The economic impact of foot and mouth disease and its control in South-East Asia: a preliminary assessment with special reference to Thailand


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Summary
A pilot study of the economic impact of foot and mouth disease (FMD) in the countries and region of South-East Asia is described. Previous economic impact assessments are reviewed and summarised and a synthesis of these contributions is constructed. A framework for the future economic impact of the disease is then developed, incorporating analyses at the sectoral (production system), national and regional levels. Data requirements for such studies are also identified. Integrated epidemiological and economic models for impact assessment were developed and applied to the case study country of Thailand. The models were used to evaluate the economic viability of FMD control programmes in the country. Scenarios evaluated include the effect of improving vaccination coverage and thus reducing productivity losses, and the effect of eventual eradication of the disease. The results indicate that economic returns to the high expenditures incurred in FMD control could be achieved in the short term if greater international trade in pork products was made possible and export prices higher than those in the domestic market could be attained. If FMD were to be eradicated from Thailand in 2010, the eradication would be economically viable, even without exports, with a predicted benefit-cost ratio of 3.73. With additional exports, the economic justification for control becomes much stronger with a benefit-cost ratio of up to 15:1 being achieved. If eradication is not achieved until 2020, returns remain positive without exports, but at a lower rate.

The authors propose that the integrated epidemiological and economic models developed be applied to other countries of the region to gain a more accurate insight into the future benefits of FMD control and eradication in the region.

Keywords
Animal health - Benefit-cost ratio - Cost-benefit analysis - Economic impact assessment - Economics - Foot and mouth disease - South-East Asia - Thailand.

Introduction
Livestock play a crucial role in economic development in South-East Asia (17), and the livestock industries within the region appear to be in a process of dramatic change. Human populations are growing at a considerable rate; this is accompanied by an increasing rate of demand for livestock products such as pork, seafood, milk and beef as societies become more affluent. This demand has been recorded both within the region, as well as further afield, where more affluent societies, such as Japan, provide a significant but demanding export market. In addition, livestock play a key role in poverty alleviation in the region in two important ways. The first is through the use of buffalo for draught...
Review of previous economic impact studies of foot and mouth disease control in the region

Several evaluations of the economic impact of FMD in the region have been conducted previously, and one of the products of this pilot study was to provide a synthesis of these. It is important to note that no comprehensive review of the economic impact of FMD seems to have been performed for the entire region. One of the characteristics of FMD is the diversity of impacts the disease appears to have on different species, production systems and sectors of the livestock industry; the differentiation and quantification of these impacts is important in order to make a valid assessment of control options which take into account the national development strategies.

The economic impact of foot and mouth disease and control in the Philippines (1997)

The first attempt to quantify the economic impact of FMD in the region was a nation-wide study conducted by Arámbulo in the Philippines (1). The study provided a comprehensive theoretical national review of the productivity effects of the disease, based on available secondary data on animal productivity in the Philippines, but often using production loss indices (such as losses in milk yield due to FMD, for example) from studies conducted in a variety of other countries. The study concluded that the Philippines sustained an annual direct economic loss of approximately US$25 million. Arámbulo then evaluated the impact of alternative control strategies, using simple deterministic models of FMD occurrence, accompanied by a financial analysis with estimated costs of control and predicted changes in productivity. As a result, the most favourable option was demonstrated to be an eradication programme for the country over four years, which would include mass vaccination of all susceptible livestock at six-monthly intervals, quarantine and eventual slaughter of infected animals. It was calculated that such a programme would have a positive benefit-cost ratio (BCR) of approximately 3:1.

The economic impact of foot and mouth disease control in South-East Asia (1983)

In 1983, a regional study was completed which supported a joint proposal by Australia and the Association for South-East Asian countries (ASEAN) for the control and eradication of FMD in the ASEAN region (8). The authors proposed a four-year project in the region, which would study the epidemiology of the disease and strengthen diagnostic and infrastructural facilities, in preparation for a more concerted effort to eradicate the disease. As part of the proposal development, disease costs and potential control benefits for
The economic impact of foot and mouth disease control in Thailand (1985)

The results of a small economic impact assessment by von Krüdener in Thailand were contained in an extensive technical report of a project on FMD control in the country supported by the German Technical Cooperation (Deutsche Gesellschaft für Technische Zusammenarbeit: GTZ) (18). Annual control costs were estimated at 100 million Baht (at that time equivalent to approximately US$4 million). Von Krüdener described, but did not value, production losses, and estimated a value for the effect of FMD on the restriction of trade for the period from 1979 to 1982 (400 million Baht of losses in foreign currency, 3.9 million Baht in loss of trade taxes and 1.4 million Baht in loss of export fees), but did not specify to which countries this trade might be. The conclusion drawn was that the BCR of FMD control was negative, the BCR was valued at 1:5, but not all the data contributing to this analysis were presented.

The economic impact of foot and mouth disease control in beef cattle in three provinces of northern Thailand (1992)

The next study reported also focused on Thailand, and was conducted by the Australian Commonwealth Scientific and Industrial Research Organisation (2), supporting an ongoing research collaboration between Thailand and Australia on FMD control undertaken in northern Thailand. The study concentrated on three northern provinces (Lampang, Lamphun and Chiangmai), and within these, on the economic benefits of reduced FMD incidence (achieved through greater vaccination coverage alone) in beef cattle only. Potential net annual benefits of 23.6 million Baht, a BCR of 11.8:1, and net present values (NPVs) of between 179 and 245 million Baht were reported.

The economic impact of foot and mouth disease control in Thailand (1998)

Harrison and Tisdell have produced what is probably the most comprehensive study to date of the economic impact of FMD and its control in any country of South-East Asia (10). These authors begin by reviewing the general subject of economic impact assessment, before reviewing the theoretical impacts of FMD and control. Previous attempts to determine the economic impact of FMD control in Thailand are then reviewed, before recounting the history of FMD control in the country. In the economic impact analysis itself, a CBA of the FMD control programme in the entire country since the formal inception of the programme in 1991 through to the year 2025 is performed. The authors assume a steadily increasing vaccination coverage in the country, FMD eradication in the year 2008, and continuing benefits which are considered in the calculations up to 2025. Eradication of FMD is considered to be economically viable, but only marginally so. The NPV was calculated to be 250 million Baht (which although positive, is not particularly large considering the magnitude of investment required), the internal rate of return (IRR) was calculated to be 7.7% (positive, but only marginally greater than the discount rate of 7%), and the BCR to be 1.08:1.

