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The Role of Animal Health Programs in
Economic Development

by

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The Commissioned Organization is the Queensland Department of Primary Industries. Collaborating institutions in Australia are CSIRO-ANHL, Geelong, Victoria and the University of Queensland (Department of Economics; Department of Geographical Sciences and Planning). In Thailand, the collaborating institutions are the Department of Livestock Development (National Institute of Animal Health; Disease Control Division), Chiang Mai University (Department of Agricultural Economics; Department of Animal Husbandry) and Thammasat University (Faculty of Economics). The collaborating institution in Laos is the Department of Livestock and Veterinary Services. Dr F.C. Baldock, Senior Principal Epidemiologist, Queensland Department of Primary Industries is the Project Leader in Australia and Dr P. Chamnanpood, Senior Epidemiologist, Thai Department of Livestock Development is the Project Leader in Thailand. Professor Clem Tisdell and Dr Steve Harrison, Department of Economics, University of Queensland are responsible mainly for the economic component of this project.

'The overall goal of this project is to develop and evaluate the necessary tools to provide decision-makers with reliable animal health information which is placed in context and analysed appropriately in both Thailand and Australia. This goal will be achieved by improving laboratory diagnostic procedures; undertaking research to obtain cost-effective population referenced data; integrating data sets using modern information management technology, namely a Geographical Information System (GIS); and providing a framework for the economic evaluation of the impact of animal diseases and their control.

A number of important diseases will be targeted in the project to test the systems being developed. In Thailand, the focus will be on smallholder livestock systems. In Australia, research will be directed at the northern beef industry as animal health information for this sector of livestock production is presently scarce.'

For more information on *Research Papers and Reports Animal Health Economics* write to Professor Clem Tisdell (c.tisdell@economics.uq.edu.au) or Dr Steve Harrison, (s.harrison@uq.edu.au) Department of Economics, University of Queensland, Brisbane, Australia, 4072.

The Role of Animal Health Programs in Economic Development

ABSTRACT

Developing countries often face severe animal health problems, with a number of endemic diseases, and lack resources to put in place the animal health programs of more developed nations. The social costs including lost trade opportunities as a result of animal diseases often exceed the private costs to livestock producers. Improved animal health is a means of promoting sustainable development¹ through more efficient resource use, additional export earnings to finance economic growth, improved livelihood of livestock producers and increased animal welfare.

Economic analyses of animal health programs have frequently considered only some of the relevant cost and benefit categories, and have sometimes used inappropriate cost and benefit measures.

This paper will examine the relationship between animal health programs and economic development, particularly in relation to development of the livestock sector, trade gains and export-led growth. Comments will be made on animal health programs in relation to foot-and-mouth disease (FMD) in Thailand as a case study

Keywords: animal health programs, export-led growth, foot and mouth disease, Thailand.

JEL Codes: O13, Q160

¹ “Sustainability” is used here in a broad sense, including socio-economic sustainability. Whether improved animal health promotes ecological sustainability is a debatable question, since the result is likely to be increased livestock numbers, which could be at the expense of more intensive industries (cropping) or less intensive land use (forestry).

The Role of Animal Health Programs in Economic Development

1. National Development Goals in Relation to Animal Industries

Developing countries typically suffer from inadequate veterinary services, such as “remote infrastructure, poor communications and lack of laboratory facilities” (Zessin and Carpenter, 1985). Livestock industries make a significant contribution to food production in most of these countries, and programs to improve animal health are important for the expansion and modernisation of these industries. Sandford (1983) identifies four main themes behind the pastoral development policies of governments and officials, viz. economic, environmental, social and political. The economic motivation is to use resources efficiently in the production of meat, milk and other products for domestic and export markets. This theme may also see livestock owners or a section of them as rural poor and a target for assistance. The environmental motivation is concerned with protecting rangeland resources and controlling pollutants. The social theme concerns livestock owners having a say in their own industry, and preservation of rural “society and its values against destructive and corrupting inroads by the outside world” (Sandford, 1983, p. 25). The political theme, particularly in countries with a history of conflict between livestock owners and their neighbours or with government, is concerned with reducing risks that pastoralists pose to national security and with their integration into the economic, social, cultural and political life of the nation. This paper focuses primarily on economic goals for livestock industries.

