the remainder has been disregarded for the purposes of this study. In Table IIa a number of estimates have been made in the light of the following observations and assumptions.

No record of the actual numbers of tracings per year was obtainable but from the annual reports it was possible to deduce the numbers of markets involved. As the eradication campaign progressed market tracing was intensified. In the early stages only immediate contacts within the market were followed up but successes in early detection of new outbreaks and persistant focuses of infection quickly led to routine tracing of all pigs at infected markets. In the three tracings studied, the averages were Leicester (1964): 22 tracings per market, Leicester and Melton Mowbray (1965): 43 and Bury St.Edmunds (1965): 110. Descriptions of the Monmouthshire (1966) tracings suggest an intensity of investigation approaching that of Bury St. Edmunds. These isolated examples were used as a basis for estimating the average numbers of tracings per affected market which appear in Table IIa. MAFF Officers felt that the Leicester market tracing was not typical and suggested the higher figure that has been used for 1965. The figures for 1967 onward are token estimates. Analysis of two of the above tracings revealed averages of 1.64 and 1.65 visits per tracing. For costing purposes 1.5 visits/premise was assumed. These could be prearranged and were often quite short. An average of two hours per visit and reduced travel have therefore been used. Form B restrictions were applied on a reducing scale year by year. Additional work was involved when a tracing led to Form B restrictions being applied but it was not considered sufficient to justify separate treatment of such tracings. (This factor is also omitted in the analysis of Programme B)

TABLE IIa. MARKET INVOLVEMENT, RELATED TRACING AND FORM B RESTRICTIONS

	1963	1964	1965	1966	1967	1968	1969	1970
Number of Markets	80	70	50	10	-	-		-
Number of Premises per Market	20	50	60	100	-	-	-	-
Total Premises	1600	3500	3000	1000	100[2]	50[2]	50[2]	50[2]

(1) Interpolations made in 1963 and 1965 where reports were incomplete.

(2) Estimates of possible actions in connection with suspect cases.

APPENDIX III

Legislation and Orders Relevant to Swine Fever

The Diseases of Animals Act 1950:

consolidated all previous legislation relating to animal health and empowered the Minister of Agriculture to make new orders as necessary.

The Swine Fever (Infected Areas Restrictions) Order 1956:

The Swine Fever (Infected Areas Restrictions) Amendment Order 1958:

provided for restriction of movement and markets for pigs in areas where swine fever was prevalent.

The Regulation of Movement of Swine Order 1959:

prescribed licences for pigs moved from public markets, shows or dealers premises and detention for 28 days at first destination. (To reduce risk of spread by contact).

The Movement of Animals (Records) Order 1960:

The Movement of Animals (Records) Amendment Order 1961:

required all parties involved in the movement of livestock to record identities, origins and destinations of the animals. (To facilitate tracing of contacts).

The Diseases of Animals (Waste Foods) Order 1957:

prescribed additional heat treatment conditions for swill.

The Diseases of Animals (Ascertainment of Compensation) Order 1959:

defined principles on which compensation was based.

The Swine Fever Order 1963:

implemented eradication.

Precautions against Disease:-

The Importation of Carcases and Animal Products Order 1954.

indicated countries from which such imports were acceptable and defined conditions where necessary.

The Importation of Carcases and Animal Products.

(Amendment) Orders 1960, 1961, 1963, 1964, 1966, 1967 (3).

removed countries from the list and/or imposed further restrictions.

FORMS USED IN CONNECTION WITH SWINE FEVER

Form	Subject
SF1	Report by Veterinary Inspector on first inquiry as to suspected outbreak.
SF 1A	Report by Veterinary Inspector on second and subsequent inquiries as to suspected outbreak.
SF 2	Notice served by V.O. altering the limits of an Infected Place.
SF 3	Notice in Form B served by V.O.
SF 4	Notice in Form C served by V.O. cancelling Form B.
SF 5	Valuation of pigs after confirmation of swine fever.
SF 5A	Valuation of healthy pigs - continuation sheet
SF 5B	Valuation of ailing pigs - continuation sheet.
SF 6	V.O 's report on confirmed outbreak.
SF 7	Licence for movement of pigs from premises under Form B restrictions to a bacon factory or slaughterhouse.
SF 8	Notice served by V.O. requiring disinfection of certain premises (at owner's expense) where a diseased pig or carcase was found.(See also SF 31).
SF 9	Notice in Form A served by V.O.
SF 10	Notice served by V.O. cancelling Form A.
SF 11	Memorandum from D.V.O. to L.V.I., V.I.O. or owner's V.S. notifying result of diagnosis.
SF 12	Poster - Notice to pig owners.
SF 13	Notice in Form D for exhibition at entrance to Infected Place.
SF 14	(In abeyance).
SF 15	Valuation of pigs slaughtered for diagnosis.
SF 16	Letter sent from Head Office to Local Authority notifying existence of swine fever.
SF 17	Accounts Form - Owner's expenses.
SF 18	Accounts Form - Other claims.
SF 19	Memorandum from D.V.O. to Valuer requesting valuation of commercial pigs
SF 20	(Not allocated)
SF 21	Statement of disposal of pigs
SF 22	Index cards for use at Head Office.
SF 23	History sheet for use at Animal Health Office.
SF 24	Letter from D.V.O. to owner when diagnosis is inconclusive.
SF 25	Telephone Report Form (diagnosis) for use by D.V.O. at Head Office.
SF 26	SF file cover for use at Head Office.

Form	Subject
SF 27	(Not allocated).
SF 28	Information slip enclosed with specimens sent to Central Veterinary Laboratory for diagnosis.
SF 29	Envelope for despatch of a single pancreas specimen in wooden container to Central Veterinary Laboratory.
SF 30	(Not allocated).
SF 31	Notice served by V.O. imposing restrictions under Article 19 of the Swine Fever Order 1963 or requiring disinfection of premises, other than an Infected Place, at owner's expense. (See also SF 8).
SF 32	Notice served by V.O. cancelling SF 31 when used to impose restrictions under Article 19 of the Swine Fever Order 1963.

APPENDIX IV.

COSTING OF PROGRAMME A FIELD ACTIVITIES

The average amount of staff time required for each type of case and tracing (Table IVa) was based mainly on statistical records made available by MAFF. This included an allowance for Divisional Office work. Mileage, Police (LA) and farm staff involvement were estimated with the help of a number of people who had played an active part in the programme.

Related costings in Table IVb were obtained by applying pay, subsistence and mileage scales prevailing in each year.

The numbers of cases in each category in Table IVc were obtained from official reports, and those for tracings were estimated from data on affected markets (Appendix II). Using the unit costs from Table IVb the total cost of field activities was calculated for each year for transfer to Table B.

TABLE IVa. PROGRAMME A - BASIS FOR STAFF COSTINGS

	VETERINARY OFFICER			TECHNICAL ASSISTANT		POLICE		FARMER/OPERATOR	
	AV.NO. VISITS	AV.TIME (HRS)	AV. DISTANCE	TIME (HRS)	DIST. (MILES)	AV.NO. VISITS	TIME (HRS)	OWN TIME (HRS)	EMPLOYEE TIME (HRS)
NRC	1	4	30	-	-	1	2	4	2
SRCN	3.2	14.8	63	2	-	1	2	8.4	8.4
SFC	2.4	15.6	66	8	30	1	2	12.8	20.8
Tracing	1.5	3	22	-	-	-	-	-	-

TABLE IVb. PROGRAMME A - RELATED COSTINGS

	1963 £ p	1964 £ p	1965 £ p	1966 £ p	1967 £ p	1968 £ p	1969 £ p	1970 £ p
NRC	11.58	11.82	13.01	13.53	13.81	14.89	15.92	17.22
SRCN	37.21	38.08	42.64	44.75	45.60	49.47	52.70	57.01
SFC	47.85	49.25	55.38	58.73	61.21	64.77	69.23	74.72
Tracing	6.45	6.55	7.35	7.65	7.81	8.47	9.07	9.81
(1) Total	103.09	105.70	118.38	124.66	128.43	137.60	146.92	158.76

Working time and mileage costs for MAFF staff and Police were costed at the rates prevailing in each year. Working time of the farmer and his employees was costed on the basis of rates given in The Changing Structure of the Agricultural Labour Force in England and Wales.

(1) These totals were used to calculate the field service index in Table IX.

TABLE IVc. PROGRAMME A. COST OF FIELD WORK

ACTIVITIES:		NRC	SRCN	SFC	TRACINGS	TOTAL COST(£)
1963	NUMBER (NO.)	1,156	2,013	1,243	1,600	
	UNIT COST (U.C.)	11.58	37.21	47.85	6.45	
	SUB TOTALS (ST)	13,410	74,884	59,478	10,320	158,092
1964	No.	711	1,897	402	3,500	
	UC. £	11.82	38.08	49.25	6.55	
	ST. £	8,390	72,276	19,799	22,925	123,390
1965	No.	679	1,239	113	3,000	
	UC. £	13.01	42.64	55.38	7.35	
	ST. £	8,827	52,843	6,260	22,050	89,980
1966	No.	359	579	25	1,000	
	UC. £	13.53	44.75	58.73	7.65	
	ST. £	4,865	25,910	1,469	7.650	39,894
1967	No.	199	220	-	250	
	UC. £	13.81	45.60	-	7.81	
	ST. £	2,748	10,032	-	1,953	14,733
1968	No.	73	64	-	100	
	UC. £	14.89	49.47	-	8.47	
	ST. £	1,087	3,166	-	847	5,100
1969	No.	64	32	-	50	
	UC. £	15.92	52.70	-	9.07	
	ST. £	1,019	1,686	-	454	3,159
1970	No.	20	23	-	50	
	UC. £	17.22	57.01	-	9.81	
	ST. £	344	1,311	-	491	2,146

NRC, SRCN & SFC Case numbers : obtained from official reports

Unit costs : from Table IVb.

Tracings : from Appendix II.

APPENDIX V

PROJECTION OF DISEASE OUTBREAKS 1963-1975.

In order to make an assessment of the benefits accruing from the eradication programme, it was necessary to project the pattern of SF which would have developed if the eradication programme had not been adopted. The data available did not lend itself to sophisticated epidemiological analysis but it was possible to piece together a picture, and elicit certain facts, on which to base trend lines:-

Historic evidence

1920-1939: Efforts were made without success, to detect a cyclical pattern, or signs of correlation between incidence and known events or changes in the pig industry. Geographical factors ought to have been considered but this was obviously impractical. Absolute numbers of outbreaks (Table Va and figure 1, page 43) showed very wide fluctuations and expressed as rates per 1000 pigs (fig Va), they showed no evidence of correlation with pig census data changes until 1941. However, a seven-year moving average did indicate a long term trend to reduced incidence.

1940-1950: Developments during and immediately after the second world war threw some light on factors involved in SF spread. There was a dramatic reduction in the size of the pig industry between 1939 and 1943 and it remained at a low level until 1948. Pig marketing came under very strict Government control, and swill was widely used for pig feeding purposes.

The seven year moving average implies a steep decline in SF incidence but it masks the high peaks of 1940 and 1944. Against this background of developments, and known characteristics of the disease, it seems justifiable to attribute the first of these peaks to the upheaval associated with the commencement of war and the second to infection through swill from increased imports of pigmeat for troops being massed to invade Europe.

Despite strengthened controls over the cooking of swill (1947) and lessened interest in swill feeding, there was steep rise in SF incidence from 1950 to 1953. This coincided with an equally steep rise in industry size and the re-establishment of normal pig marketing and slaughtering systems. It would seem, therefore, that greater freedom and extent of movement of pigs was the principal factor in SF spread at this stage.

Impact of Technical Developments

Although the pig population fluctuated fairly closely around the new high level between 1954 and 1960, recorded SF incidence declined abruptly in 1954 and then fluctuated around a fairly low level. New developments almost certainly influenced these trends.