The economic impact of foot and mouth disease control in production systems of Laos, Vietnam and Cambodia

In 1997, consultants from the Food and Agriculture Organization of the United Nations (FAO) undertook a technical assessment mission to Laos, Vietnam and Cambodia with the aim of enhancing capabilities for FMD control and assisting in control strategy formulation (7). As part of the report of this mission, economic impact assessment studies were performed. In contrast to most of the studies referred to above, the impact assessments carried out by the FAO consultants attempted to focus on the different production systems of the region. Three main systems were singled out for the analysis: the village cattle and buffalo in Laos, the smallholder dairy sector in southern Vietnam, and the smallholder commercial pig sector common to much of the region. Data were gathered when possible at the farm level through interviews by the consultants and from secondary sources. The results illustrated the contrasting impacts of FMD control in different production systems. In the cattle/buffalo system, the calculated average return to FMD control per head ranged from US$0.2 to US$0.5 depending on FMD incidence (of between 0.1 and 0.3). The authors considered that returns would be much more significant in areas with draught animal shortages than those with draught animal surpluses. It was concluded that FMD vaccination would only be financially viable in areas where a draught shortage existed and where the FMD incidence was greater than 0.2.

In smallholder dairy systems, the picture was quite different. The calculations demonstrated that benefits of US$9-US$29 per cow would be achieved through FMD control (with FMD incidences of 0.1-0.3 respectively), resulting in an increase of 7%–24% in the gross margin per cow.

The impact on the pig industry is considerably more complex, and difficult to summarise. However, as examples, the authors calculated that FMD control could give an improved gross margin per sow of US$7.50, and an improved gross margin of US$1.50 per finished pig in fattening units. The latter
amounted to a 24% improvement in gross margin with an incidence of FMD of 0.05.

**Summary of previous impact studies of foot and mouth disease control in the region**

The studies undertaken to date and described above vary widely in quality and value as decision support aids. Many of the studies have been short-term and low-input exercises intended to supplement technical reports. However, the steady improvement in the quality of evaluations with time is encouraging. The improvements were apparent in two contrasting aspects, enhancing the quality and range of data considered in the analysis (reflected in the study of Harrison and Tisdell [10]), and adopting a production systems approach to the assessments (reflected in the FAO study [7]). The value of the study by Harrison and Tisdell is that a broad framework for a national impact assessment has been mapped out, building on the concepts that appear in the estimation made by Arambulo (1), and the relevant data have been carefully assembled. However, the inability of the authors to fulfill all the demanding obligations they set themselves clearly illustrates the difficulties in performing such national evaluations, namely: the lack of accurate data, and possibly more importantly, the lack of data in a form appropriate for the analysis.

The value of the FAO study is in the division of impacts by production system, demonstrating that for some systems real benefits can be derived from FMD control and eradication, for other systems benefits will be marginal, and for some no benefits will accrue. This approach deserves further study. In this analysis no consideration was made of external trade benefits. While the initial results of the FAO study illustrated the value of a systems approach by quantifying the considerable between-system differences in impact of FMD control, the study demonstrated the requirement for more accurate data to be acquired from a sample of each system throughout the region. This data is crucial if this approach is to provide valuable support to decision makers.

**Overview of the regional impacts of foot and mouth disease and control, and regional and international trade**

The impacts of FMD and the control of the disease form something of a matrix between countries of the region, production systems of the region, between costs of control and losses due to reduced productivity, between public and private sectors, and between the current impacts versus the benefits from regional freedom in the future.

Commencing with the countries, the greatest economic impact is probably felt by Thailand, the Philippines and Malaysia in the form of massive expenditures by the public sector on FMD control. Added to this are the considerable losses in productivity experienced in these countries, particularly in the more developed livestock industries, such as the pig and beef industries, and in the case of Thailand in particular, the dairy industry. In contrast, the impact in the form of control costs appears to be considerably less for Myanmar, Laos, Cambodia and Vietnam, where severe constraints to high government expenditures on FMD control exist.

In regard to production systems, FMD exerts the most influence on the three following systems:

a) the traction component of small-scale mixed farming (where heavy losses are incurred when outbreaks occur in buffalo during the planting season, particularly in Myanmar, Laos, Cambodia and Vietnam [12])

b) commercial pig production (with high costs of vaccination which are borne by the producers in many countries, together with considerable productivity losses where control is ineffective)

c) the small-scale dairy system which is particularly important in southern Thailand and southern Vietnam (where higher costs of control are incurred by the public sector, considerable production losses in terms of milk yield are incurred by the private sector, and lost domestic production of milk results in continued importation).

Impacts are recorded in terms of production losses and control costs. Production losses are greatest in the more productive breeds of pigs and cattle, and within this group, the greatest losses are typically to be found in an intermediate group of commercial producer. Small-scale producers are more likely to employ indigenous breeds in which effects of disease on productivity are less, and large-scale commercial producers are more likely to implement an effective control programme (at considerable cost). Control costs are greatest in the commercial pig sector (where these costs are borne by the producers), in the dairy sector of Thailand (costs borne by public funds) and in the small-scale producers of the region (costs borne by the public sector coffers of all the countries of the region).

The balance between the current impacts, documented above, and the benefits in the future from enhanced regional trade is a complex issue. The driving force behind FMD control within the South-East Asian region is often stated to be the potential increase in export markets, and the resulting benefits to individual nations and to the region as a whole. This reasoning should be reviewed by considering the feasibility of FMD control and eradication in the region, and the international and regional demand for livestock products.

It is widely recognised that FMD control and eradication will only be achieved through a regional effort and commitment, given the physical and economic juxtaposition of the countries involved, and the extraordinary traffic of susceptible
and infected livestock between and within countries (16). However, in terms of the benefits of future enhanced trade, considerable differences appear to exist between the countries of the region.

Future trade opportunities will exist both within the South-East Asian region, and outside of the region, particularly in the high-priced Asian markets. Other potential markets include the 'transition economies' of Eastern Europe and the countries of the former Soviet Union, should the economic situation in these countries improve. Hong Kong has been a strong potential market, but this is likely to be filled increasingly by products from other parts of the People's Republic of China. Another important market within the region exists in Singapore.

The situation in Thailand, which is chosen as a case-study country in this paper, is very complex. The country is self-sufficient in pig production, but imports beef and milk to satisfy domestic demands. With the advent of the hand-held tractor and the migration of labour from rural to urban areas that has accompanied the economic boom, the buffalo population is declining rapidly. The country has an expanding dairy industry (growing by 18% per annum in some regions), encouraged by many government initiatives. These include the provision of loans at favourable interest rates for the purchase of dairy cattle and the provision of certain veterinary services, including vaccination against FMD.

A framework for assessing and quantifying the impact of foot and mouth disease and control

A framework for determining the economic impact of FMD and the control of the disease in countries of the region was developed; this is provided in Figure 1. The key to a good impact assessment of FMD and control is the acquisition and analysis of data on the basis of the production system or sector, not the species. This is due to the differences in disease epidemiology, in potential control options and in impacts (in terms of control costs, productivity effects and export potential benefits). The framework is based on the acquisition of available secondary data through official reports and publications, from key informant interviews, and supplemented by primary data collection through well-designed field studies where possible. The data requirements are divided into four main sections as follows:

- FMD impact
- FMD control activities
- trade in livestock and livestock products
- veterinary services in FMD control

Data in each category were collected in some detail from one case-study country, Thailand. The authors envisage that this format can be more widely applied to other countries in the future.
Foot and mouth disease control in the case study country, Thailand

Thailand has a livestock population of 0.29 million dairy cattle, 4.56 million beef cattle, 1.95 million buffalo, 8.77 million pigs and 0.17 million sheep and goats (14). FMD is endemic in much of the country (11, 13, 14). Three regions of the country are considered FMD-free, these being regions 8 and 9 in the south of the country, and region 2 in the east. However, FMD has been reported sporadically from regions 8 and 9. The control of the disease is based on mass vaccination, epidemiological surveillance, animal movement control and mass slaughter of infected and in-contact animals in FMD-free zones (so-called 'stamping-out'). These measures are supported by public relations programmes and cooperation with neighbouring countries.