2. Costs and Benefits of Animal Health Programs

Animal health programs may be concerned with prevention, reduction, outbreak control or eradication of livestock diseases². Major national campaigns have been carried out in various countries for eradication or rinderpest, contagious bovine pleuropneumonia (CBPP), foot-and-mouth disease (FMD) and swine fever. These programs are forms of public intervention, justified on grounds of market failure (Tisdell et al., 1994), which usually include elements of

² In this context, “diseases” are usually defined to include internal parasites (sometimes referred to as parasitic diseases) and nutrient deficiencies (non-infectious diseases).

government expenditure (in training veterinarians, in providing infrastructure, in producing vaccines), regulation (on disease reporting, stock movements, vaccination programs) and extension. For example, eradication or at least limitation of FMD may be achieved by one of two approaches, viz. regular vaccination (with slaughter, ring vaccination and stock movement bans in the case of an outbreak) or so-called “stamping out” where there is no regular vaccination but where any animals contracting the disease and others in contact with them are destroyed.

Program measures vary between diseases, and for any particular disease vary between regions and move through different regimes over time. For example, a FMD eradication campaign may have a duration of more than a decade, and involve regular vaccination and controls over stock movements, but with stamping-out progressively introduced in areas where frequency of outbreaks has been successfully reduced.

Berentsen et al. (1992a) classify benefits and costs of animal health programs into those of producers, consumers and government. To this list we could add livestock traders, since in livestock industries there are typically a number of middlemen and facilitators (agents, stock dealers, meat export companies) and these receive a significant share of the revenue from domestic stock sales and exports.

Animal health programs generate benefits and incur costs, at both the private and public (or social) level. Some of the important private and social benefit categories are indicated in Table 1. Trade benefits are included here as both private and social benefits. If new or expanded export markets become available, extra revenue may be gained by the private sector (producers, dealers, etc), some of which will be appropriated by the government, in the form of taxes and charges, i.e. it will become a social rather than private benefit.

Animal health programs can involve a variety of costs. Producers may incur costs for additional labour, stock medicines and vaccines, veterinary services, and construction of improving stock handling facilities. Consumers may face higher prices for animal products due to increased exports. Public or social costs are incurred in implementing animal health programs. Increased training and salaries of veterinary staff, provision of additional diagnostic facilities and their consumables, vehicles and other equipment are required. Vaccine production plants may be established and vaccines provided to livestock owners at

subsidised prices. Field vaccination equipment, cold chain equipment³ and maintenance, field allowances for vaccination crews, and compensation for condemned animals may add to costs. There will also be a need for surveillance and enforcement of regulations, including transport checkpoints and information systems, including surveys, computer equipment and data entry.

Table 1: Benefits of improved animal health

Private benefits

- Production, reproduction⁴
- Draft, transport, dung
- Less restrictions on stock sales
- Higher sale prices for livestock
- Potential future reduced animal health expenditure
- Trade gains to producers and traders

Public/social benefits

- Livestock quality (genetic) improvements
- Industry modernisation and intensification
- Potential reduced future expenditures on animal health programs
- Livestock product trade benefits
- Enhanced industry and national development
- Public health improvement
- Social welfare costs avoided
- Animal welfare gains

3. Economic Development Aspects of Improved Animal Health

Costs and benefits of improved animal health will now be examined in greater detail, with particular attention to major social (as distinct from private) costs and benefits.