In 1953 there was a marked increase in the amount of Crystal Violet Vaccine used; the percentage of pigs at risk which were vaccinated rose from a 1952 level of 2.6% to 7.3% (MAFF records). From then on the annual increase was very small and the long term impact may not have been great (Beynon 1962) but the vaccine must have made some contribution.

The trend lines in Fig.Vb, prepared from Table Vb, suggest that other technical factors came into play after 1956. The increased percentages of SF confirmations out of the total numbers of reports suggest that the additional diagnostic techniques (Appendix I) were beginning to detect more atypical disease. The parallel relationship between this line and the percentage of secondary cases suggests that the main gain was through tracing and other epidemiological work. It also leads to the conclusion that there was less disease entering the country to cause primary cases.

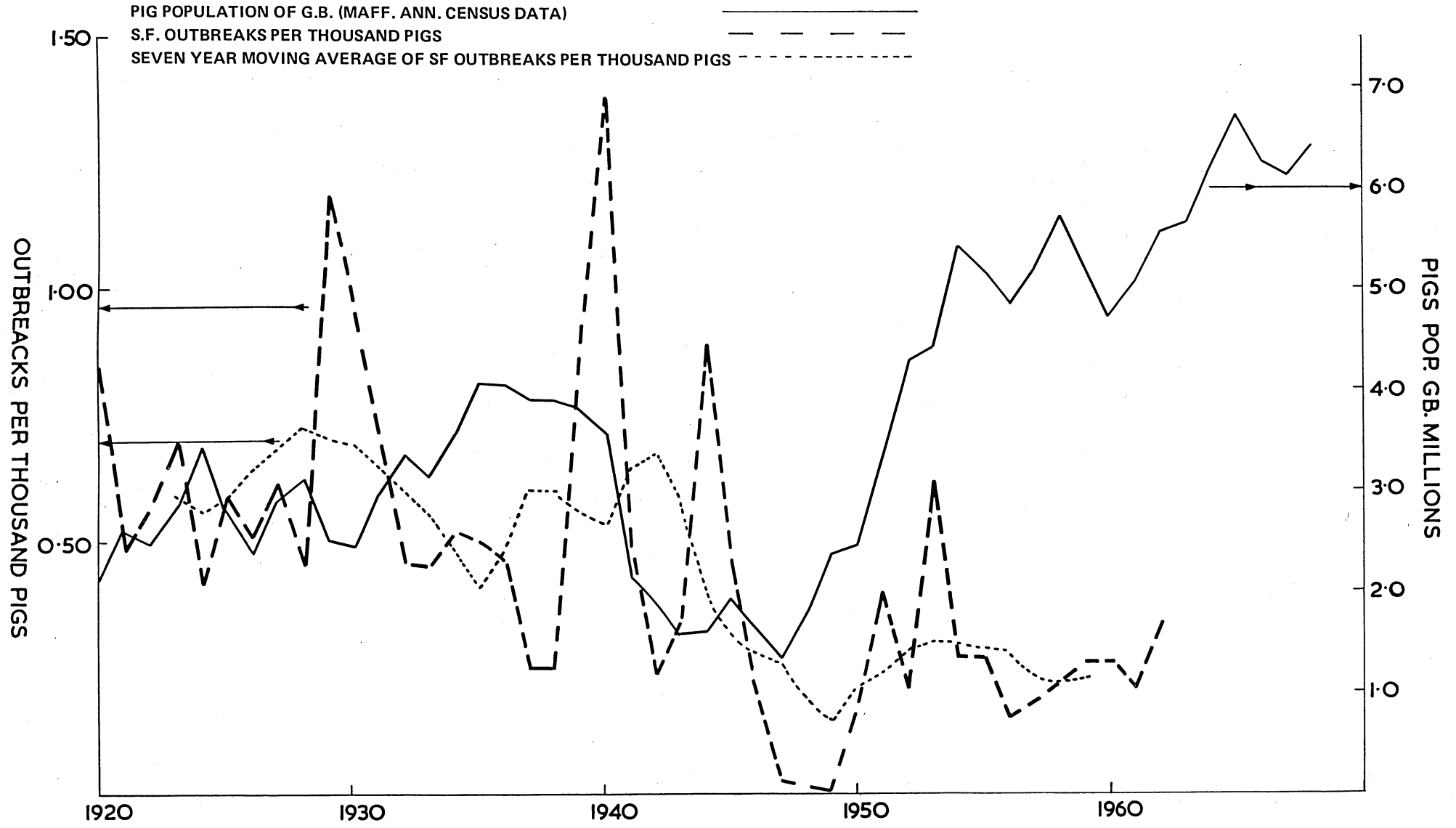


FIG. Va RELATIONSHIP OF SF INCIDENCE TO PIG INDUSTRY SIZE

TABLE Va. RELATIONSHIPS OF TOTAL SF REPORTS AND CONFIRMATIONS TO CENSUS DATA

Year	TOTAL PIGS ('000s)G.B.	TOTAL SF REPORTS	TOTAL SF CONFIRMATIONS	REPORTS PER THOUSAND PIGS	SFCs PER THOUSAND PIGS
1920	2122	10,694	1816	5.04	0.86
21	2651	9,507	1285	3.59	0.48
22	2450	9,241	1390	3.77	0.57
23	2798	11,768	1968	4.21	0.70
24	3427	10,921	1441	3.19	0.42
1925	2799	9,202	1643	3.29	0.59
26	2345	7.642	1200	3.26	0.51
27	2888	11,170	1794	3.87	0.62
28	3167	9,958	1472	3.14	0.46
29	2509	12,325	2981	4.91	1.19
1930	2454	13,746	2408	5.60	0.98
31	2945	13,499	2026	4.58	0.69
32	3350	11,576	1555	3.46	0.46
33	3236	11,036	1414	3.41	0.45
34	3526	14,192	1833	4.02	0.52
1935	4074	15,541	2049	3.81	0.50
36	4040	15,233	1873	3.77	0.46
37	3883	11,576	982	2.98	0.25
38	3822	11,759	951	3.08	0.25
39	3767	16,690	3286	4.43	0.87
1940	3631	17,385	5019	4.79	1.38
41	2207	8,462	1088	3.83	0.49
42	1872	6,248	451	3.34	0.24
43	1571	5,499	547	3.50	0.35
44	1639	8,771	1449	5.38	0.89
1945	1903	7,476	928	3.93	0.49
46	1644	4,895	347	2.98	0.21
47	1294	3,535	37	2.73	0.03
48	1816	5,211	27	2.87	0.02
49	2364	5,996	5	2.54	0.00
1950	2463	6,130	430	2.49	0.17
51	3306	9,987	1343	3.02	0.41
52	4287	8,783	891	2.05	0.21
53	4406	11,660	2713	2.65	0.62
54	5431	7,809	1455	1.44	0.27
1955	5157	5,864	1403	1.14	0.27
56	4821	4,278	741	0.89	0.15
57	5232	4,313	960	0.82	0.18
58	5695	4,462	1263	0.78	0.22
59	5135	3,792	1321	0.74	0.26
1960	4739	3,584	1213	0.77	0.26
61	5009	3,096	1071	0.62	0.21
62	5540	4,096	1874	0.74	0.34
63	5670	4,412	1243	0.78	0.22
64	6227	3,010	402	-	-
1965	6731	2,031	113	-	-
66	6277	963	25	-	-
67	6131	419	-	-	-
68	6425	137	-	-	-
69	NA	96	-	-	-
1970	NA	43	-	-	-

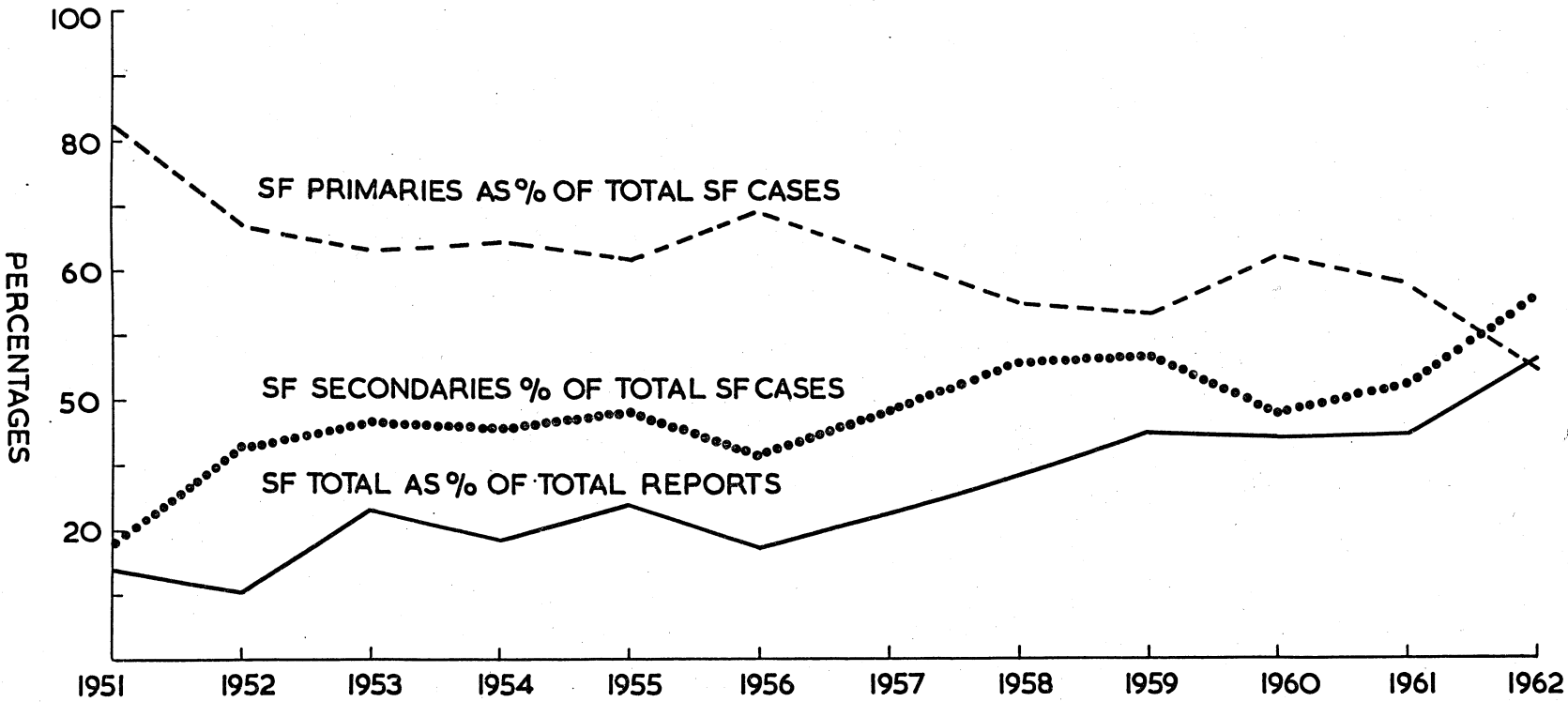


FIG. Vb RELATIONSHIPS BETWEEN PRIMARY SF CASES, SECONDARY CASES AND TOTAL REPORTS

TABLE Vb. RELATIONSHIPS BETWEEN PRIMARY SF CASES, SECONDARY CASES AND TOTAL REPORTS

YEAR	TOTAL (TR) REPORTS	SFC TOTAL	SFCs % OF TR	SFC PRIMARY	SFC PRIM AS % OF SFC TOTAL	SFC SECONDARY	SFC SECONDARY AS % OF SFC TOTAL
1951	9,987	1,343	13.4	1,107	82.4	236	17.6
1952	8,783	891	10.1	599	67.2	292	32.8
1953	11,660	2,713	23.2	1,718	63.3	995	36.7
1954	7,809	1,455	18.6	935	64.3	520	35.7
1955	5,864	1,403	23.9	866	61.7	537	38.2
1956	4,278	741	17.3	510	68.8	231	31.2
1957	4,313	960	22.3	595	62.0	365	38.0
1958	4,462	1,263	28.3	694	54.9	569	45.1
1959	3,792	1,321	34.8	702	53.1	619	46.9
1960	3,584	1,213	33.8	753	62.0	460	37.9
1961	3,096	1,071	34.6	619	57.8	452	42.2
1962	4,096	1,874	45.8	825	44.0	1,049	56.0