Vaccination is conducted at six-monthly intervals with trivalent vaccines for virus types O, A, and Asia 1 with the objective of establishing and maintaining herd immunity. The first vaccination round of the year is conducted in May/June and the second in November/December. The trivalent vaccines are produced by the Division of Veterinary Biologics. Vaccination against FMD is provided free of charge for cattle and buffalo, and swine producers are responsible for vaccinating their own animals.

A serological monitoring programme is conducted approximately one month after vaccination in randomly selected villages to evaluate the efficiency of vaccination.

Surveillance for FMD is conducted by the personnel of the provincial and district Veterinary Services with the cooperation of village keymen, livestock owners, village headmen and others involved at various levels of livestock marketing. Developing dairy and beef cattle cooperatives in some parts of the country also conduct disease surveillance activities. Disease surveillance is intensified in areas where FMD has not been reported for at least more than one year.

In the case of an outbreak of FMD, reports are sent through the provincial and regional livestock offices to the Department of Livestock Development (DLD) central office. In each outbreak, the possible source and extent of the infection is determined. Monthly reports by the provincial and regional

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![Fig. 1](image-url)

**A framework for assessing the regional impact of foot and mouth disease**
livestock offices are also submitted to the DLD headquarters. Statistical information on the occurrence of FMD forms a basis for reports to international organisations such as the OIE.

Animal movement from one province to another or across the borders requires formal approval from the veterinary authorities. However, it is believed that extensive unrecorded international movement of livestock into Thailand, particularly of buffalo and cattle, occurs. In addition, movement of animals within provinces occurs without official approval and is difficult to control.

Slaughter of FMD-infected and in-contact animals is applied in the FMD-free zones.

An epidemiological model to determine the relationship between foot and mouth disease vaccination and disease incidence in the region

In the few CBAs of FMD control that have been performed, the major obstacle has been the lack of substantive data on the relationship between vaccination strategies and the resultant incidence of FMD. Thus, these two variables have usually been considered as almost separate entities. The difficulty appears to be in establishing what vaccination coverages are actually being achieved (a combination of the vaccination frequency and the proportion of the population at risk being vaccinated, leading to an estimate of population immunity), and how different levels of population immunity affect FMD incidence. Without empirical data on such relationships, as is the situation throughout much of South-East Asia, meaningful CBAs are difficult to undertake. The authors therefore employ an epidemiological modelling approach. Previous studies have tended to assume a simple linear relationship between control effort and changes in disease incidence (10). Such an approach ignores the complicated non-linearities associated with infectious disease transmission and the impact of control. In the pilot study reported here, a framework is developed based on accepted epidemiological theory which provides the basis for formal investigation of the link between different control activities and changes in disease occurrence, thus providing a quantitative basis to conduct cost-benefit evaluations. However, the epidemiological framework presented below is only a first attempt to formally address the complicated questions associated with disease control efforts and changes in disease transmission patterns. As detailed field data was lacking, several simplifying assumptions have been made, including an absence of any spatial considerations. However, all assumptions are made clear and the limitations of the model addressed. The exercise highlights the need for an expansion of basic epidemiological data collection, which is geo-referenced by sector.

Epidemiological model requirements

To investigate the economic costs and benefits of alternative control strategies (see below for details) the epidemiological model must be able to predict the following, for each production system under different levels of control effort:

- the number of FMD outbreaks
- the total number of infected animals.

For the analysis presented below the four following sectors where identified:

- dairy
- small-scale commercial swine
- large-scale commercial swine
- village smallholder (divided into village swine and village cattle and buffalo).

Epidemiological model framework

An epidemiological model was developed which begins to address the issue of the link between control activity and change of FMD incidence in a quantitative manner (6). Figure 2 is a schematic representation of the basic model design. The model may be formally described by a set of coupled, first-order differential equations which are not shown here for the sake of brevity (6). The model is applied to FMD in Thailand. The major assumptions used in the model are as follows:

a) FMD virus persists in cattle and buffalo populations of the village smallholder system, which in turn acts as a source of FMD infection for all other sectors.

b) No consideration is made of external introduction of FMD from neighbouring countries. No data were available to quantify this possible source of FMD persistence.

c) From an epidemiological perspective, the cattle and buffalo populations are assumed to be a single, homogeneous, free-mixing host population.

d) A compartmental, deterministic model is used to predict the annual incidence of FMD cases in the village cattle and buffalo population (Fig. 2). The basic structure of this model has been used previously to investigate the transmission dynamics of many directly transmitted infectious diseases, including FMD (19). The exclusion of spatial and other heterogeneities are major simplifying assumptions, but given the absence of detailed epidemiological data and an accepted theoretical framework to describe FMD through space and time, to attempt to construct a more complicated spatial model was felt to be premature.

e) The demography of the village cattle and buffalo population was estimated from the trend in animal numbers provided by the DLD in Thailand.
Fig. 2
Diagram of the compartmental model of foot and mouth disease in village populations of cattle and buffalo

Animals may be in one of five states: susceptible to infection (S), latently infected but not yet infectious (L), infectious (I), naturally recovered from infection and immune to re-infection (R), immune to infection following vaccination (V).

Solid lines indicate transitions between states; unlabelled inputs and outputs represent births and deaths, respectively.

The population size \( N = S + L + I + R + V \);

\( \beta \) is the transmission coefficient, the per capita rate at which infectious animals infect susceptible cattle;

\( 1/\gamma \) is the mean latent period;

\( 1/\mu \) is the mean infectious period before cattle showing clinical signs are removed from the population;

\( 1/\varepsilon \) is the mean period of natural immunity;

\( e \) is the rate at which vaccinated animals lose immunity and become susceptible to infection, and \( 1/E \) is thus the mean period of vaccine-induced immunity.

For convenience and due to lack of data, it was assumed that \( \alpha = \varepsilon \). The demography of the host population is described by the per capita birth rate, \( \nu \), and death rate, \( \delta \), where the mean life expectancy of an animal is \( 1/\delta \). The population will grow at a per capita rate \( r = \nu - \delta \). The proportion of the population vaccinated at each time step is \( \phi \). Routine vaccination is assumed to take place in a pulse, such that over a short period of time a proportion, \( p \), of the total population is vaccinated.

The model was simulated using daily time steps and it was assumed that each vaccination pulse was conducted at the national level over a two-week period. Therefore, during a vaccination pulse \( \phi = p/14 \) and between vaccination pulses \( \phi = 0 \). Vaccination of already infected animals was assumed to have no influence on the course of infection.