Industry Modernisation

Perhaps the most significant yet least obvious production aspect of improved animal health is what may be loosely termed “industry modernization”, i.e. improvements in livestock quality and progress towards more commercial and high-volume low-cost production systems. When diseases are prevalent, management tends to be preoccupied with their control. Diseases and

³ Equipment for keeping vaccines chilled during transport and use.

⁴ Ellis and James (1979) argue that production benefits should be estimated in terms of resource savings rather than increased output, on the grounds that most developed countries control levels of livestock production. This does not, however, seem applicable for developing countries.

parasites tend to mask genetic quality, and make breeding improvement programs difficult to implement (Morris, c1990). They also make intensive production systems more difficult to manage and more prone to failure. For example, with high animal densities, stamping out in terms of depopulating large production units is extremely expensive, and very high percentages of immune animals have to be ensured to prevent disease outbreak or continuation in subclinical form (Ellis and James, 1979).

The combination of improved productivity due to improved animal health and of genetic improvement and more intensive production systems has the potential to considerably reduce production costs per unit of output, i.e. shift the supply curve for livestock products to the right⁵.

Gains from Increased Access to Foreign Markets

Animal health has become an increasingly important issue in international trade of livestock (Dunn, 1991, Forsythe and Bredahl, 1991). The concern has centred on the possibility of transmission of diseases and on healthiness of food. With regard to food quality, the FAO in 1984 set up an expert committee to investigate residues of veterinary drugs in animals and foods “in response to a growing concern about mass-medication of food producing animals and the implications for human health and international trade”⁶

Livestock diseases have been recognized to have very large costs in terms of export market lost. Governments in Australia and New Zealand have long been concerned about the devastating cost should there be an outbreak of an exotic livestock disease, with subsequent closure of important meat markets in the USA, Japan and other countries. Research indicates that an outbreak of swine fever in Denmark “would have a disastrous effect on the balance of payments, because of the loss of export markets” (Ellis and James, 1979, referring to Ellis et al., 1977). Studies have revealed the high potential cost of FMD outbreaks in the UK (Power and Harris, 1973), Australia (Johnston, 1982), Canada (Krystynak and Charlebois, 1987) and various European countries (Dijkhuizen, 1989, Berentsen et al., 1990). The studies by Johnston, Krystynak and Charlebois, and Berentsen, paid particular attention to economic impacts of trade bans.

⁵ It is to be noted that industry modernisation may result in costs as well as benefits, such as reduced sustainability and reduced genetic diversity (Scoones, 1992).

⁶ In 1992, this committee carried out an evaluation and recommended maximum residue levels (MRLs) for 10 compounds, including five anthelmintics, two antimicrobial agents, two production aids (including bovine somatotropin) and trypanocide (JECFA, 1992).

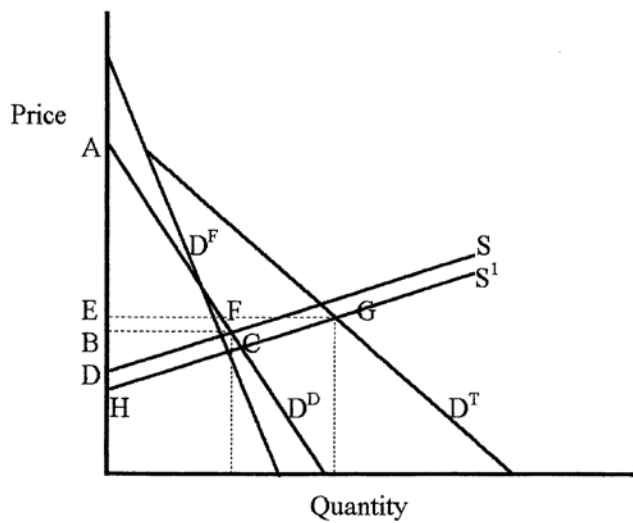
Just as trade bans due to livestock diseases can have spectacular costs, international recognition of disease-free status in relation to particular diseases and consequent increased export opportunities potentially have very large economic benefits⁷. FMD has been eradicated in Europe and Indonesia, Argentina may achieve free status in the near future, and Thailand is also striving towards this goal.