TABLE Vc. RELATIONSHIPS BETWEEN AVERAGE HOLDING SIZE AND SFC SIZE

	1 PIG POP. G.B. '000s	2 PIG HOLDINGS GB '000s (1)	3 AVERAGE HERD SIZE	4 TOTAL SFCs	5 SFCs AS % PIG HOLDINGS	6 TOTAL PIGS IN AFFECTED HERDS	7 AV.PIGS PER SFC	8 SFC PIGS AS % TOT. PIGS(4)	9 RATIO SFC TO AV.HERD SIZE (3)
1948	1,816	206.1	8.8	27	-	-	41.2	-	4.68
1951	3,306	NA	NA	1,343	-	91,934	68.5	2.78	-
1952	4,287	NA	NA	891	-	63,554	71.3	1.48	-
1953	4,406	NA	NA	2,713	-	197,388	72.8	4.48	-
1954	5,431	NA	NA	1,455	-	146,043	100.4	2.69	-
1955	5,157	(2) 164.2	31.4	1,403	0.85	143,350	102.2	2.78	3.57 (2)
1956	4,821	NA	NA	741	-	87,830	118.5	1.82	-
1957	5,232	155.8	33.5	960	0.62	121,787	126.9	2.33	3.79
1958	5,695	150.9	37.8	1,263	0.84	170,943	135.3	3.00	3.58
1959	5,135	NA	NA	1,321	-	161,649	122.4	3.15	-
1960	4,739	121.0	39.0	1,213	1.00	184,744	152.3	3.90	3.90
1961	5,009	120.3	42.0	1,071	0.89	177,417	165.7	3.54	3.95
1962	5,540	118.1	47.0	1,874	1.58	351,290	187.5	6.34	3.99 (3)
(Averages)					(0.94)				

(1) GB holding numbers derived from England & Wales and UK statistics.

(2) Based on "1 in 21" sample quoted by Thornton.

(3) The subsequent ratios were 1963: 4.33, 1964: 4.76 1965: 5.74, 1966:4.63

(4) Column 6 ÷ Col. 1 x 100

While it could not be said that new regulatory measures such as "The Infected Area Restrictions Order" (1956, and 1958 amendment) and "The Regulation of Movement of Swine, Order" 1959 reduced incidence, they probably slowed the rate of increase and facilitated tracing.

Influence of Industry Structure

Since each outbreak signified a holding affected, incidence rates would, undoubtedly, have been more useful if they could have been expressed in terms of totals and types of pig holdings in Britain, in all of the years considered. Unfortunately holding data was not routinely recorded until 1957, (and then only for England and Wales) and no distinction was made between fattening and integrated (breeding and fattening) herds until after 1962.

Despite these limitations, incorporation of available holding data did throw additional light on the character of herds affected and broaden the basis for SF outbreak projections. Column 5 of Table Vc shows the percentage of affected holdings for most years from 1955 to 1962 and indicates a rising trend with an average of 0.94 outbreaks per 100 herds. From Column 9 it would appear that the average affected herd was consistently between 3.5 and 4 times the average herd size from 1955 to 1962. (It was even higher in the years 1963 to 1966).

Census data for years subsequent to 1963 revealed that herds without breeding stock, presumably devoted exclusively to fattening, represented 30% of total holdings. When the ratios of sows to other pigs in herds affected in the years 1956 to 1958 is compared with that of normal herds, as shown in the following table, it appears that about 50% of outbreaks must have occurred in herds with no breeding stock.

TABLE Vd.

NUMBER OF PIGS IN SF HERDS AT TIME OF CONFIRMATION

	1956	1957	1958	MLC * 1970
Number of outbreaks	741	960	1,263	-
" " Boars	232	395	463	5
" " Sows	2,720	4,660	5,934	100
" " Other pigs	68,953	94,291	135,222	1,065
	71,905	99,346	141,619	-
Ratio Sows : Other Stock	25.4	20.3	22.8	10.7

*Derived from Table 84 Pig Facts 1971.

This conclusion is consistent with the views of experienced observers and the knowledge that movement of store stock through markets was one of the principal means of SF spread.

Average holding size increased rapidly between 1963 and 1969 and this trend is continuing. In view of the above evidence on herd size and structure relationships it seemed appropriate to correlate SF outbreak projections with expected herd size and numbers. The projections D in Columns 1, 2 and 3 of Table Vg are derived from OECD(1968 extrapolations of the U.K. pig population to 1985 with interpolations agreed with MAFF. Herd size averages are based on a linear extrapolation of the known trend line to 1968. In fact, as indicated in a footnote to the table, these projections are already proving conservative. However, resulting errors underestimate the significance of outbreaks avoided by eradication.

Numbers and Size of Outbreaks assumed to have been avoided.

The amount of swine fever that would have occurred from 1963 onward would have depended on the interaction of the many factors. While a reduction in incidence is implied

by the long term trend line, a number of new factors were operating in the post-war period which would have had conflicting effects on the pattern of disease.

Improved detection of the disease and strengthened control measures should eventually have led to reduction of secondary outbreaks, while further restrictions on the importation of dangerous pig products from infected countries and a general reduction in levels of infection in these countries should have reduced the incidence of true primary outbreaks. Increasing vertical integration, with breeders supplying weaners directly to certain fattening units which, in turn, delivered fatstock direct to certain meat processors would have helped to reduce multiple contact infection. Improved hygiene and management, perhaps with increased amounts of vaccination, would also have been favourable factors.

To set against these factors would have been the rapidly increasing average size of holdings which meant more pigs at risk in each case and greater frequency of movements especially to and from fattening units. As mentioned above, the average affected herd was much larger than the national average herd size. Vertical integration could have removed some of the risk associated with the volume of movements per holding, but the steady proportion of store pig sales through markets 1958 to 1965 (Table Ve) to total slaughterings implies that partial or complete integration had no significant effect on the marketing of the most dangerous age-group. Continuance of swine fever might eventually have accelerated integration and diminished store market sales but there was no trend in this direction prior to eradication and, following it, sales through store markets increased.

To these considerations must be added the important fact that the slaughter for food of apparently healthy pigs from infected holdings would have continued. With the difficulties of cooking swill and detecting early clinical disease this would have perpetuated a major source of further infection. Furthermore the problem of recovered carrier sow would have persisted until additional control measures could be devised.

Evidence from other countries which have not yet adopted swine fever eradication schemes (Table Vf) indicates that even with the further improved diagnostic methods and vaccines that have become available since 1962, periodic upsurges of the infection continued to occur. While Britain's island status would exclude infection across the land borders, the recurrence of a single outbreak in a swill feeding establishment in Yorkshire in 1971 implies that the threat of the disease from overseas sources did persist.

ASSUMPTIONS

Since mathematical technique could not be carried further, two assumptions were formulated in the light of the above considerations. These are depicted in Fig.Vc and assume that:-

I. The short term upward trend in outbreaks per hundred holdings would have risen to 2, levelled, then declined steadily to 1.0 by 1975. This hypothesis assumed that increasing herd size and movement, coupled with the risks of swill contamination, would have had an over-riding near term influence if eradication had not been begun in 1963. However, from 1966 onward improved diagnosis and the strengthened controls likely to have been devised would have steadily reduced incidence to historically low levels by 1975, or that,

II. The long term declining trend in numbers of outbreaks and outbreaks per thousand pigs would have been resumed but that the incidence relative to holding numbers would have remained steady at 1%. This assumption implied a measure of equilibrium between the increasing risks of infection due to larger herd size on the one hand, and improving diagnosis and control measures on the other.

Several other assumptions were tested but proved untenable because they implied trends in numbers of outbreaks, or of animals affected, which were incompatible with epidemiological evidence.

The application of these assumptions and the associated figures are discussed in Chapter 5 of the main text.

The number of outbreaks (SFCs) for each year (Table Vg. Columns 5 and 8) were obtained by applying the percentage of holdings affected to the recorded or projected numbers of holdings (Columns 2, 4 and 7). Fig.Vd shows the resulting SFC estimates alongside the recorded SFC numbers from 1951 to 1962.

To obtain the total numbers of animals in affected herds (Columns 6 & 9 Table Vg) for each year, the average herd size (Column 3, Table Vg) was multiplied by 3.5 (Table Vc) and by the number of SFCs.

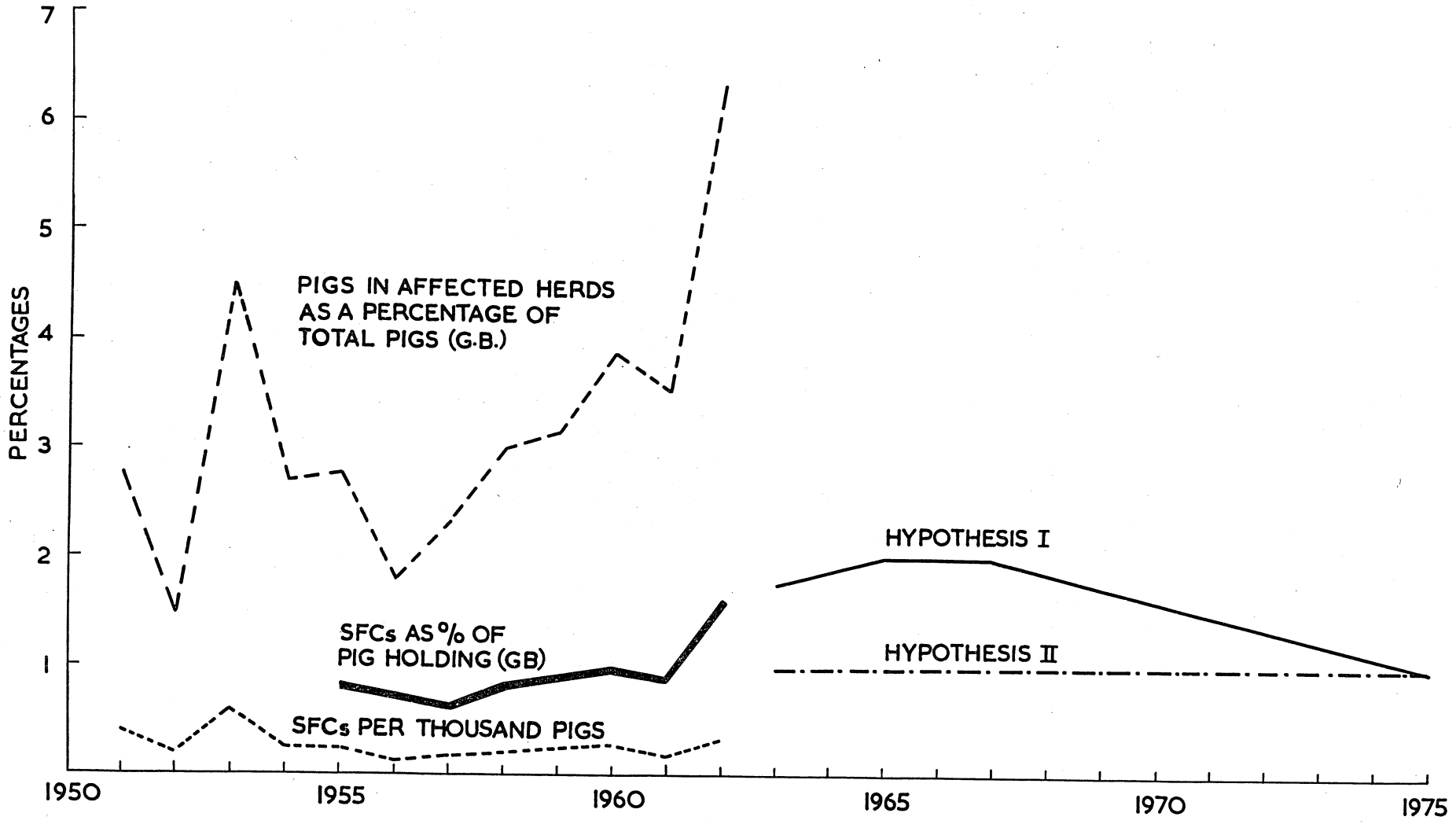


FIG. Vc RELATIONSHIPS: SFCs AND PIG INDUSTRY STRUCTURE

TABLE Ve. RELATIONSHIP OF STORE PIGS SOLD THROUGH MARKETS TO TOTAL SLAUGHTERINGS

	STORE PIGS SOLD THROUGH MARKETS	TOTAL PIGS SLAUGHTERED U.K. '000s	% STORES/TOTAL PIGS SLAUGHTERED
1958	5,117,243	11,016	46%
1959	5,260,453	10,827	48%
1960	5,224,724	10,272	48%
1961	4,885,617	10,729	46%
1962	5,337,880	12,060	44%
1963	4,235,810	12,200	35%
1964	6,043,855	12,802	47%
1965	6,098,415	14,315	43%
1966	7,223,185	13,498	53%
1967	7,611,320	12,340	62%
1968	7,317,800	12,987	56%
1969	9,222,846	14,028	66%