The dashed lines indicate that village cattle and buffalo act as a source of infection for other sectors. The annual probability of an outbreak, \( P \), in an enterprise of any sector is correlated to the incidence of disease in the village cattle and buffalo. The annual probability of an outbreak was shown to differ for cattle (\( P_{\text{cattle}} \)) and swine (\( P_{\text{swine}} \)) enterprises.

\( j \) Outbreaks in livestock production enterprises in sectors other than the cattle and buffalo village sector are the result of FMD transmission from the village cattle and buffalo population.

\( g \) The annual probability of infection spreading from the village populations and entering an enterprise in any other sector was quantified from empirical data and shown to be linearly correlated to the annual incidence in the village cattle and buffalo population. The observed data and fitted regression line are shown in Figure 3.

\( h \) The annual probability of an outbreak differs for cattle and swine enterprises. However, in both enterprises the linear regression was significant \( (P < 0.05) \) and the intercept was not significantly different from zero \( (P > 0.05) \).

\( i \) Once the virus has entered an enterprise in a sector other than the village cattle and buffalo sector, no transmission occurs to enterprises in other sectors (i.e. it is a 'dead-end' outbreak).

\( j \) The mean herd sizes for the enterprises of each sector were calculated from DLD figures. For any enterprise in any sector, the average number of animals susceptible to infection following virus introduction, at any time in a given year, was calculated for each type of enterprise based on the vaccination regimen (see below), decrease in vaccine induced immunity.
Fig. 3
Relationship between disease incidence in cattle/buffalo populations and annual risk of an outbreak in cattle and swine enterprises
The filled squares and open circles refer to the observed outbreak data for cattle and swine enterprises, respectively (calculated from Cleland et al. [5]) and herd demography (based on DLD population figures).

All the rate parameters in the model (Fig. 2), apart from the transmission coefficient $\beta$, were estimated from DLD data or published experimental or field studies. The compartmental model was simulated in Microsoft Excel$^\text{©}$ using a daily time interval. According to a standard statistical technique for fitting models, the value of $\beta$ was varied so as to minimise the sum of the squared difference between the predicted and observed incidence in the combined cattle and buffalo populations recorded in Thailand between 1992 and 1997 (Fig. 4). The model was then simulated from 1997 onwards and the predicted incidence in the village cattle and buffalo (Fig. 4) used to estimate the number of outbreaks in enterprises of the different sectors (using the relationships described in Fig. 3). The model was used to predict the incidence in the village cattle and buffalo populations under different control scenarios.

The first scenario was the baseline scenario to which other scenarios were compared. This scenario was considered over two time horizons, firstly in the ten-year period from 1996 to the end of 2005, and secondly in a fifty-year period from 1996 to the end of 2045. The choice of time-frame is dictated primarily by the economic analysis. A shorter time-frame is used when evaluating a change in control strategies that involves increased costs and benefits each year. The longer time-frame is necessary for evaluating a single investment in eradication which generates benefits in the period following eradication. The results of the epidemiological model are only slightly affected by the extended time-frame since the trend suggests that FMD incidence will steadily decline and reach low levels by 2010.

Fig. 4
Predicted incidence of disease in village cattle and buffalo from 1996 to 2005 for the different control scenarios
The open circles are the observed incidence and the filled squares the recorded vaccination coverage.
The three different scenarios examined using the framework described are detailed below.

Baseline scenario
In each sector, two vaccination rounds were conducted, with the coverage remaining constant at the 1997 level. As vaccination coverage data were not available for each sector, the coverage in the dairy and large-scale commercial swine sectors was taken to be the same as that recorded for cattle at the national level. The coverage in the small-scale commercial swine sector was taken to be 90% of that achieved in the large-scale sector. The village swine coverage was assumed to be constant at 30% per pulse over the initial ten-year period.

Scenario 1
The first alternative control scenario again assumes two vaccination rounds in all sectors each year. The village coverage of cattle and buffalo is assumed to plateau at 70% each year from 1998 onwards. The coverage in village pigs was assumed to be the same as the baseline scenario for 1996 and 1997, but from 1998, maintained at a constant level of 40%. Vaccination coverage in dairy and large-scale commercial pig systems was based on the cattle vaccination coverage achieved between 1992 and 1997 and extrapolated to 2005. The vaccination coverage achieved in the small-scale commercial swine sector was again taken to be 90% of that achieved in the large-scale commercial swine sector.

Scenario 2
In the second control scenario evaluated over the ten-year period, the vaccination regimen in each sector is as that described for scenario 1 except that the dairy sector is subjected to three annual vaccinations from 1998.

Scenario 3
Finally, the sectoral vaccination regimens conducted up to year 2005 are as those described in scenario 2. From 2006 to the end of 2020, the vaccination activities were maintained at the 2005 levels. It was assumed that following an intensive three-year campaign, FMD was eradicated from Thailand at the end of 2020 and no further vaccination occurred in any sector from 2021. The year 2020 is used as a conservative, worst-case scenario reflecting the potential difficulties in achieving eradication. To test the sensitivity of the results to this assumption, the eradication date was advanced by five and ten years to 2015 and 2010 in two additional, more optimistic scenarios.

Important considerations of the epidemiological model
The predictions of the model are briefly discussed and, in addition, the important aspects of FMD epidemiology which are not addressed by the model are identified in the following section.

a) A major limitation of the model is the exclusion of any spatial component to the disease. However, this is a reflection of the lack of available spatial data of FMD incidence, control activities and animal movement patterns in the region. The collection of basic epidemiological data which can be referenced both geographically and to the production sector is a major priority for the region.

b) Foot and mouth disease is assumed to be maintained in the village buffalo and cattle populations, while outbreaks in other sectors are the result of transmission of infection from the reservoir population and are not important in the long-term maintenance of the disease. Thus, within the defined framework, increasing the frequency of vaccination in these other sectors does not reduce the probability of FMD being introduced into enterprises of these sectors. Therefore, the number of outbreaks (i.e. virus introduction events) is not reduced by increasing the number of vaccinations per year from two to three in the dairy sector. However, the average proportion of the population susceptible to disease from 1998 onwards does decrease, leading to a reduction in the number of infected animals in each outbreak.

c) The model has not examined other interventions that reduce the probability of infection being introduced into an enterprise (e.g. movement restrictions and quarantine measures). Similarly, as no external input of FMD is allowed (i.e. cross-border infection), the impact of international movement restrictions cannot be evaluated, which is a major limitation of the model. However, empirical estimates of the risk of disease introduction through cross-border trade need to be gathered.

d) The possibility of transmission between enterprises is not considered, although this is quite likely to occur, for example between dairy sector enterprises. A more complex spatial component of disease transmission is required to model the transmission between enterprises and the potential effects of different ring vaccination policies following an outbreak.

e) As the model is fully deterministic, the disease can approach but never actually reach eradication (i.e. the number of infected animals can never equal zero). Therefore, an arbitrary disease eradication date must be imposed on the model. To overcome this limitation, a stochastic model is required, which would be able to predict the probability of extinction in any year.

f) The model assumes vaccine efficacy against the circulating strains of FMD, and does not cater for the introduction of new strains into the region.

g) A more realistic demography of livestock production systems needs to be included in the model (5).

h) The assumptions made concerning the decay of antibodies are very simplistic (19). Differential responses due to vaccination history are ignored, the model assumes exponential decay of antibodies and that protection is linked to an antibody cut-off level.
Development of an economic impact assessment model of foot and mouth disease and control: the application of the model to a case-study country (Thailand)

Overview of the economic model

To assess the economic implications of different FMD control scenarios, the information generated by the epidemiological model is used as the basis for performing a CBA in a spreadsheet-based model. (The economic impact simulation model was programmed in Microsoft Excel® 5.0 for Windows 97, using the add-in @Risk [15]. The @Risk software enables the use of probability distributions, which allows variation and uncertainty regarding key parameters to be included in the model, to evaluate the robustness of the results.)