As noted by Berentsen et al. (1992) and Tisdell (1994), changes in domestic prices of livestock products and consequent impacts on consumer surplus are often overlooked in economic analysis of animal health programs. An exception is the study for Indonesia by Patrick and Vere (1994). While improved animal health could be expected to reduce production costs, the price effect could be more than offset by increased exports, such that domestic prices increase. The impact of improved animal health on production costs and meat prices can be quite complex.

Figure 1 depicts the impact on economic surplus of improved animal health resulting in new trade opportunities. S represents domestic supply, and D^D domestic demand, for a livestock product, with consumer surplus of ABC and producer surplus of BCD. Suppose that due to eradication of a disease, foreign markets become available with combined demand D^F . The total demand facing domestic producers (including traders) is the horizontal summation of these two demand curves, represented by the kinked line with lower segment D^T . At the same time, there is a decrease in animal health cost, resulting in a shift to the right in the domestic supply curve to S^1 . The result will be a reduction in consumer surplus to AEF and an increase in producer surplus to EGH. Both are relevant economic impacts, through most analysts concentrate on the latter only.

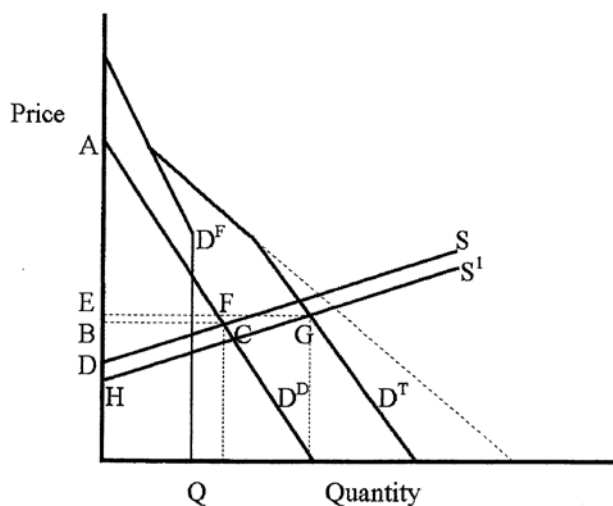
⁷ This requires that a country or particular region be classified by the international epidemiology organisation (Office International des Epizooties or OIE) as free of a particular disease. For FMD-free status, it is necessary that vaccination be ceased, since if on blood testing animals are found to have immunity it is not possible to distinguish between vaccination or exposure to the disease as the source of this immunity.

Figure 1: Changes in producer and consumer surplus arising from market access



If importing countries impose quantity restrictions, which is typical in international meat markets, the producer gains and consumer losses may be reduced though not eliminated, as indicated in Figure 2 where an import quantity constraint of Q is imposed.

Figure 2: Changes in producer and consumer surplus, under quantity limits on trade



The question may be asked as to whether such trade gains are a zero-sum- game from an international perspective. If a country secures improved export markets, will these be at the expense of current exporters? FMD-free status for Argentina would certainly reduce

Australia's beef trade. So long as the new trade entrant has comparative advantage of existing traders, some global welfare gains should arise, though individual nation can be expected to be motivated by their own gains, resulting in a redistribution of earnings from livestock trade.

The conclusions drawn from Figures 1 and 2 will of course depend on the shapes and locations of the various supply and demand curves. If production costs were reduced sufficiently, and supply were sufficiently elastic, domestic producers could gain little or no price increase. The relevant supply curve is that for the long run, and cost reduction and supply elasticity are both likely to increase over time, the former as productivity increases progressively due to improved animal health and associated genetic improvement and commercialisation of production, and the latter due to gradual movement of resources into the exporting industries. The shape of the long-run average cost and supply curves for livestock industries has been a matter of contention. Kerr (1985) suggested that in Canada the long-run supply curve would be flat or even decreasing with increasing output, due to excess capacity among producers at the time. This view was challenged by Loynes (1985), who argued that the prices of resources would be bid upwards and considerable infrastructure improvements and other costs would be involved in securing new export markets.