Source: MLC Market Records

TABLE Vf. SWINE FEVER : OUTBREAKS IN OTHER EUROPEAN COUNTRIES

YEAR	WEST GERMANY	BELGIUM	FRANCE	HOLLAND	PORTUGAL	SPAIN
1959	222	163	212	1,317	1.227	309
1960	404	109	392	1,519	1,246	336
1961	2,823	215	727	1,728	4,287	199
1962	2,366	1,705	1,350	512	751	251
1963	1,553	647	662	974	475	816
1964	769	507	711	781	529	250
1965	351	337	116	1,118	590	392
1966	1,908	184	50	473	363	430
1967	517	283	32	333	241	314
1968	142	316	137	283	252	241
1969	106	390	161	144	162	425
1970	343	433	130	927	202	554

TABLE Vg. PROGRAMME B - SFC PROJECTIONS AND ESTIMATE ANIMALS INVOLVED.

	1	2	3	4	5	6	7	8	9
				ASSUMPTIONS I			ASSUMPTIONS II		
	G.B.PIG POP MILLIONS	G.B.PIG HOLDINGS THOUSANDS	AV.HERD SIZE	% HOLDINGS	SFCs	TOTAL PIGS IN AFFECTED HERDS (2) '000s	% HOLDINGS	SFCs	TOTAL PIGS IN AFFECTED HERDS(2) '000s
1963	5.7	110.0	51	1.750	1925	343.6	1%	1100	196.4
1964	6.2	108.0	58	1.875	2025	411.1	1.00	1080	219.2
1965	6.7	103.1	65	2.000	2062	469.1	1.00	1031	234.6
1966	6.3	89.0	70	2.000	1780	436.0	1.00	890	218.1
1967	6.1	80.3	76	2.000	1606	427.2	1.00	803	213.6
1968	6.4	(3) 79.3	81	1,875	1488	421.8	1.00	793	224.8
1969	6.6	(1) 76.7	86	1,750	1342	403.9	1.00	767	230.9
1970	(1) 6.9	(1) 75.0	92	1,625	1219	392.5	1.00	750	241.5
1971	(1) 7.1	(1) 73.2	97	1,500	1098	372.8	1.00	732	248.5
1972	(1) 7.4	(1) 71.8	103	1,375	987	355.8	1.00	718	258.8
1973	(1) 7.7	(1) 71.3	108	1,250	891	336.8	1.00	713	269.5
1974	(1) 8.0	(1) 70.8	113	1,125	797	315.2	1.00	708	280.0
1975	(1) 8.2	(1) 69.5	118	1,000	695	287.0	1.00	695	287.0

(1) O.E.C.D./MAFF Projections

(2) Average SFC assumed to be 3.5 times Av.Herd Size (see text). Total pigs Col.6 = Col.3 x Col 5 x 3.5. Total pigs Col.9 = Col.3 x Col.8 x 3.5.

(3) 1968 projected number of holdings was higher than census figure indicating accelerating concentration.

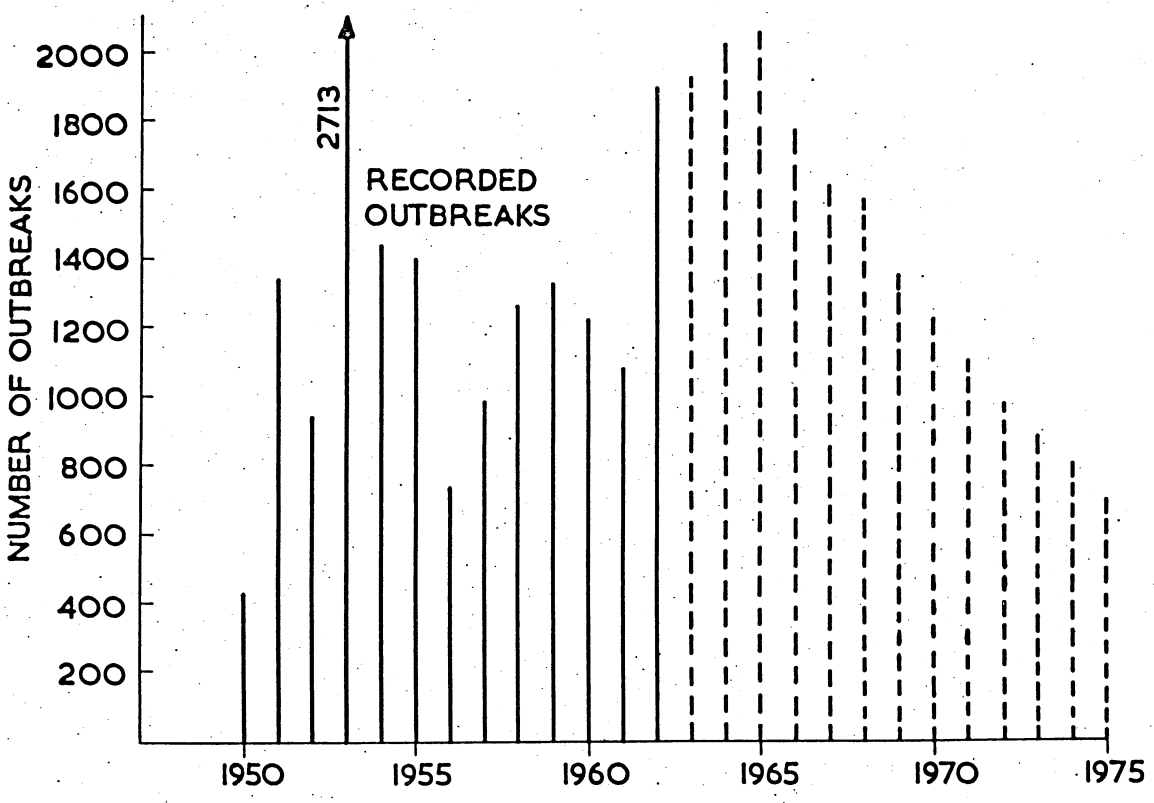


FIG. Vd ASSUMPTION I PROJECTED SFCs

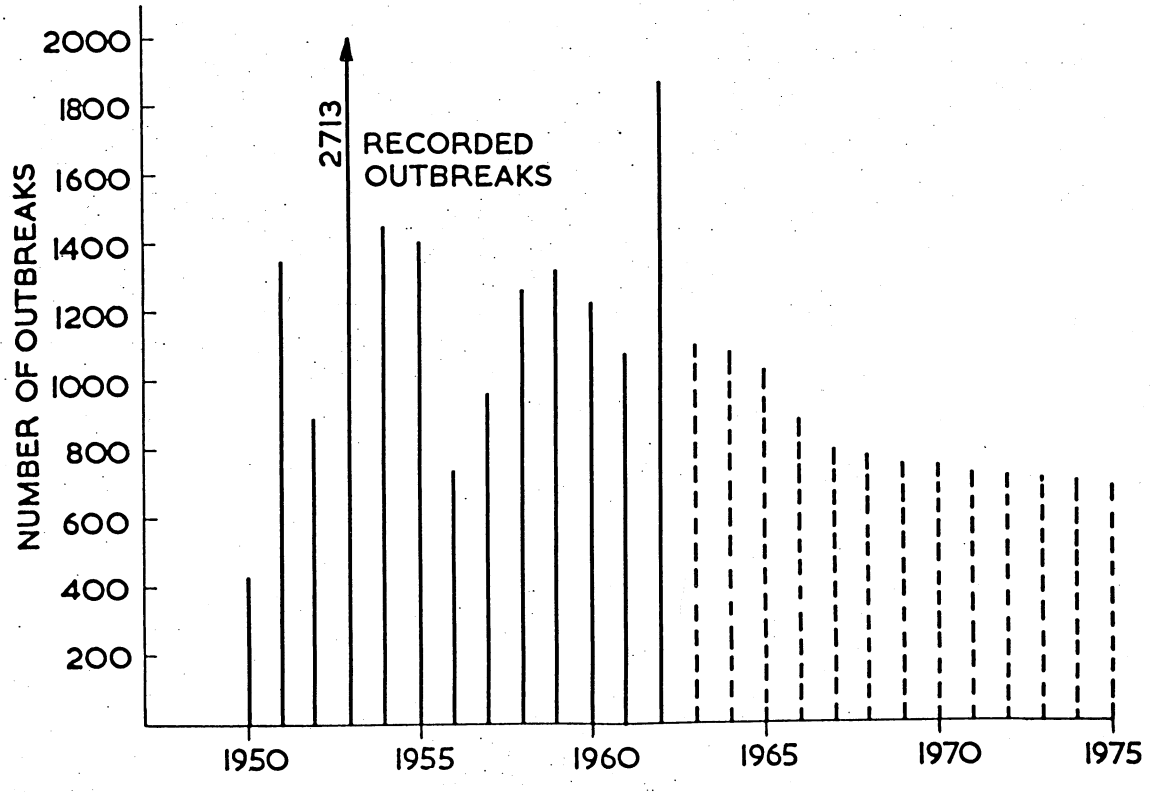


FIG. Vd ASSUMPTION II PROJECTED SFCs

APPENDIX VI : PROGRAMME B FIELD ACTIVITIES

The time and distance involved in each type of case and tracing (Table Vla) were estimated with the help of staff who had played an active part in the SF programme in 1962 and earlier years.

Unit costs in Table Vlb were calculated at prevailing rates in each year.

The numbers of cases in each category in Tables Vlc and Vld were calculated from the SFCs estimated in Assumptions I and II (Appendix V) according to the ratio 2 SFC : 2 SRCN : I NRC discussed in Chapter 5. The annual cost of field activities in Programmes B/I and B/II were obtained for Tables C & D by applying the unit costs from Table Vlb. (Appendix VI).