The basic approach is to describe first how control costs and benefits are expected to evolve over a given time horizon, and then to repeat the exercise under different control strategies. The first two scenarios are essentially short-term evaluations of the returns from enhanced vaccination and improved control over a ten-year period. A third scenario considers eventual freedom from FMD, and is performed over fifty years. The benefits associated with freedom from FMD are known to be substantially greater than from control, as vaccination costs are eliminated. However, as the time to eventual eradication can only be estimated, the modelling of this scenario presents difficulties. The authors therefore assumed that freedom would be achieved in 2020, some twenty-one years from the present date, a purely arbitrary year, but probably representing the conservative estimate of when eradication could be achieved. In addition, the authors evaluated how benefits might change if eradication was achieved earlier (in 2010 or 2015). The fifty-year time-frame for the analysis might appear long, but eradication is assumed to occur only at the mid-point of the fifty-year period. The fifty-year period therefore provides a twenty-five year FMD-free benefit period, which is the time period commonly used in project CBA when there is no reason to believe that the economic life of the investment will end sooner (9).

For the first two scenarios considered, for short-term FMD control in Thailand, no impact on revenues is anticipated, so incremental costs are limited to new preventive control costs. Generally, two types of costs are associated with a change in control strategy, as follows:

a) to implement the control measures, new control costs are incurred that would not have been incurred under the existing control strategy

b) any livestock production revenues foregone that are no longer earned due to the control measures.

The principal assumptions underlying the baseline and three alternative control scenarios, including those concerning the evolution of key epidemiological parameters as described in the preceding section, are summarised in Table I. When available, actual historical data are used in the model for the first two years (1996 and 1997), while for the remaining years, data values are predicted based on trend analysis or expert opinion. For each control alternative, the analysis is conducted under varying assumptions about the potential for expanding exports, particularly to the high-value Asian markets. Additional assumptions for the economic models are mainly related to the types of incremental costs and benefits represented.

Incremental costs associated with a change in control strategy

Generally, two types of costs are associated with a change in control strategy, as follows:

a) by the government in the form of disease surveillance functions, movement controls, awareness and education activities, and free public provision of vaccination for livestock in the village, small-scale swine, and dairy sectors

b) directly by producers in the commercial swine sector who pay privately for vaccination of the stock against FMD.

Sector- and species-specific vaccination costs are estimated based on average unit vaccination expense (DLD data), animal numbers (DLD data, assumed to increase on trend), estimated vaccination coverage, and frequency of vaccination. The latter two are DLD estimates for 1996 and 1997, and are subsequently determined directly by the defined control scenarios. Public expenditures for government-provided
Table I
Principal assumptions used in an economic impact model of three foot and mouth disease control strategies for Thailand

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Baseline scenario</th>
<th>Scenario 1: increased vaccination coverage</th>
<th>Scenario 2: scenario 1 + added vaccination in dairy sector</th>
<th>Scenario 3: scenario 2 + total eradication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time horizon of analysis</td>
<td>Beginning 1996</td>
<td>10 years</td>
<td>10 years</td>
<td>50 years</td>
</tr>
<tr>
<td>Animal numbers</td>
<td>Increase on trend until 2005 and then remain constant thereafter</td>
<td>Increase on trend until 2005 and then remain constant thereafter</td>
<td>Increase on trend until 2005 and then remain constant thereafter</td>
<td>Increase on trend until 2005 and then remain constant thereafter</td>
</tr>
<tr>
<td>Vaccination coverage</td>
<td>Remains constant at 1997 levels</td>
<td>Increases until 2005 and then remains constant</td>
<td>Increases until 2005 and then remains constant</td>
<td>Increases until 2005 and then remains constant</td>
</tr>
<tr>
<td>Numbers of outbreaks and animals affected</td>
<td>Predicted by model; trends downward until 2005 when low steady state is reached</td>
<td>Predicted by model as a function of vaccination coverage; trends downward over time horizon</td>
<td>Predicted by model as a function of vaccination coverage; trends downward over time horizon</td>
<td>Predicted by model from vaccination coverage; trends downward until eradication</td>
</tr>
<tr>
<td>Incremental costs</td>
<td>Preventive</td>
<td>Vaccination costs</td>
<td>Vaccination costs</td>
<td>Vaccination costs, only until eradication</td>
</tr>
<tr>
<td></td>
<td>Eradication</td>
<td>NA</td>
<td>NA</td>
<td>Assumed to occur over three years leading up to eradication, but costs assumed to be zero</td>
</tr>
<tr>
<td>Incremental benefits</td>
<td>Avoided production losses</td>
<td>NA</td>
<td>Based on differences in numbers of animals affected compared to the baseline scenario, and loss per animal estimates</td>
<td>Based on differences in numbers of animals affected compared to the baseline scenario, and loss per animal estimates</td>
</tr>
<tr>
<td>Preventive control cost savings</td>
<td>NA</td>
<td>None</td>
<td>None</td>
<td>Cost for movement controls, awareness campaigns, vaccinations stops with eradication; monitoring continued</td>
</tr>
<tr>
<td>Intervention control cost savings</td>
<td>NA</td>
<td>Based on differences in number of outbreaks compared to the baseline scenario</td>
<td>Based on differences in number of outbreaks compared to the baseline scenario</td>
<td>Based on differences in number of outbreaks compared to the baseline scenario, with full cost savings after eradication</td>
</tr>
<tr>
<td>Expanded exports</td>
<td>NA</td>
<td>Four different scenarios considered:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prices</td>
<td>Assumed constant at 1997 levels</td>
<td>Assumed constant at 1997 levels</td>
<td>Assumed constant at 1997 levels</td>
<td>Assumed constant at 1997 levels</td>
</tr>
<tr>
<td>Discount rate</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
</tr>
</tbody>
</table>

NA: not applicable
FMD: foot and mouth disease
DLD: Department of Livestock Development

Preventive services (surveillance, movement control, awareness) are assumed to be constant and are based on DLD data. Thus, the only 'new' incremental costs associated with the short-term scenarios are changing vaccination costs due to varying vaccination coverage and frequency of vaccination. For the long-term eradication scenarios, all preventive control costs are assumed to cease upon achieving eradication at the end of the year 2020 (or 2015 and 2010 in the two additional scenarios), except those related to continued surveillance and monitoring. Undoubtedly, in order to eradicate FMD, an
intensive and costly campaign would be required during the last few years. This would entail additional incremental control costs, for which no estimates are available. Instead, the approach adopted is one of estimating the additional expenses that could be incurred for eradication while maintaining a BCR greater than or equal to one (these estimates are detailed in the results section below).