Animal Health Impacts on National Economic Development

Growth of the livestock sector has been recognised to play an important part in national economic development. A collection of papers prepared by the World Bank explored the place of livestock within the broad scope of economic and social development, particularly in developing countries (Cunningham, 1992). The potential contribution of increased livestock production for the Canadian economy was noted by Kerr (1985), who argued that this benefit could only be gained by increased exports. Less attention has been paid to the role of animal health in economic development, an exception being Jawara (1990).

Improved animal health may make a significant contribution to both development of the livestock sector and overall national development, and be particularly important to developing countries and countries placing a high priority on export income (Hubbard, 1986). These industries have been regarded as significant in "export-led" growth (e.g. Houck, 1991). Export-led growth of the livestock sector will take place in parallel with growth due to increased domestic demand, which may be rapid in newly industrialising countries with rapid income and population growth. While many economists are now more interested in "beyond-export-led" growth, in developing countries the role of livestock exports in capital formation

to finance industrialisation remains significant (Lubeck, 1984).

A number of theories have been advanced to explain the process of export-led growth. In a study of the Botswana livestock exports, Hubbard (1986) identified two strands of theory concerning exports and economic growth:

1. *neoclassical* hypotheses portraying the relationship between exports and economic growth as a cumulative and harmonious process, based on classical Ricardian ideas of trade, factor proportions theory (after Heckscher-Ohlin), induced innovation theory (after Hayami and Ruttan) and staple theory (originated by Innis in Canada).
2. *neo-Marxist* theories portraying a negative relationship between trade and economic growth of colonised or dominated territories as a feature of global capital accumulation; these include structural arguments (dependency, centre- periphery, secularly declining terms of trade) and more direct Marxian theory on merchant capital in underdeveloped countries.

Increased activity in the livestock sector can have important flow-on effects in an economy. Expanded markets will result in increased demand for stock feeds (comprising about 70% of costs in intensive livestock production), transport, labour and other inputs. Increased livestock production could be expected to lead to changes in cropping patterns, with relatively more inputs devoted to stockfeed production and less to other crops. Downstream benefits arise from transport and food and leather processing.

There can of course also be negative socio-economic impacts of the growth and intensification of livestock industries. For example, small-scale livestock producers may find they are unable to compete with the prices or quality requirements of the changed industry. Animal health programs can also have environmental impacts; more efficient input-output transformation will lead to relatively less resource pressure, but consequent intensification of livestock industries and expanded production at the expense of cropping could have both positive and negative environmental impacts (Tisdell and Harrison, 1995).

Public Health Improvements

Improved animal health has the potential to improve human health, both through improved nutrition and by prevention of transfer of diseases. A number of livestock diseases are recognised as posing human health risks, and this has been the motivation for eradication

programs for bovine tuberculosis and brucellosis. Some large-animal diseases have been recorded as causing mild illness in humans, e.g. FMD⁸. Salmonella is frequently the cause of food-borne infections, Newcastle disease sometimes causes mild or subclinical infections in poultry slaughterhouse workers (Acha and Szyfres, 1980), and occasionally causes conjunctivitis in persons exposed to the virus (Steele, 1992, p. 33), but otherwise avian diseases are rarely transferred to humans.

Social Welfare Costs Avoided

Health and productivity of livestock is critical to the livelihood of many low-income people, including poor villagers and nomadic herdsman. Livestock provide an emergency food reserve, store of wealth, asset against which to secure credit, food and clothing, fuel, fertiliser and insect repellent. Livestock are often a highly efficient value-adding production system which does not compete strongly with crops for resources. Improvements in livestock productivity can strengthen the economic base of rural communities and help secure rural lifestyles, preventing the need for migration of poor families to cities and the welfare dependency which often follows.