TABLE Vla. - 1. BASIS FOR STAFF COSTINGS PER CASE INVESTIGATED

	VETERINARY OFFICER			TECHNICAL ASST.		POLICE		FARMER/OPERATOR	
	No.Visits (1)	Time (hrs)	Distance Miles	Time (hrs)	Distance (miles)	No. Visits	Time	Own Time	Staff Time
NRC	1	4	30	-	-	1	2	4	2
SRCN	3.0	14	60	2	-	1	2	8	8
SFC	3.5	18	68	4	15	1	2	12	12
TRACING	1.5	3	22	-	-	-	-	-	-

(1) Based on limited pre-eradication statistics

TABLE VIb. PROGRAMME B. UNIT COSTS OF EACH TYPE OF INVESTIGATION

	1963	1964	1965	1966	1967	1968	1969	1970
	£ p	£ p	£ p	£ p	£ p	£ p	£ p	£ p
NRC	11.58	11.82	13.01	13.53	13.81	14.89	15.92	17.22
SRCN	35.44	36.29	40.61	42.61	43.53	47.13	50.19	54.29
SFC	47.03	48.24	54.08	56.92	58.20	62.93	67.09	72.53
Tracing	6.45	6.54	7.34	7.64	7.81	8.47	9.07	9.81

Working time and mileage costs for MAFF staff and Police costed at prevailing rates.

Working time of farmer and his employees was costed on the basis of rates given in "The Changing Structure of the Agricultural Labour Force in England and Wales".

TABLE V1d. PROGRAMME B, ASSUMPTION I : COST OF FIELD WORK

ACTIVITIES :		NRC	SRCN	SFC	TRACINGS (2)	TOTAL COSTS
1963	NUMBER	963	1,925	1,925	2,888	
	(1)COST(£)	11,146	70,258	90,533	18,628	190,565
1964	NUMBER	1,013	2,025	2,025	3,038	
	COST (£)	11,966	74,494	97,686	19,869	204,015
1965	NUMBER	1,031	2,062	2,062	3,093	
	COST (£)	13,414	83,738	111,513	22,703	231,368
1966	NUMBER	890	1,780	1,780	2,670	
	COST (£)	12,042	75,846	101,318	20,399	209,605
1967	NUMBER	803	1,606	1,606	2,409	
	COST (£)	11,090	79,912	93,469	18,814	203,285
1968	NUMBER	734	1,467	1,467	2,201	
	COST (£)	10,922	69,186	92,318	18,642	191,068
1969	NUMBER	671	1,342	1,342	2,013	
	COST (£)	10,683	67,354	90,035	18,258	186,330
1970	NUMBER	610	1,219	1,219	1,829	
	COST (£)	10,521	66,232	88,414	17,942	183,109
1971	NUMBER	549	1,098	1,098	1,647	
	COST (£)	9,454	59,610	79,638	16,157	164,859
1972	NUMBER	494	987	987	1,481	
	COST (£)	8,498	53,638	71,587	14,529	148,252
1973	NUMBER	446	891	891	1,337	
	COST (£)	7,672	48,426	64,624	13,116	133,838
1974	NUMBER	399	797	797	1,196	
	COST (£)	6,862	43,324	57,806	11,733	119,725
1975	NUMBER	348	695	695	1,043	
	COST (£)	5,984	37,786	50,408	10,232	104,410

(1) Cost = Number of cases or tracing X unit cost from Table V1b.

(2) Tracings = 1.5/SFC (See Chap.5).

TABLE VIe. PROGRAMME B, ASSUMPTION II : COST OF FIELD WORK

ACTIVITIES :		NRC	SRCN	SFC	TRACINGS	TOTAL COST
1963	NUMBER	550	1,100	1,100	1,650	
	COST £	6,369	38,984	51,733	10,643	107,729
1964	NUMBER	540	1,080	1,080	1,620	
	COST £	6,383	39,194	52,099	10,595	108,271
1965	NUMBER	516	1,031	1,031	1,547	
	COST £	6,567	41,910	52,756	11,355	112,588
1966	NUMBER	445	890	890	1,335	
	COST £	6,021	37,922	50,659	10,199	104,801
1967	NUMBER	402	803	803	1,205	
	COST £	5,545	34,998	46,735	9,411	96,689
1968	NUMBER	397	793	793	1,190	
	COST £	5,904	37,420	49,903	10,079	103,306
1969	NUMBER	384	767	767	1,151	
	COST £	6,106	38,546	51,458	10,440	106,550
1970	NUMBER	375	750	750	1,125	
	COST £	6,458	40,718	54,398	11,036	112,610
1971	NUMBER	366	732	732	1,098	
	COST £	6,303	39,740	53,092	10,771	109,906
1972	NUMBER	359	718	718	1,077	
	COST £	6,182	38,980	52,077	10,565	107,804
1973	NUMBER	357	713	713	1,070	
	COST £	6,139	38,762	51,714	10,496	107,111
1974	NUMBER	354	708	708	1,062	
	COST £	6,096	38,438	51,351	10,418	106,303
1975	NUMBER	348	695	695	1,043	
	COST £	5,984	37,786	50,408	10,231	104,409

(1) Cost - Number of Cases or Tracings X Unit Cost from Table Vlb.

(2) Tracings = 1.5/SFC (See Chap.5 .)

APPENDIX VII

SWINE FEVER CASE HISTORIES

The following notes were prepared following interviews with a series of farmers, arranged with the help of the Meat and Livestock Commission:-

SHROPSHIRE, CHESHIRE, STAFFORDSHIRE.

1. Outbreak Confirmed 16/1/61.

At the time the breeding herd consisted of 30-40 sows and progeny were fattened through to bacon weight in a house holding 300. The disease was introduced with an exceptional purchase of a few stores from a market to fill up the bacon house.

The outbreak was very severe and the diagnosis unquestionable. Within two days all marketable pigs (80lbs deadweight or more) were sent for slaughter and made good prices with negligible condemnations. Deaths among younger stock were numerous, particularly in piglets, but also among stores. In the latter the owner remembered destroying 28 among one lot of 60 and recalled that all eventually died or were destroyed. Three sows also were severely affected but none died.

The immediate loss was placed at between £500 and £1000. Loss from premature slaughter was not considered significant but the owner claimed that he did not succeed in re-establishing the herd satisfactorily. In fact he went out of pig production for some time and then restocked with minimal disease pigs. He now has 250 sows.

2. Outbreak Confirmed 15/9/60.

This Large White herd comprised 50-60 sows and progeny were fattened for bacon. Sows were kept outdoors at the time. Mortality was severe in young pigs up to about six weeks. All fatstock was sent away immediately and sporadic deaths continued in the remainder for many weeks. In fact the disease was said to have taken six months to run its course. An estimate at the time placed the loss at £1,000, most if not all of the pig revenue, but the pig enterprise was not costed separately from the other units.

3. Outbreak Confirmed 14/2/62.

The herd consisted of 60 Large White sows and feeding stock. Twenty of the sows and their litters were on free-range in an arc and tether system some distance from the farm buildings. The young of this group were the main sufferers and deaths continued for several weeks with the result that the premises were under restrictions for about five months. The sows were not so seriously affected but they were eventually sent for slaughter.

Thanks to very strict isolation of the infected group, the remaining 40 sows and the fattening stock were kept free of swine fever. Thus it was possible to rebuild the breeding herd with home-bred gilts in the course of the following year.

The owner and his veterinary surgeon were convinced that the disease was introduced from a nearby infected farm by rooks which descended on the piglet feeding troughs in large numbers at feeding time. No pigs had been introduced, no swill was used and their location kept them free of contact with visitors.

4. Outbreak Confirmed 8/2/63.

This outbreak also started among sows in outdoor pens. It was particularly disastrous because, with the prospect of slaughter and compensation the following month, there was no point in sending any but the fully finished stock away for slaughter. Mortality was therefore, high in the younger age groups. One lot of 50 young stores had, for example, to be destroyed. Unfortunately no more detailed figures could be obtained.

The herd was self contained and there was no obvious possibility of contact with infected farms. The owner suspected birds as the carriers.

5. Outbreak Confirmed 15/9/60.

At the time the herd comprised about 30 sows and 150 store pigs. The disease first appeared in piglets about a week old following the introduction of a number of gilts from Essex. Very heavy mortality followed in unweaned piglets ("they died like flies") and some of the 10-12 wk stores were also severely affected. All marketable pigs were sent for slaughter but the returns were poor. The owner recalled that one lorry load only made £65. He estimated that twelve months elapsed before production returned to normal.

6. Outbreak Confirmed 26/10/62.

A small herd of 35 pedigree Landrace pigs of outstanding quality was involved. The disease was suspected when two piglets died in two litters and about half their litter mates looked pale, listless and trembling. These other piglets died in a matter of hours and confirmation was quickly obtained. The affected litters and their dams were housed along with nine other sows in a farrowing unit 800 yards from the dry sow and fattening houses. All piglets in the farrowing unit were destroyed soon after confirmation to reduce the risk of further spread and eight sows were sent for slaughter for meat. The remaining three, two of which farrowed later, were retained. Four days after confirmation hyperimmune serum, imported from Yugoslavia, was given to all the remaining sows and to the boars while Weybridge crystal violet vaccine was used on the other stock.

Strict isolation, disinfection and separate feeding of the dry sows and fatstock were practiced in an effort to save these parts of the herd. Two pens of fattening pigs were sent for slaughter for pork without significant loss and the remainder were kept on to fatten as usual to bacon weight. No further signs of the disease were seen.

The loss was estimated at £1,000 at 1960 prices but the following figures gave a larger total:-

90 piglets at £5		£450
8 sows : pedigree replacement cost		
	(one at £200 and seven at £100)	
	less deadweight value (270)	£630
	Vaccine and serum applied	£150
		£1,230

Furthermore, this total did not allow for the extra labour costs incurred during quarantine nor the loss of income while the breeding herd was rebuilt and the lost potential breeding value of the dead piglets.

7. Outbreak Confirmed 8/2/62.

The owner had a 160 sow unit on an outdoor system selling weaners. This was normally a closed herd but he bought in two in-pig gilts at an auction to introduce fresh blood. Some time later, 2-3 day old pigs became ill and died. It was sometime before SF was diagnosed and most litters were affected. When the disease was confirmed the whole herd was eliminated, healthy stock and sows, which did not appear to become infected, were sold fat. Trade was not good at the time and the loss was £7,000 to £8,000.

All weaners had normally been sold to a swill feeder in Lancashire and the above owner believed that SF was also confirmed at this second farm.

YORKSHIRE

8. Outbreak Confirmed 1961

The disease broke out among piglets 3-4 wks. of age being reared outdoors and the whole herd was very severely affected. Some 600, out of 1,200, young stock were shot and buried; 60 out of the 180 sows had to be slaughtered and all fattening stock around or above minimum pork weight were sent for slaughter. CVV was normally used in all pigs and surviving stock was revaccinated.

There was a long gap before production returned to normal due to loss of gilts normally kept for breeding. However, the owner made a point of the fact that growth rates were notably higher after the fattening houses had been given 3 months rest : bacon weight was achieved 3 wks earlier than prior to SF.

9. Commentary of a Veterinary Surgeon on SF in a large fattening unit in Yorkshire (several outbreaks).

Total throughput was several thousand pigs per year. The disease appeared with incoming batches of stores, shortly after arrival, and ran its course over 3-4 wks. Mortality was usually around 20%, and in the remainder growth was retarded by about 4 wks representing a loss of about £6 (present value) per head. Some failed to develop satisfactorily due to secondary infection and from occasional batches 20-30% were sent for casualty slaughter.

10. Outbreak Confirmed August 1955 (approximately) in Wiltshire.

A small herd of pedigree Large White pigs was affected and the disease appeared in animals which had previously received crystal violet vaccine. Piglets developed severe scouring and high mortality, and other stock including maiden gilts were affected. Hyperimmune serum was used but all stock except one (or two) sows were eventually sold for slaughter. From the survivor(s) the herd was very slowly rebuilt.

The immediate loss was said to have been £6,000.

APPENDIX VIII.

ASSESSMENT OF THE LOSS TO A FARMER RESULTING FROM AN OUTBREAK OF SWINE FEVER.