**Incremental benefits associated with a change in control strategy**

The benefit component of the BCR captures increased revenue from improved productivity, in addition to savings in control costs avoided by using the alternative control strategy.

**Production losses**

Improved productivity is the most obvious benefit from improved FMD control, and this is measured in the model in terms of avoided production losses. Productivity losses are estimated by sector under each scenario as a function of the following:

a) type and amount of loss per animal (milk for dairy cattle, growth weight for swine and village cattle, workdays lost for buffalo, and sow abortion and piglet mortality for swine; all based on DLD estimates)

b) representative product market prices for 1996 and 1997 (DLD data)

c) the number of animals in each category affected by FMD (generated by the epidemiological model).

The total value of production losses is estimated in this manner for each control scenario. The change in the total value between scenarios then represents the incremental benefit.

**Control cost savings**

If an alternative control strategy effectively reduces FMD incidence, then costs of intervention controls for outbreaks should be reduced, and should reach zero when the disease is eradicated. The approach is similar to that used for production losses in that total intervention costs are first estimated under each scenario, and then compared across scenarios to compute the incremental change. Differences in intervention control costs are driven entirely by changes in numbers of outbreaks and animals affected. Government intervention cost savings are associated with reduced ring vaccination programmes, reduced compensation for slaughter, and reduced need to enforce movement restrictions (costs per outbreak based on DLD estimates). For livestock producers, savings take the following forms:

a) reduced FMD treatment costs

b) fewer movement restrictions (which can lead to lost market sales for dairy milk and commercial swine)

c) reduced requirement for precautionary vaccination in commercial swine operations as protection during outbreaks (DLD estimates).

Under the eradication scenario, nearly all preventive control costs (vaccinations, movement controls, awareness campaigns) are presumed to cease after 2020 (or 2015, or 2010 in the sensitivity analysis), whereas in the baseline scenario, all such costs must be continued. The value of preventive control costs avoided is therefore added to intervention control cost savings beginning in 2021. The only preventive control costs assumed to continue are those related to monitoring and surveillance.

**Increased exports**

As noted earlier, the main impetus for improved FMD control is to gain access to high-value export markets. If the control strategies under consideration are sufficiently successful in reducing FMD, Thailand may be able to increase export capacity, or divert some supplies from domestic or lower-value export markets to the more demanding, higher-value markets, and thereby realise increased revenues and foreign exchange earnings. The current version of the model attempts to capture this dynamic by considering the four export sub-scenarios listed in Table I, which are applied to each of the control strategies evaluated. The export scenarios serve as a crude sensitivity analysis. In the future, refinement of these scenarios using more in-depth analysis of the meat trade sector in South-East Asia will be important.

**Other limitations of the model**

Several simplifying assumptions were made for the purposes of the economic analysis that will also merit review and refinement in the future, but were beyond the scope of the present study. Firstly, not all costs and benefits have been captured adequately. Regarding costs, information is lacking on possible expenditures required to achieve eradication, and the feasibility of the success of the eradication measures, particularly with respect to effective control of cross-border movements. In an attempt to address this problem, the amount of money that could be reasonably spent on eradication whilst still generating sufficient returns to the public investment in eradication has been estimated. No additional costs for FMD surveillance and monitoring or for border controls after eradication have been included besides those currently incurred.

Importing countries may require documented freedom from other diseases, such as classical swine fever (hog cholera), and any additional costs required to achieve this status have not been considered in this analysis.

In regard to benefits, no attempt has been made to value the advantages in the control of other diseases, due to enhanced infrastructure for delivery of health services, information gathering and surveillance created by the FMD control efforts. Such advantages are likely to be substantial, but are difficult to quantify. If FMD control does indeed enhance veterinary infrastructure, it is safe to assume that opportunities for improved trade will not be significantly constrained by other diseases.
Finally, in the present form, the economic model does not permit the characterisation of the distribution of benefits in terms of welfare transfers. The question of who gains from improved FMD control (consumers, producers or the public sector) is not answered. Techniques such as the economic surplus model, are available for addressing these types of issues, while at the same time, describing how improved livestock productivity due to FMD control will affect domestic markets for livestock and livestock products. Furthermore, an auxiliary analysis could be incorporated to capture the savings to the nation in terms of protecting foreign currency reserves as avoided production losses substitute for import supplies.

Results of the combined epidemiological-economic impact model

The results generated by the economic impact model are summarised in Table II.

Alternative control scenario 1

Improved vaccination coverage as extrapolated from available data incurs increased average annual costs of 51 million Baht (discounted), most of which (89%) is borne by the commercial swine sector. The remaining 11% is a public expense since the government provides the vaccinations to the village, small-scale and dairy sub-sectors free of charge.

Assuming no dramatic change occurs in exports of livestock products, improved vaccination coverage generates average incremental benefits of only 1.4 million Baht annually, principally (over 80%) due to lower intervention costs as the number of FMD outbreaks per year is reduced. The commercial swine sub-sector captures the majority of these benefits (61% of total benefits, due to the reduced probability of virus introduction), followed by the public sector (21%).

Thus, the efforts to improve vaccination coverage and reduce productivity losses do not succeed in generating sufficient benefits to justify the additional costs incurred. This conclusion is reflected in the summary indicators: the NPV, which is negative, and the BCR, which is well below one.

However, the situation changes dramatically if improved vaccination coverage enables swine producers in Thailand to enter the high-value markets of Asia, by contributing to the creation of disease-free zones. If, beginning in 2003, Thailand could supply 5,000 tonnes of frozen or chilled pork at $5.80 per kg to such markets, the incremental benefits exceed the costs of increased vaccination coverage. The NPV for the 1996-2005 time horizon becomes positive, and the BCR rises to 1.73. Increasing exports of processed meat alone has a similar effect, with the BCR rising to 1.21. The impact of improving access to these markets is clearly illustrated in Figure 5, which demonstrates the impact on the BCR of increasing export volumes under different assumptions of export price levels. The BCR improves rapidly as Thailand begins exporting chilled or frozen pork, achieving break-even profitability for the improved vaccination efforts when high-value exports reach 2,800 tonnes annually (assuming a price of $5.80 per kg). However, as the export price approaches domestic price levels, the FMD control strategy no longer generates sufficient returns (the BCR falls below one