Animal Welfare Benefits

Diseases and parasites obviously cause suffering and stress to animals, and to the extent that humans are concerned about animal welfare, improved animal health has utilitarian benefits. In this context, Zessin and Carpenter (1985, p. 336) note the “anguish and suffering among cattlemen that is a result of losing their beloved animals”. While some economists advocate that animals should be recognised as having rights independent of the interests of mankind, little progress had been made in valuing animal welfare benefits. In this context, Morris (c1990) asserts that animal welfare deserves more attention in planning animal health programs, but appears not to have been factored into animal health cost-benefit analyses.

4. Risks Associated with Animal Health Programs

Investment in animal health programs, like most other major public investment programs, is not without risk. The more ambitious the program, the greater the risk that tends to be associated with it. A program to reduce the incidence of a disease may fail if livestock

⁸ “Man is rarely affected [by FMD], but when he is the symptoms are usually mild fever, characterised by vesicles around the mouth and possibly on the hands” (Steele, 1992, p. 19).

owners do not co-operate actively with it. For example, producers may fail to notify veterinary officials of cases of infectious diseases if they are not concerned about the private costs of these diseases or if they think animals will be sold compulsorily with inadequate compensation. National and regional vaccination programs are unlikely to be effective unless an adequate coverage level is attained (Cameron, 1994). Disease eradication is an attractive policy in that it potentially removes future costs associated with a disease; however, eradication programs can involve huge costs, and should they fail may result in disillusionment and loss of support of producers, and explosive disease outbreaks due to loss of immunity. For example, Zessin and Carpenter (1985, p. 336) concluded in relation to Sudan that “mass vaccination would not reduce CBPP prevalence to a practical level when continuous reinfection from neighbouring areas is very likely”, and recommended instead a surveillance alternative with selective disease control actions.

More costly still, would be the situation where a disease is successfully eradicated, and producers gear up for export markets, then there is a subsequent outbreak which is not rapidly brought under control.

5. Economic Analysis Techniques and Estimation Problems

The above conceptualisation of costs and benefits raises problems and suggests approaches for economic comparison of alternative animal health programs. At the livestock owner level, improved animal health will be reflected in part in improved reproduction rates, the benefits of which will only be realised over a number of years. Simulation modelling, perhaps of a “regional herd”, with reproduction, weight gain and mortality parameters improving over a number of years would be an effective way to model producer benefits. Information is also needed on the way in which domestic production is likely to respond to availability of new overseas markets, and the constraints which would apply such as villager and commercial producer attitudes and resources (e.g. feed supplies).

From a macroeconomic modelling viewpoint, econometric methods could be used to estimate domestic supply and demand relationships and price elasticities for livestock products. Estimates are also needed of the potential export markets, perhaps based on considerations of international commodity “balance sheets” of production and consumption, and likely political support for protective quotas in export markets. In evaluation of planned animal health programs, some explicit recognition of risk is desirable, perhaps using risk simulation and

stochastic dominance analysis.

6. Specific Issues in Thailand

The pig, poultry and cattle (meat and dairy) industries are important in Thailand, both at the village level and in small to medium scale commercial production systems. Buffalo are of decreasing importance as a source of draught power, but a continuing source of meat in some areas. A policy of increasing milk production has been introduced, as a means to improve children's protein intake. A number of diseases have been identified by the Division of Livestock Development (DLD), some of which are being investigated in Australian Centre for International Agricultural Research (ACIAR) Project No. 9204; these include FMD and gastrointestinal parasitism in cattle and buffalo, swine fever and Aujeszky's disease in pigs, and Newcastle disease and infectious bursal disease in poultry.