Section 5.3.3 of Chapter 5 contains an explanation of the approach that has been adopted for this element of the study. Losses comprised mortality, reduced value of animals sent prematurely to slaughter, delayed growth in infected pigs which recovered and loss of income until normal production levels were restored. It was not possible to collect suitable financial data from farms known to have been infected prior to eradication, so a method of assessing losses from known physical effects, with the aid of elementary mathematical models of pig herds, was devised. Mortality was dealt with as a separate item and the other three were assessed together, as an "operating loss," by means of their effect on the cash flow pattern of the model herds.

1. Data Sources

a. S.F.Case Histories: (Appendix VII) No detailed financial loss data was available but information on physical losses supported information gathered in discussion with veterinarians, farmers and others involved in the livestock industry.

b. Annual Statistics 1938 to 1956 quoted by Wilsdon (1958) and partially extracted in Table VIIIa.

c. Annual Summaries in reports of the Animal Health Services in Great Britain 1956 to 1962 : numbers of animals in affected herds and other material, also used in Appendix V.

d.(i)Pig Facts 1971, Meat and Livestock Commission, (ii) Economics of Pig Production, Ridgeon R.F. and Sturrock R.G. (1969) : data on characteristics and costings of pig herds.

2. Mortality Losses

From Table VIIIc,based on Wilsdon's (1958) table, it may be concluded that average mortality attributed to swine fever among all pigs on premises during SF outbreaks, including those born or moved on during the quarantine period, was 20.4%.

TABLE VIIIa. A WEIGHTED AVERAGE VALUE FOR PIGS WHICH DIED OR WERE DESTROYED DUE TO SWINE FEVER.

	NUMBERS (3)	RELATIVE NUMBERS	ESTIMATED UNIT VALUE	AGGREGATE VALUE	WEIGHTED AVERAGE VALUE (1970)
			£ (2)	£	£
Sows	4,827	1	23	23	-
Boars	374	0.08	29	2.4	-
Unweaned Piglets	58,648	10(1) (12.2)	2	20	-
Fattening Pigs	43,227	8.1	13	105.3	-
Store & Other	46,663	9.7	9	87.3	-
Totals	153,739	28.88	-	240.0	8.3

(1) reduced to exclude deaths from other causes during first 28 days of outbreak.

(2) From Pig Facts 1971

(3) Totals from first section of Table VIIIc.

The distribution of dead pigs according to age group is shown in the first column of Table VIIIa. These numbers were used to calculate the relative numbers in each age group with one sow as the starting point. The figure for unweaned piglets required adjustment because, as a matter of policy, all deaths in the first 28 days of quarantine were attributed to S.F. Other causes, mainly physical and developmental, are responsible for substantial mortality in young piglets so this element of ratio was reduced to 10.

A weighted average value for a dead pig was then deduced, using the prices suggested for each age group by MLC in Pig Facts 1971. The average thus obtained was £8.3 per pig. This was regarded as the 1970 value and the corresponding values for earlier years were calculated with the store pig price index (Appendix IX). A store price index was developed for this purpose because it was linked to replacement values. Furthermore, fat stock market prices were complicated by changes of definition and the system of guarantee payments.

Tables VIIIb and VIIId, estimating annual mortality losses, were then compiled by applying the 20.4% mortality rate to the total numbers of pigs involved according to each assumption, (Appendix V), and multiplying by the average value of a dead pig.

VIIIb. ESTIMATED FARM LOSSES : ASSUMPTION I

1. MORTALITY

	(1) NO.PIGS INVOLVED '000s	MORTALITY (20.4%) '000s	(2) AVERAGE VALUE £	LOSS £'000s
1963	343.6	70.1	6.64	465
1964	411.1	83.9	6.72	564
1965	469.1	95.7	6.31	604
1966	436.0	88.9	6.81	605
1967	427.2	87.1	7.47	651
1968	421.8	86.0	7.72	664
1969	403.9	82.4	7.72	636
1970	392.5	80.1	8.3	665
1971	372.8	76.1	8.3	632
1972	355.8	72.6	8.3	603
1973	336.8	68.7	8.3	570
1974	315.2	64.3	8.3	534
1975	287.0	58.5	8.3	486

(1) Number of pigs involved as projected in Appendix V, Table Vg. Col.6.

(2) 1970 price adjusted by Store Price Index for years 1963 to 1969.

TABLE VIIIc. MORTALITY, SURVIVAL & DESPATCH FOR SLAUGHTER (FROM WILSDON 1958)

YEAR	TOTAL NO. OF PIGS(1)	NUMBER OF PIGS WHICH DIED OR WERE DESTROYED DUE TO SWINE FEVER (2)					NUMBER OF PIGS REMAINING ON PREMISES AT DATE OF RELEASE					NUMBERS SLAUGHTERED FOR FOOD
		BOARS	BREEDING SOWS	UNWEANED PIGS	FATTENERS	OTHERS (STORES)	BOARS	BREEDING SOWS	UNWEANED PIGS	FATTENERS	OTHERS (STORES)	
1950	24,040 (22,282)	22	218	873	1,977	2,087	45	559	1,454	915	1,477	14,263
1951	91,934 (75,837)	108	1,310	8,182	4,906	7,095	264	2,354	6,527	9,230	6,776	44,713
1952	63,554 (54,756)	51	643	5,098	3,190	4,398	144	1,666	4,604	5,260	5,485	32,614
1953	197,388 (161,046)	123	1,512	16,780	9,435	13,298	434	5,425	15,352	18,886	9,000	106,059
1954	146,043 (118,673)	29	500	11,862	8,893	7,999	413	5,157	15,961	18,994	10,277	68,880
1955	143,350 (120,737)	26	446	10,553	9,485	7,841	309	4,023	8,132	20,839	10,623	69,380
1956	87,830 (71,905)	15	198	5,300	5,341	3,945	216	2,510	5,815	14,876	6,097	42,757
TOTALS	754,139 (625,236)	374	4,827	58,648	43,227	46,663	1,825	21,694	57,845	89,000	49,735	378,666
YEARLY AV.	107,734 (89,319)	53	689	8,378	6,175	6,666	261	3,099	8,263	12,714	7,105	54,095
AS % TOT. PIGS(1)	-	0.049 (0.059)	0.64 (0.77)	7.78 (9.38)	5.73 (6.91)	6.19 (7.46)	0.24 (0.29)	2.88 (3.47)	7.67 (9.25)	11.80 (14.23)	6.59 (7.95)	50.21 (60.56)

As a percentage of Total pigs Mortality = 20.39% (24.58%) Stock Remaining = 29.18% (35.14%) Slaughtered for food = 50.21% (60.56%)

(1) On premises during outbreak, including births and introductions (In brackets population at start of outbreak)

(2) Mortality (< 1%) from other causes excluded (After 28days).

VIId. ESTIMATED FARM LOSSES ASSUMPTION II.

1. MORTALITY

	(1) NO.PIGS INVOLVED ('000s)	MORTALITY (20.4%) ('000s)	(2) AVERAGE VALUE £	LOSS (£'000s)
1963	196.4	40.1	6.64	266
1964	219.2	44.7	6.72	300
1965	234.6	47.9	6.31	302
1966	218.1	44.5	6.81	303
1967	213.6	43.6	7.47	326
1968	224.8	45.9	7.72	354
1969	230.9	47.1	7.72	364
1970	241.5	49.3	8.3	409
1971	248.5	50.7	8.3	421
1972	258.8	52.8	8.3	438
1973	269.5	55.0	8.3	456
1974	280.0	57.1	8.3	474
1975	287.0	58.5	8.3	486

(1) Total pigs in affected herds from App.V Table Vg, Col.9.

(2) 1970 price adjusted by Store Price Index for years 1963 to 1969.

3. Premature Slaughter and Operating Losses

In order to assess these losses it was first necessary to deduce certain characteristics of the populations involved. The type of herd affected and policies adopted by herd owners undoubtedly influenced the extent of losses.

When the ratios of sows to other pigs involved in the years 1956 to 1958 (Table VIIIb) were compared with that estimated for normal herds (1:11.5) from MLC examples it seemed probable that about 50% of the outbreaks had occurred in herds with no breeding stock, i.e. fattening establishments. This conclusion was consistent with views of experienced observers, and the knowledge that movement of store stock through markets was one of the principal means of SF spread.

When numbers of dead and surviving sows were added for the year 1956, they totalled to the same number as were on the premises at the date of confirmation. The ratio of sows to other stock in outbreaks in this and the following years was 1:25.4. for 1956 1:20.3 for 1957 and 1:22.8 for 1958. The same sum based on dead and surviving sows for the whole period 1950-56 gave a ratio of 1:22.3 and tended to confirm that only a very small proportion of sows had been sent to slaughter. Farmers consulted had indicated that only fat and younger stock, likely to make a meat grade were despatched.

TABLE VIIIe NUMBER OF PIGS IN SF HERDS AT TIME OF CONFIRMATION

	1956	1957	1958
Number of Outbreaks	741	960	1,263
Number of Boars	232	395	463
Number of Sows	2,720	4,660	5,934
Number of Other pigs	68,953	94,291	135,222
	71,905	99,346	141,619
Ratio Sows to Other Stock	25.4	20.3	22.8
Ratio Sows : Other Stock(MLC)	11.0		

Similar arithmetical exercises led to the conclusion that surviving sows farrowing during three months of quarantine could have accounted for more than two thirds of the numbers of stock "born or moved on". In fact, purchased stores and young breeding stock could only have amounted to about 5.7% of stock to be accounted for in 1956. Confirmation of the reduced activity comes from the sow to other stock ratio of 1:9 when quarantine ceased, a figure which is well below the balance of stock in a normal breeding herd and assumes that no stock remained in any exclusively fattening unit.

Assumptions Regarding Premature Slaughter

From these deductions, the case histories and statements of Wilsdon (1958) it was evident that the pigs licenced to slaughter were, on average, considerably younger and smaller than normal. For the purposes of this study they were assumed to have been four score (80 lbs) in average dead weight.

Since the sale was a matter of urgency the farmer could not obtain the most favourable price. Furthermore, condemnations at meat inspection, due to infection or immaturity, were usually numerous. Estimates of such losses varied so widely that it was possible to do nothing more than apply an arbitrary average of 25% loss to the assumed typical (80 lb) pig sent for slaughter at pork price.

Assumptions Regarding Operating Losses

Mortality, the early removal of pigs being fattened and delayed growth of unweaned and store pigs recovering from the infection, left facilities unoccupied. The above evidence supports numerous observations to the effect that very little stock was brought in during the quarantine period.

For the purposes of this study it was, assumed, that

a. "Integrated" units, with both breeding and fattening facilities, would rebuild their herds with the unit's own progeny: and

b. "Fattening" Units would begin to restock in the third month of quarantine.

c. The animals which recovered would require an extra month to reach marketable condition.

Determination of Losses

It proved impossible to estimate the components of this loss individually without substantial "double counting" and with any degree of accuracy. However, their joint assessment when introduced into two simple mathematical models of pig herds did appear to produce useful results. Computer simulation models would simplify this task and allow for a wider variety of assessments e.g. for other types of production.

The operating characteristics of the Integrated herd were derived from a 100 sow herd, breeding and feeding progeny to cutter weight, as described in Table 82 of M.L.C.Pig Facts 1971. The detailed assumptions and procedure are listed in the preface and footnotes to Table VIIIf. Table VIIIf shows the changes in structure of the herd as it recovers production after an outbreak. Table VIIIg presents the corresponding financial picture month by month and shows a net loss of £6,418, equivalent to £64.2 per sow in the herd.

The operating characteristics of the fattening herd were derived from the above herd by deducting the costs of the weaner production section and valuing weaners bought in at the sale price of weaners (£7) used in Pig Facts 1971. Assumptions 7 to 16, and 18 also apply in this case but purchase of weaners (8 wks) and heavy stores (14 wks) recommences in the third month. Table VIIIh presents the changes and cash flow pattern for such a unit and Table VIIIj shows the effect of complete destocking, disinfection and restocking at the beginning of month two. The losses calculated are £5.9 and £6 per pig place respectively.