Table II

<table>
<thead>
<tr>
<th>Foot and mouth disease control scenario</th>
<th>Export scenario 0: no change</th>
<th>Export scenario A: 5,000 tonnes of chilled pork exports</th>
<th>Export scenario B: 20% in processed meat exports</th>
<th>Export scenario C: scenarios A and B combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control scenario 1: increased vaccination coverage</td>
<td>Incremental costs 514</td>
<td>514</td>
<td>514</td>
<td>514</td>
</tr>
<tr>
<td>Incremental benefits 14</td>
<td>891</td>
<td>622</td>
<td>1,499</td>
<td></td>
</tr>
<tr>
<td>Net present value -500</td>
<td>377</td>
<td>108</td>
<td>985</td>
<td></td>
</tr>
<tr>
<td>Benefit-cost ratio 0.03</td>
<td>1.73</td>
<td>1.21</td>
<td>2.92</td>
<td></td>
</tr>
<tr>
<td>Control scenario 2: increased coverage and an added vaccination in dairy</td>
<td>Incremental costs 527</td>
<td>527</td>
<td>527</td>
<td>527</td>
</tr>
<tr>
<td>Incremental benefits 15</td>
<td>882</td>
<td>622</td>
<td>1,500</td>
<td></td>
</tr>
<tr>
<td>Net present value -512</td>
<td>385</td>
<td>96</td>
<td>973</td>
<td></td>
</tr>
<tr>
<td>Benefit-cost ratio 0.03</td>
<td>1.68</td>
<td>1.18</td>
<td>2.85</td>
<td></td>
</tr>
<tr>
<td>Control scenario 3: increased coverage, added vaccination in dairy, and eradication in the year 2020</td>
<td>Incremental costs 1,378</td>
<td>1,378</td>
<td>1,378</td>
<td>1,378</td>
</tr>
<tr>
<td>Incremental benefits 1,887</td>
<td>6,994</td>
<td>4,750</td>
<td>12,057</td>
<td></td>
</tr>
<tr>
<td>Net present value 308</td>
<td>7,615</td>
<td>3,372</td>
<td>10,679</td>
<td></td>
</tr>
<tr>
<td>Benefit-cost ratio 1.22</td>
<td>6.52</td>
<td>3.45</td>
<td>8.75</td>
<td></td>
</tr>
</tbody>
</table>

Amounts for foot and mouth disease (FMD) control scenarios 1 and 2 are discounted totals for the ten-year period 1996-2005

Amounts for FMD control scenario 3 are discounted totals for the fifty-year period 1996-2045

Exchange rate at the time of the study: US$1 = 35 Baht
over the full range of export volumes). Thus, if exporters in Thailand are not able to command sufficiently high export prices in the higher-value markets of Asia, more intensive FMD control may not be justified.

**Alternative control scenario 2**

In the second alternative control scenario, improved vaccination coverage is combined with increased frequency of vaccination in the dairy sector (three instead of two vaccinations annually). If no change in exports is assumed, the additional vaccination for dairy cows increases incremental costs by 2.4% compared to the first scenario, while raising incremental benefits by 4.5%. These modest changes have a substantial impact on the relative profitability of additional control under the various export scenarios. In general, the results follow those described for the first scenario.

**Alternative control scenario 3**

Under the third scenario, FMD is eventually eradicated in 2020. To capture future benefit streams, the time horizon for the analysis is extended to fifty years, covering twenty-five years with FMD and twenty-five years of FMD-free production. In this case, even assuming no additional exports, increased FMD control and eradication is shown to be economically viable as it generates a BCR of 1.22. With additional exports, the economic justification becomes much stronger, achieving a BCR of 6.52 under the scenario of 5,000 tonnes of high-value chilled pork exports, and a BCR of 3.45 for the 20% annual growth in processed meat exports over the period 2000-2005.

As indicated in Figure 6, the results are only moderately sensitive to the choice of length of time period for the analysis. Lengthening the time horizon improves the BCR since more benefits are allowed to accrue in the post-eradication period, during which incremental costs are no longer incurred. After eradication in year 25 the BCR rises at a faster rate as incremental costs cease and large control cost savings are realised since vaccinations and control measures are no longer necessary. Assuming the most unlikely scenario that FMD eradication does not contribute to an expansion in exports, fifteen years are required to generate sufficient post-eradication benefits (in terms of avoided production losses and control costs) to achieve a BCR of one, and thus justify the eradication programme. If exports are assumed to have expanded prior to eradication, due to reduced FMD incidence, then the eradication only improves the BCRs already over one.

The analysis of the eradication scenario does not consider any additional costs, such as intensified movement control, monitoring, and slaughter, that might be required during the final stages of eradication. To address this issue, rather than arbitrarily assume some eradication cost for which no estimates exist, the authors consider the amount of funds that could be allocated to such an effort in the last three years prior to eradication (years 23-25) while still maintaining a BCR superior to one. These amounts are reported in Table III for each of the export scenarios. Clearly, any reasonable expenditure required for such a campaign would be well within these limits.

---

**Table III**

Possible expenditure on an eradication campaign while maintaining the benefit-cost ratio greater than one

<table>
<thead>
<tr>
<th>Export scenario</th>
<th>Expenditure ceiling (million Baht per year over 3-year period)</th>
<th>Total annual government control costs, 1997 (billion Baht)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario B: no exports</td>
<td>350</td>
<td>192 (182 for preventive actions plus 10 for interventions)</td>
</tr>
<tr>
<td>Scenario A: 5,000 tonnes chilled pork</td>
<td>8,580</td>
<td></td>
</tr>
<tr>
<td>Scenario B: 20% processed meat</td>
<td>3,800</td>
<td></td>
</tr>
<tr>
<td>Scenario C: scenarios A and B combined</td>
<td>12,050</td>
<td></td>
</tr>
</tbody>
</table>
The effect of varying the year in which eradication occurs

The eradication scenario evaluated assumes that the programme achieves success only by 2020. This date takes into account the considerable time that could elapse before various constraints to implementation of an eradication programme were overcome (particularly the difficulties expected in effectively controlling cross-border livestock movements). However, a precise date of eradication is clearly difficult to predict. It is therefore important to evaluate the implications of achieving eradication earlier than 2020, which is certainly the hope of many. To attain this goal, the simulation was re-run assuming eradication is achieved in 2010 and 2015. The results are reported in Tables IV and V.