Thailand has a relatively well developed veterinary service infrastructure, and modern diagnostic laboratories. The level of reporting of livestock diseases by villagers is low, and private costs probably are not fully recognised. Foregone export opportunities, however, are a concern to the government. While an importer of beef, Thailand is a major exporter of poultry meats, and has the potential for major expansion of pig meat exports, but is excluded from lucrative markets by presence of FMD. Taiwan has been a major pig meat exporter to Japan, but is facing increasing environmental problems and land scarcity hence Thailand could have an opportunity to share this market.

Thailand is implementing an FMD eradication program, initially using widespread vaccination of cattle, buffalo and pigs. More intensive methods will be applied as the disease incidence is reduced. Special problems arise because of the long land borders with Myanmar, Cambodia and Laos, each of which has limited veterinary services and disease management, and price gradients attracting legal and illegal movement of cattle into Thailand. With the formation of an economic union in Europe, new provisions have been introduced whereby a country can obtain FMD-free status for particular regions. While FMD eradication nationally in Thailand will be difficult, free status in the southern part of the country is a feasible objective.

Thailand has considerable capacity to expand production of pig meats if new export markets can be secured. Additional supply would come from expansion of existing commercial

piggeries and construction of new piggeries. Larger scale production would probably lead to reduction in average costs. However, limited domestic production of feed grains could give rise to diseconomies at larger outputs. While increased effort on animal health programs would appear warranted, more information is needed on the returns from these programs and the most cost-effective ways in which they can be carried out.

7. Concluding Comments

Livestock diseases are of considerable economic significance in developing countries. It is clear that the economic impacts of improved animal health are complex and not easily estimated. Dynamics changes in benefits and costs over time need to be taken into account. Animal health programs have impacts on both producers and consumers. Social benefits of these programs can be large relative to private benefits, hence returns from public intervention can be substantial. In Thailand, eradication of FMD and reduction in incidence of other livestock diseases could have major economic benefits, and make a significant contribution to development of the livestock sector and to national economic progress.

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9. References

- Acha, P.N. and Szyfres, B. (1980), *Zoonoses and Communicable Diseases Common to Man and Animals*, Scientific Publication No. 354, Pan American Health Organisation and World Health Organisation, Washington, DC.
- Berentsen, P.B.M., Dijkhuizen, A.A. and Oskam, A.J. (1990), *Foot-and-Mouth Disease and Export: An Economic Evaluation of Preventative and Control Strategies for The Netherlands*, Wageningen Economic Studies No. 20, Wageningen Agricultural University, Wageningen.

- Berentsen, P.B.M., Dijkhuizen, A.A. and Oskam, A.J. (1992a), 'A Critique of Published Cost-Benefit Analyses of Foot-and-Mouth Disease', *Preventive Veterinary Medicine*, **12**, 217-227.
- Berentsen, P.B.M., Dijkhuizen, A.A. and Oskam, A.J. (1992b), 'A Dynamic Model of Cost-Benefit Analyses of Foot-and-Mouth Disease Control Strategies', *Preventive Veterinary Medicine*, **12**, 229-243.
- Cameron, A. (1994), personal communication.
- Copland, J.W., Gleeson, L.J. and Chamnanpood, C. (1994), *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, proceedings of a workshop held in Lampang, Thailand, Australian Centre for International Agricultural Research, Canberra.
- Dijkhuizen, A.A. (1989), 'Epidemiological and Economic Evaluation of Foot-and-Mouth Disease Control Strategies in the Netherlands', *Netherlands Journal of Agricultural Science*, **37**: 1-12.
- Dunn, K.J. (1991), 'Evolution of the veterinary role in international trade in the 1990s', Proceedings of the Society of Veterinary Epidemiology and Preventative Medicine, April 17-19, London, pp. 7-17.
- Ellis, P.R. and James, A.D. (1979), 'The Economics of Animal Health - (1) Major Disease Control Programmes', *The Veterinary Record*, December 1, pp. 504-506.
- Ellis, P.R., James, A.D. and Shaw, A.P. (1977), *Studies in the Epidemiology and Economics of Swine Fever Eradication in the EEC Commission of the European Communities*, EUR 5738 e.
- Forsythe, K.W. and Bredahl, M.E. (1991), 'Effects of animal health regulations on market access for exports of livestock products', *Journal of Agribusiness*, **9**(2): 41-51.
- Houck, J.P. (1991), 'Observations on Export-Led Growth as a Development Strategy', in Timmer, C.P. ed., *Agriculture and the State: Growth, Employment, and Poverty in Developing Countries*, Cornell University Press, Ithaca, pp. 116-22.
- Hubbard, M. (1986), *Agricultural Exports and Economic Growth: A Case Study of*