Results: With these unit losses, Tables VIIIK and VIII L were prepared. Column one indicates half the numbers of pigs (representing the stock in integrated herds) expected to have been involved in SF outbreaks. From this figure the number of sows involved has been calculated with the ratio 1 sow to 11 total pigs and the loss per sow (adjusted by the store price index) then used to estimate the total annual loss in integrated herds. To obtain the annual loss in fattening herds the figures in column one were multiplied by unit losses in column 5. The resulting mortality and operating loss totals are incorporated into tables. C and D. (Chapter 5.).

Explanation of Tables VIIIf and VIIIg: Characteristics Assumed for the Integrated Herd.

Breeding unit.

1. Average number of pigs reared per sow per year - 18.0
2. Sows fed 26 cwt. meal equivalent per year at £2.10/cwt.
3. Boars fed 20 cwt. meal equivalent per year at £2.10/cwt.
4. Weaners fed $\frac{1}{4}$ cwt. rearer meal each at £2.10/cwt.
5. Weaners transferred out at 40 lbs. (8 wks).
6. Herd consists of 100 sows plus 5 boars.

Fattening Unit.

7. Unit divided into store section (9-14 wks) and fattening section (15-28 wks) to correspond to SF loss statistics. Neither physical separation nor management differences are implied.
8. Food conversion ratio 3.5.
9. Cost per cwt. meal equivalent £1.80
10. Mortality due to other causes than SF 3%.
11. Liveweight at slaughter 185 lbs.
12. Half feed, labour and other costs charged for pigs which died from other causes.

Swine Fever.

13. All mortality occurs within one month after SF confirmation.
14. All stock over 14 wks sent immediately for slaughter as pork at estimated 80lbs dead carcase weight.
15. Sale price of £2.90 per score dead weight reduced by 25% to cover condenmations from disease and immaturity giving £8.70 per pig.
16. Growth of surviving store pigs and weaners transferred in during month 1, retarded by one month.
17. Replacement sows (normal rate 3/month) and boars obtained from own stock by delayed culling : no stock bought in.
18. Sales in fourth and subsequent months at cutter weight and price £18.25 per pig.

General.

The herd normally traded continuously since it was designed to represent a large group of herds scattered throughout the country.

Procedure

Table VIIIf. The stock remaining in the herd after the SF outbreak is shown against Month 1. The numbers in each group are changed month by month to reflect the normal birth and growth rates.

Table VIIIg. Value of sales and costs of feed are calculated from the numbers of animals shown in the respective columns of Table VIIIg for each month. Fixed costs and normal profit margin are pro-rated from the annual MLC standard figures listed above.

TABLE VIIIf. CHANGES EXPECTED IN, AS A RESULT OF SF, 100 SOW HERD BREEDING AND FATTENING TO CUTTER WEIGHT (BASED ON MLC PIG FACTS 1971)

	TOTAL	BOARS	SOWS	PIGLETS (0-8 WKS)	STORES (9-14 wks)	FATTENERS (15-26 wks)	NO.SOLD PER MNTH
Normal Herd	1080	5	100	300	225	450	150
*SF.Mortality	-	1	8	101	81	75	-
Premature Slaughter	-	-	-	-	-	375	-
Herd Structure at end of:							
Month 1	-	4	92	238	243	-	375
Month 2	-	4	95	281	247	96	-
Month 3	-	4	98	290	236	245	-
Month 4	-	5	100	297	228	395	-
Month 5	-	5	100	300	225	449	96
Month 6	-	5	100	300	225	450	149
Month 7	-	5	100	300	225	450	150

*Based on % mortality among stock at commencement of SF (Table VIIIc)

TABLE VIIIg. CASH FLOW CHART OF THE 100 SOW HERD IN TABLE VIIIf.

PERIOD FOLLOWING SF CONFIRMATION	A VALUE OF SALES £	B (3) COST OF FEED USED £	C (4) OTHER COSTS £	(B+C) TOTAL COST £	A-(B+C) GAIN OR (LOSS)£	D NORMAL MARGIN £	A-(B+C+D) NET GAIN OR (LOSS)
Month 1	3263(1)	932	768	1,700	1,563	124	1,439
Month 2	-	1,136	768	1,904	(1,904)	124	(2,028)
Month 3	-	1,401	768	2,169	(2,169)	124	(2,293)
Month 4	1	1,671	768	2,439	(2,439)	124	(2,563)
Month 5	*1,697(2)	1,758	768	2,526	(831)	124	(955)
Month 6	*2,634(2)	1,760	768	2,528	106	124	(18)
Month 7	*2,652(2)	1,760	768	2,528	124	124	-
Loss = £64.2 per sow in the unit						Total =	£(6,418)

(2) * Sale price = £18.23 less 3% for normal mortality = £17.68/pig.

(3) * Feed costs per month : Boars £3.5, Sows £4.55, Piglets £0.26 and fattening pigs £1.80 (adjusted for minor "rounding" error in months 5,6 & 7).

(4) *See Assumption 15 (Attach.Table VIIIf.) (4) Normal fixed operating costs per month excluding feed.

TABLE VIIIh. LOSSES IN A FATTENING HERD AIMING TO PRODUCE 1800 CUTTER-WEIGHT PIGS PER YEAR (3)
WITHOUT COMPLETE DESTOCKING

	NO.STORES (9-14 WKS)	NO.FATTENERS (15-26 WKS)	NO. SOLD	VALUE OF SALES £	COST OF (1) WEANERS £	COST OF FEED £	OTHER COSTS £	TOTAL COST(£)	GAIN OR (LOSS)£	NORMAL MARGIN £	NET GAIN OR (LOSS)£
Normal Herd	225	450	150	2,652	1,050	1,210	343	2,603	49	49	-
Mortality	81	75	-	-	-	-	-	-	-	-	-
Prem.Slaughter	-	375	-	-	-	-	-	-	-	-	-
Herd Structure at end of:											
Month 1	144	-	375	3,263	2,625	259	343	3,227	36	49	13
Month 2	48	96	-	-	-	259	343	602	(602)	49	(651)
Month 3(2)	150	246	-	-	-	713	343	1,056	(1,056)	49	(1,105)
Month 4	225	396	-	-	-	1,118	343	1,561	(1,561)	49	(1,660)
Month 5	225	450	96	1,697	672	1,210	343	2,230	(533)	49	(581)
Month 6	225	450	150	2,652	1,050	1,210	343	2,603	49	49	-
									Net Loss=£(3,984)		

(1) Original purchase price of stock being sold.

(2) Restocking commences Month 3.

(3) Assumptions 7 to 16 and 18 Page 65, apply.

$$\text{Loss per pig place} = \frac{£3,984}{675} = £5.9 \text{ (1970 prices)}$$

TABLE VIIIj. LOSSES IN FATTENING HERD AIMING TO PRODUCE 1,800 CUTTER-WEIGHT PIGS PER YEAR. COMPLETE DESTOCKING, AND REPOPULATION DURING MONTH 2.

	STORES 9-14 WKS	FATTENERS 15-26 WKS	NO. SOLD	VALUE OF SALES £	COST OF(2) WEANERS	COST OF FEED	OTHER COSTS	TOTAL COST	GAIN OR (LOSS)	NORMAL MARGIN	NET GAIN OR (LOSS)
Normal Herd	225	450	150	2,652	1,050	1,210	343	2,603	49	49	-
Mortality	81	75	-	-	-	-	-	-	-	-	-
Prem.Slaught	-	375	-	-	-	-	-	-	-	-	-
Herd Structure at end of:-											
Month 1	-	-	375 144(1)	3,263 576	3,633	-	343	3,976	(137)	49	(186)
Month 2	150	150	-	-	-	540	343	883	(883)	49	(932)
Month 3	225	300	-	-	-	945	343	1,288	(1,288)	49	(1,337)
Month 4	225	450	-	-	-	1,210	343	1,553	(1,553)	49	(1,602)
Month 5	225	450	150	2,652	1,050	1,210	343	2,603	39	49	-
										Net Loss =£(4,057)	

(1) at £4 each

(2) Original purchase price of stock being sold

(3) Assumptions 7 to 16 and 18, Table VIIIf, apply

$$\text{Loss per pig place} = \frac{£4,057}{675} = £6 \text{ (1970 prices)}$$

TABLE VIIIk. ESTIMATED FARM LOSSES - ASSUMPTION I: PREMATURE SLAUGHTER, DELAYED FATTENING AND LOST FARM INCOME

YEAR	NO.PIGS '000s	INTEGRATED HERDS			FATTENING HERD		TOTAL ALL HERDS £'000s
		SOWS '000s	LOSS/SOW £	SUBTOTAL £'000s	LOSS/PIG PLACE,£	SUBTOTAL £'000s	
1963	171.6	15.6	51.2	799	4.7	807	1606
1964	205.5	18.7	51.9	971	4.8	986	1957
1965	234.5	21.3	49.0	1,044	4.5	1,055	2099
1966	218.0	19.9	52.6	1,047	4.9	1,068	2115
1967	213.6	19.4	57.7	1,119	5.3	1,132	2251
1968	210.9	19.2	59.5	1,142	5.5	1,160	2302
1969	201.9	18.4	59.6	1,097	5.5	1,110	2207
1970	196.2	17.8	64.2	1,143	5.9	1,158	2301
1971	186.9	16.9	64.2	1,085	5.9	1,103	2188
1972	177.9	16.2	64.2	1,040	5.9	1,050	2090
1973	168.4	15.3	64.2	982	5.9	994	1976
1974	157.6	14.3	64.2	918	5.9	930	1848
1975	143.5	13.0	64.2	835	5.9	847	1682
1976	129.1	11.7	64.2	751	5.9	762	1513
1977	116.1	10.6	64.2	681	5.9	685	1366
1978	101.6	9.2	64.2	591	5.9	599	1190
1979	88.2	8.0	64.3	514	5.9	520	1034
1980	74.3	6.8	64.2	437	5.9	438	875

(1) Half estimated total pigs involved assuming half the pigs were in integrated herds.

TABLE VIII 1.ESTIMATED FARM LOSSES - ASSUMPTIONS II : PREMATURE SLAUGHTER, DELAYED FATTENING AND LOST FARM INCOME

YEAR	NO.PIGS '000s	INTEGRATED HERDS			FATTENING HERDS		TOTAL ALL HERDS £'000s
		SOWS (1) '000s	LOSS/SOW £ (2)	SUB TOTAL £'000s	LOSS/PIG PLACE £	SUB TOTAL £'000s	
1963	98.2	8.9	51.2	456	4.7	462	918
1964	109.6	10.0	51.9	519	4.8	526	1045
1965	117.3	10.7	49.0	524	4.5	528	1052
1966	109.1	9.9	52.6	521	4.9	535	1056
1967	106.8	9.7	57.7	560	5.3	566	1126
1968	112.4	10.2	59.5	607	5.5	618	1225
1969	115.5	10.5	59.6	626	5.5	635	1261
1970	120.8	11.0	64.2	706	5.9	713	1419
1971	124.3	11.3	64.2	725	5.9	733	1458
1972	129.4	11.8	64.2	728	5.9	763	1491
1973	134.8	12.3	64.2	790	5.9	795	1585
1974	140.0	12.7	64.2	815	5.9	826	1641
1975	143.5	13.0	64.2	835	5.9	847	1682
1976	143.6	13.1	64.2	841	5.9	847	1688
1977	145.2	13.2	64.2	847	5.9	857	1704
1978	145.3	13.2	64.2	847	5.9	857	1704
1979	147.0	13.4	64.2	860	5.9	867	1727
1980	148.8	13.5	64.2	867	5.9	878	1745

(1) 1 sow/11 total pigs.