Earlier eradication improves the economic returns markedly, approximately doubling the BCRs across the different export scenarios if eradication can be completed in 2010. The returns remain fairly positive even if the time horizon for the analysis, and more specifically, the post-eradication benefit period, is reduced by fifteen years. Assuming there is no expansion of exports, the amount of expenditures that could be devoted to the eradication programme, while still maintaining a BCR greater than one, increases as the time-span to eradication is reduced. This reflects the fact that as eradication is advanced to an earlier date, the main benefit stream under this scenario

**Table IV**

<table>
<thead>
<tr>
<th>Export scenario</th>
<th>Year of final eradication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010</td>
</tr>
<tr>
<td><strong>50-year time horizon</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3.73</td>
</tr>
<tr>
<td>A</td>
<td>11.76</td>
</tr>
<tr>
<td>B</td>
<td>7.09</td>
</tr>
<tr>
<td>C</td>
<td>15.12</td>
</tr>
<tr>
<td><strong>35-year time horizon</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3.00</td>
</tr>
<tr>
<td>A</td>
<td>10.21</td>
</tr>
<tr>
<td>B</td>
<td>6.02</td>
</tr>
<tr>
<td>C</td>
<td>13.24</td>
</tr>
</tbody>
</table>

Scenario B : no additional exports
Scenario A : 5% annual increase in exports of processed products until 2005
Scenario B : additional 5,000 tonnes chilled pork exports to high-value markets
Scenario C : scenarios A and B combined
Table V
Break-even values for the cost of a foot and mouth disease eradication programme under varying export scenarios and time horizons (billion Baht)

<table>
<thead>
<tr>
<th>Export scenario</th>
<th>Year of final eradication</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50-year time horizon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>2.00</td>
<td>1.37</td>
<td>0.49</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>7.88</td>
<td>9.61</td>
<td>12.05</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>4.46</td>
<td>4.83</td>
<td>5.34</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>10.34</td>
<td>13.07</td>
<td>18.90</td>
</tr>
<tr>
<td></td>
<td>35-year time horizon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>1.46</td>
<td>0.62</td>
<td>-0.56</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>6.75</td>
<td>8.03</td>
<td>9.83</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>3.68</td>
<td>3.73</td>
<td>3.80</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>8.96</td>
<td>11.14</td>
<td>14.19</td>
</tr>
</tbody>
</table>

Scenario 0: no additional exports
Scenario A: 5% annual increase in exports of processed products until 2005
Scenario B: additional 5,000 tonnes chilled pork exports to high-value markets
Scenario C: scenarios A and B combined

is lengthened. Under the scenarios with export expansion, the opposite occurs, since such a large portion of the discounted benefits occur prior to eradication.

Conclusions

Foot and mouth disease has wide-ranging impacts on livestock production and economic development in South-East Asia. This impact differs considerably according to the country and production system in question.

The results obtained in previous studies of the economic impact of FMD in the region vary considerably. However, only one study has attempted a national level CBA and even here future exports associated with zone or country FMD freedom are only discussed briefly (10). The results of that study indicated marginally positive returns to FMD eradication.

To ensure that the control scenarios evaluated are as realistic as possible, a sound epidemiological base for the economic impact assessment is essential.

Epidemiological and economic frameworks for the evaluation of national control and eradication scenarios have been developed. These can be systematically applied to other countries of the region in the future.

These frameworks were applied to a case-study country, Thailand. The results suggest that should FMD eradication be achieved by 2020, the eradication measures would be economically viable. If an eradication date of 2010 could be achieved, the economic returns would be greater. In all cases, the estimated returns from access to meat export markets would dramatically increase the economic viability of FMD eradication.

In evaluating the effects of improved control, rather than eradication, over a ten-year period, the results suggest that such improved control efforts would only be viable if new export markets could be initiated.

Acknowledgements

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Impact économique de la fièvre aphteuse et de sa prophylaxie en Asie du Sud-Est : évaluation préliminaire dans le cas de la Thaïlande


Résumé
Les auteurs décrivent une étude pilote portant sur l'impact économique de la fièvre aphteuse dans les pays et la région de l'Asie du Sud-Est. Ils prennent en compte les évaluations antérieures de cet impact et en font la synthèse. Ils élaborent ensuite un cadre pour évaluer l'impact économique futur de la maladie, en intégrant des analyses aux niveaux sectoriel (système de production), national et régional. Ils définissent également les données requises pour la réalisation de ces études. Des modèles épidémiologiques et économiques intégrés ont été mis au point pour évaluer cet impact, et une application du modèle au cas de la Thaïlande est proposée. Les modèles ont permis d'évaluer la rentabilité des programmes de lutte contre la fièvre aphteuse dans ce pays. Les scénarios évalués concernent notamment les effets d’une meilleure couverture vaccinale et, partant, de la réduction des pertes de productivité, ainsi que les résultats attendus de l’éradication de la maladie. Il ressort des résultats obtenus que les coûts élevés de la lutte contre la fièvre aphteuse pourraient être rentabilisés à court terme par l’accroissement des échanges internationaux de produits d’origine porcine et par des prix à l’exportation supérieurs à ceux pratiqués sur le marché intérieur. Ainsi, l’éradication de la fièvre aphteuse en Thaïlande en 2010 serait une opération rentable, même hors exportations, avec un rapport bénéfice-coût estimé à 3,73. En cas d’accroissement des exportations, la prophylaxie se justifie encore plus au plan économique, le rapport bénéfice-coût étant alors de 15:1. Si l’éradication n’était effective qu’en 2020, l’opération resterait intéressante, hors exportations, mais avec un taux de rentabilité inférieur. Les auteurs proposent que les modèles épidémiologiques et économiques intégrés ainsi élaborés soient appliqués à d’autres pays de la région afin d’avoir une idée plus précise des avantages à venir de la lutte contre la fièvre aphteuse et de l’éradication de la maladie dans cette région.

Mots-clés

Impacto económico de la fiebre aftosa y su control en el Sudeste asiático: evaluación preliminar, con especial referencia a Tailandia


Resumen
Los autores describen un estudio piloto sobre el impacto económico de la fiebre aftosa en los países del Sudeste asiático. En primer lugar repasan y resumen anteriores evaluaciones del impacto económico, y hacen una síntesis de esos trabajos. A continuación describen un sistema de referencia para futuras evaluaciones, incorporando análisis a diversas escalas –sectorial (sistema
productivo), nacional y regional—y especificando los datos necesarios para efectuar ese tipo de estudios. Tras elaborar modelos epidemiológicos y económicos integrados para evaluar el impacto de la enfermedad, los autores aplicaron dichos modelos al análisis de un país, concretamente Tailandia, utilizándolos para estudiar la viabilidad económica de los programas de lucha contra la fiebre aftosa en ese país. Trabajaron con varias hipótesis, incluyendo el efecto de la ampliación de la cobertura de vacunaciones, cuyo resultado sería el de reducir las pérdidas de productividad, y el efecto de la erradicación posible de la enfermedad. Los resultados indican que las elevadas inversiones económicas necesarias para controlar la fiebre aftosa podrían rentabilizarse a corto plazo, siempre y cuando se posibilitara un mayor comercio internacional de productos porcinos y los precios de exportación quedaran fijados a un nivel superior al del mercado interno. Si para el año 2010 llegara a erradicarse la fiebre aftosa de Tailandia, la erradicación sería económicamente viable aun en ausencia de exportaciones, con una relación beneficios/costes prevista del 3,73. Añadiendo a ese cálculo las exportaciones, el argumento económico resulta inapelable, con una relación beneficios/costes de hasta 15 a 1. De no conseguirse la erradicación hasta el año 2020, los resultados seguirían siendo positivos incluso sin exportaciones, aunque a una tasa menor. Para obtener una idea más exacta de los beneficios que podrían derivarse del control y la erradicación de la fiebre aftosa en la región, los autores proponen aplicar a otros países de la zona los modelos epidemiológicos y económicos integrados.

Palabras clave

References