theBotswana Beef Industry, KPI, London.

Jawara, A.S. (1990), 'Animal Disease as a Factor Limiting Economic Development in Africa', *Cornell Veterinarian*, **80**(1): 17-25.

JECFA (Joint FAO/WHO Expert Committee on Food Additives), 1993, 'Residues of Some Veterinary Drugs in Animals and Foods', FAO Food and Nutrition Paper 41/5, Geneva.

Johnston, J.H. (1982), *Exotic Animal Disease Emergencies in the Australian Grazing Sector*, Bureau of Animal Health and Department of Primary Industries, Canberra.

Kerr, W.A. (1985), 'The Livestock Industry and Canadian Economic Development', *Canadian Journal of Agricultural Economics*; **32**: 64-104.

Krystynak, R.H.E. and Charlebois, P.A. (1987), 'The Potential Economic Impact of an Outbreak of Foot-and-Mount Disease in Canada', *Canadian Veterinary Journal*, **28**: 523-527.

Loyns, R. M. A. (1985), 'The Livestock Industry and Canadian Economic Development: Rapporteur's Report', *Canadian Journal of Agricultural Economics*; **32**: 105-

Lubeck, H.G. (1984), *The Role of Livestock Production in the Process of the Initial Capital Growth for Industrialisation in Uruguay*, Gesellschaft für Wirtschafts - und Regionalsoziologie, Giessen.

Morris, R.S. (c1990), *Animal Health Economics, Principles and Applications: How Economically Important is Animal Disease and Why?*, International Training Centre, Wageningen Agricultural University.

Patrick, I.W. and Vere, D.T. (1994), 'Ex ante assessment of the returns to livestock disease control in Indonesia', *Agricultural Economics*, **11**(1): 83-91.

Power, A.P. and Harris, S.A. (1973), 'A Cost/Benefit Evaluation of Alternative Control Policies for Foot-and-Mouth Disease in Great Britain', *Journal of Agricultural Economics*, **24**: 573-597.

Sandford, S. (1983), *Management of Pastoral Development in the Third World*, Wiley, New York.

- Scoones, I. (1992), 'Land Degradation and Livestock Production in Zimbabwe's Communal Areas', *Land Degradation and Rehabilitation*, **3**: 99-113.
- Steele, J.H. (1962), *Animal Disease and Human Health*, FAO, Rome.
- Tisdell, C.A. (1994), 'Animal Health and the Control of Diseases: Economic Issues with Particular Reference to a Developing Country', *Research Papers and Reports in Animal Health Economics* No. 2, Department of Economics, University of Queensland.
- Tisdell, C.A., Harrison, S. and Baldock, F.C. (1994) 'Assessing Public Programmes for Control of Animal Diseases in Developing Countries: General Economic Issues with Thai Examples', *The Kenya Veterinarian*, **18**(2): 236-238.
- Tisdell, C.A. and Harrison, S.R. (1995), 'Livestock, Environment and Sustainable Development', Third International Conference on Development and Future Studies, Helsinki, Finland, July 31-August 2, 1995.
- Zessin, K-H. and Carpenter, T.E. (1985), 'Benefit-Cost Analysis of an Epidemiologic Approach to Provision of Veterinary Service in the Sudan', *Preventive Veterinary Medicine*, **3**: 323-337.

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