(2) Adjusted by store price index 1963 to 1970

APPENDIX IX

INDICES USED TO ESTABLISH RELATIVE VALUES FOR EACH YEAR

	RETAIL PRICE INDEX (1)		STORE PIG PRICE INDEX (3)	FIELD SERVICE INDEX (3)	
	INDEX	FACTOR		INDEX	FACTOR
1963	103.6	0.74	0.80	100	0.65
1964	107.0	0.76	0.81	103	0.67
1965	112.1	0.80	0.76	115	0.75
1966	116.5	0.83	0.82	121	0.79
1967	119.4	0.85	0.90	125	0.81
1968	125.0	0.89	0.93	133	0.86
1969	131.8	0.94	0.93	143	0.93
1970	140.2	1.00	1.00	154	1.00

(1) Source:Board of Trade Statistics

(2) Derived from the average price of store pigs (8-10 wks and 12-14 wks) for each year according to MAFF reports.

(3) Derived from Grand totals of Table IVb., representing the cost of the same amounts of staff time, travel and subsistence for each year.

APPENDIX X

THE SWINE FEVER OUTBREAK - JULY 1971

The following is a report supplied by the Annual Health Division, MAFF:-

" No case of Swine Fever had occurred in the United Kingdom since 27 June 1966 until an outbreak was confirmed near Filey in the East Riding of Yorkshire on 21 July 1971.

It may not be generally realised that the East Riding of Yorkshire has the third largest pig population in Great Britain and as such suffered from this disease on numerous occasions. After the first uneasy year or two during which one felt that Swine Fever might reappear at any time, it was inevitable that a certain sense of security began to colour one's dealings with pig diseases. This was abruptly shattered in July of this year and it seems desirable that this case should be recorded, not for its unusual features, but because it followed the almost classical pattern so often seen in the past and because it brings home the need to keep this disease well in mind in one's dealings with pigs.

Location

The outbreak began on premises situated in the north eastern coastal area of the county, one mile from Filey and 6 miles from Scarborough. The owner, a landscape gardener, kept pigs supplied and disposed of by a third party. The piggery was a poorly ventilated building constructed mainly of corrugated and asbestos sheeting, lacking any form of thermo-insulation, very hot in the summer and extremely cold in the winter. The same building also housed poultry and machinery. An adjacent tin shed type of hut housed a steam injection swill processing plant comprising a boiler, a galvanised tank for raw swill and a bath used for washing bins. Close by the swill plant there was an untidy overgrown muck heap.

The disease was diagnosed as heat stroke by the owner's practitioner and symptomatic treatment was undertaken between the 1 and 15 July when a carcase was submitted to the Veterinary Investigation Centre and as a result suspected Swine Fever was reported.

SWINE FEVER INQUIRY

Symptons and post-mortem findings

When first seen 36 out of 51 pigs were found to be ailing and disease had spread to all pens except one. In all 20 pigs had died since the onset of symptoms. Pigs showed temperatures ranging from 104° to 106°F. All showed chronic unthriftiness with razor backs and a reluctance to move for long. Many showed a marked cyanosis of the ears and patchy reddening of the skin. There was some diarrhoea and coughing and posterior inco-ordination. Post-mortem findings were as reported by the VIO. Material from two pigs was despatched to Weybridge for diagnosis.

Seen two days later, symptoms remained the same. Two pigs were post-mortemed and one showed lesions indistinguishable from Swine Fever. This was a 10 to 12 week old pig in very poor condition. The ears had an intense purple colouration. The sides, ventral surface of the abdomen and extremeties of the limbs were covered in numerous haemorrhages which extended into the subcutaneous fascia. All carcase and visceral lymph glands were enlarged and haemorrhagic. The epiglottis had numerous petechiae and haemorrhages. There was some myocarditis with haemorrhages on the epicardium and the pericardial sac was full of haemorrhagic fluid. Both lungs showed numerous circular haemorrhages. The serosal surface of the stomach and large and small bowel showed numerous splashy haemorrhages which were also visible under the parietal peritoneum. Circular areas (the bases of ulcers) could be seen through the large gut wall. These areas had numerous haemorrhages. There were numerous petechiae on the gastric mucosa and also the mucosa of the large and small intestine. Typical Swine Fever ulcers were present in the large bowel and caecum. These varied in size from $\frac{1}{8}$" to $\frac{1}{2}$" in diameter, had raised edges and haemorrhagic bases. In addition there were some areas of necrosis of the bowel. The kidneys showed punctiform haemorrhages on the surface and there were numerous similar haemorrhages in the cortex and medulla. Similarly the bladder showed numerous petechial haemorrhages. Haemorrhages were also noted along the aorta. Further material was despatched to Weybridge between 16 and 19 July and Swine Fever duly confirmed. The results are summarized as follows:-

Brain (Neuropathology)	7 positive	1 negative	1 doubtful
Spleen	8 positive	1 negative	
Tonsil	5 positive	1 negative	3 no result

(Material was submitted from 9 pigs).

Tracing and subsequent action

It will be obvious that the importance of extensive tracing both to establish the origin of disease and to control the extension and spread of disease was of paramount importance. The situation was complicated by the fact that the IP owner only looked after and fed the pigs and that all movements were through an agent who kept pigs himself and who also owned pigs on another swill feeder's premises. Moreover fat pigs had been moved fromthe IP to Seamer Market in the North Riding. Extensive tracing and service of forms B where necessary was carried out in respect of pig movements, agent's vehicle movements and veterinary surgeon's movements. In addition, Seamer Market was traced in its entirety, both purchasers and vendors. It was felt that the importance of establishing an origin justified tracing to this degree.

Consequential outbreaks

It seems fortunate that given the length of time which elapsed before suspected disease was reported only two secondary outbreaks occurred. In one case disease was commencing when the premises were traced and in the other disease began whilst the pigs were under restriction and frequent inspection, so that both were confirmed in a relatively short time.

1. Outbreak (a)

This outbreak originated in store pigs purchased in Seamer Market. Disease here began in a mild form with few symptoms other than high temperatures and staggering gait with a lack of response to antibiotics. In all, four pigs became affected none died and slaughter for diagnosis resulted in laboratory confirmation. The only lesions indicative of Swine Fever found on post-mortem examination were a few petechial haemorrhages in the kidney cortex, caecal mucosa and enlarged and haemorrhagic lymph glands.

2. Outbreak (b)

The second outbreak occurred on premises housing pigs owned by the agent and transported by him in his vehicle. This was also a swill feeder and the swill used was in fact collected and delivered by the primary outbreak owner. Disease began in much the same way but ran a more acute course. Of two pigs slaughtered for diagnosis the clinical and post-mortem picture was so typical of Swine Fever that confirmation was possible without resort to the laboratory. (This diagnosis was subsequently confirmed by Weybridge.)

Origin

In the absence of any other source it must be concluded that infection in this case was swill born. The actual boiling of swill is not disputed. The nature of the plant and the fact that the owner frequently hand picked pig bones, particularly ribs and bacon rinds, from the raw swill and discarded them on the muck heap makes it highly probable that active virus reached the pigs either directly or indirectly.

The IP owner collected swill from hotels and cafes in both Scarborough and Filey. Butchers supplying these premises and the origins of their pig meat were the subject of a detailed exercise. A significantly high proportion of the bacon and ham being retailed and used in the catering trade in Scarborough and Filey was of imported origin mainly through the Port of Hull.

Conclusions

The lesson to be drawn are clear. Swine Fever can reappear at any time. Swill feeders continue to be a menace in this as in other diseases. Any disease in pigs on swill feeders' premises must be regarded with the utmost suspicion particularly where there is no response to antibiotics. Constant vigilance on swill processing plants is a very necessary part of our duties. Any confirmed outbreak of Swine Fever must be pursued with as much attention to detail as one would with any other exotic disease."

Authors comment:-

Estimated Costs

The number of animals slaughtered as a result of these three outbreaks was 195 and a total of approximately £2,200 was paid in compensation to the owners. Rough estimates of the work involved indicated that detailed costings were not justified. The net benefit estimated for 1971 in this study would not have been significantly affected.

APPENDIX XI

TABLE XIa. AN EVALUATION OF PROGRAMME A IN COMPARISON WITH PROGRAMME B/I, WITH 1963 AS THE BASE YEAR

(All values in £'000s)

YEAR	NET GAIN OR (LOSS)	RPI (1) ADJUSTMENT FACTOR	1963 VALUE	DISCOUNT FACTOR (10%)	NPV (1963)
1963	(1410)	1.00	(1410)	-	(1410)
1964	1291	0.97	1252	0.909	1138
1965	2627	0.93	2443	0.826	2018
1966	3174	0.89	2825	0.751	2122
1967	3487	0.87	3034	0.683	2072
1968	3590	0.83	2980	0.621	1851
1969	3494	0.79	2760	0.564	1557
1970	3502	0.74	2591	0.513	1329
1971	3499*	0.74	2589	0.467	1209
1972	3376*	0.74	2498	0.424	1059
1973	3232*	0.74	2392	0.386	923
1974	3075*	0.74	2276	0.350	797
1975	2827*	0.74	2114	0.319	674
TOTALS:		-	28,344	-	15,339

* at 1970 prices.

(1) Retail Price Index, Appendix IX

Net Present Value (1963) = £15,339,000

This is the hypothetical NPV of SF eradication calculated as though all costs of Programmes A & B/I had been estimated in 1963 at 1963 prices. Net benefits from 1964 to 1975 have been discounted back to 1963 values.

Average Rate of Return (Table XIb) based on the above assumptions = 80%

Cost/Benefit Ratio (Table XIc) also based on the above assumptions = 1:3.43

TABLE XIb. AVERAGE RATE OF RETURN FROM PROGRAMME A COMPARED WITH PROGRAMME B/I USING 1963 AS THE BASE YEAR

YEAR	1963 VALUES (TABLE XIa.)	(1) DISCOUNT FACTOR (80%)	DISCOUNTED VALUE
1963	(1410)	-	(1410
1964	1252	.3086	386
1965	2443	.1715	419
1966	2825	.0952	269
1967	3034	.0529	161
1968	2980	.0294	88
1969	2760	.0163	45
1970	2591	.0091	24
1971	2589	.0050	13
1972	2498	.0028	7
1973	2392	.0016	4
1974	2276	.0086	2
1975	2114	.0005	1
TOTAL	28,344	-	9

(1) Determined by trial and error using different discount rates.

A rate of 80% used to discount benefits almost eliminates net benefits from the programme. In this hypothetical case, therefore, the Average Rate of Return would be 80%

TABLE XIc. DETERMINATION OF COST/BENEFIT RATIO

YEAR	(1) 1963 VALUE OF BENEFITS	DISCOUNTED VALUE OF BENEFITS	(1) 1963 VALUE OF COSTS	DISCOUNTED VALUE OF COSTS	DISCOUNT FACTORS (AT 10%)
1963	2610	2610	4020	4020	1.00
1964	3010	2736	1758	1598	0.909
1965	3123	2580	680	562	0.826
1966	2980	2238	155	116	0.751
1967	3054	2086	20	14	0.683
1968	2987	1855	7	4	0.621
1969	2765	1559	5	3	0.564
1970	2708	1389	4	2	0.513
1971	2595	1212	6	3	0.467
1972	2504	1062	6	3	0.424
1973	2398	926	6	2	0.386
1974	2281	798	6	2	0.350
1975	2120	676	6	2	0.319
TOTAL	35,135	21,727	6,679	6,331	

(1) Annual Values from table adjusted by RPI factors in Table XIa

$$\text{Cost/Benefit Ratio} = \frac{\text{NPV OF BENEFITS (1963)}}{\text{NPV OF COSTS (1963)}} = \frac{21,727}{6,331} = 1:3.43$$

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