MODELLING ANIMAL HEALTH ECONOMICS

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Mr. Rector Magnificus, ladies and gentlemen,

There is still a tendency among non-economists to qualify economics as the discipline that simply measures things in monetary units, while everyone else uses physical units. This view, however, is far too simple and is inappropriate. Economics - as a science - primarily deals with decision-making, in which money is only one of the elements of the system (Boehlje and Eidman, 1984). Animal Health Economics, therefore, can be described as the discipline that aims to provide a framework of concepts, procedures, and data to support the decision-making process in optimizing animal health management.

The scientific foundation for the discipline of Animal Health Economics was laid 20 to 25 years ago in Australia (Morris, 1969) and England (Ellis, 1972). The two authors successfully introduced a simple but essential economic principle in making veterinary decisions. Disease control input should be increased to the level where the cost of an additional input equals the return from the additional output. This so-called equimarginal principle can be considered a fundamentally different approach from the previously more common opinion of disease control being an all-or-nothing affair. Since then, increasing effort has been made to apply this principle in the various areas of Animal Health Economics (Howe and McInerney, 1987).

The Netherlands is among the countries that first adopted the new approach, initiated by the work of Renkema and Stelwagen (1979). Systematic research was started that includes three interrelated phases (Dijkhuizen, 1983): (1) quantifying the financial losses caused by animal disease, (2) optimizing decisions when individual animals, herds, or populations are being affected, and (3) determining the costs and benefits of preventive disease control. Experiences in this approach will be used to present and discuss the promising field of Animal Health Economics in the remainder part of this public lecture.

The Economic Framework of Livestock Disease

The basic conceptual model underlying economic analyses includes three major components: people, products, and resources (McInerney, 1987). It is people who want things and make decisions, therefore providing the driving force for economic activity. Products are goods and services that satisfy what people want, and may be regarded as the outcome of economic activity. Resources are the physical factors and services that are the basis for generating the products, and, as such, are the starting point of economic activity.

Animal disease in this context can be considered an influence which affects the resource transformation process and causes extra resource use and/or less production to result than before. These effects may be immediately visible (death, abortion), or obscured (reduced weight gain). To express the physical effects in economic terms, the 'value' of products and 'cost' of resources are required. The idea of value is not intrinsic in any product or service, but is determined by the people's request for the products, and is relative to its availability ('supply and demand'). Economics attempt to deal with the real value of any product, which may or may not be accurately captured by its recorded price. Similarly, the idea of cost comes from the resources that are used in making a product available. This underlies the definition of the real cost (or 'opportunity cost'), which again may not be adequately reflected by financial expenditures incurred in its production. Both 'real value' and 'real cost' - and hence the losses of one and the same disease - may differ considerably across the various economic levels to be considered, i.e., the individual farmer, the joint livestock owners, the consumers, and the national economy (Dijkhuizen et al., 1991).

In the case of common diseases that the individual farmer can control (the so-called enzootic disease, such as mastitis), supply and demand force animal product market prices to move over time with the average disease level. Thus the resulting losses are transferred to the consumers, and conversely it is the consumer who benefits from improved animal health. In a sufficiently large market (such as the EC) there is hardly any relation between the extent and seriousness of these diseases on the one hand, and the average income of the joint livestock owners on the other. However, for the individual farmer this linkage does exist. The farm in question may suffer more (or less) from disease than is compensated by the average 'disease margin' included in the market price. To a lesser extent this also applies to a group of livestock owners.

In the case of an incidental outbreak of contagious diseases (the so-called epizootic diseases, such as Swine Fever), market prices of output will primarily depend on whether or not foreign trade restrictions occur. When an outbreak does not lead to export bans, the market prices may temporarily rise a little, depending on the spread and duration of the outbreak. If exports are restricted, however, prices in highly exporting countries will drop substantially due to an oversupply of the domestic market. This fall in price causes losses which may greatly exceed the direct losses of the disease due to mortality, for instance. Unaffected farms also suffer from this drop in market prices. Consumers will benefit, however, making the losses for the national economy considerably less than those for the joint livestock owners. Income transfers namely between consumers and producers, are not relevant to the assessment of national economic losses (Renkema, 1980).

The calculation of the losses is, in itself, not very important but can help provide a better overall view of the impact of disease and can contribute in estimating the extent of the losses to be avoided. The latter is particularly the case if the spread in losses between farms (or countries) is indicated in addition to the losses in the average situation. The accuracy of the outcome highly depends on the availability and usefulness of the underlying data. But even with enough data available it is not a simple task to quantify the losses of disease because their effects (Ngategize and Kaneene, 1985): (1) are not always obvious and pronounced, (2) are influenced by other factors such as nutrition and housing, (3) have a temporal dimension which adds to the complexity of determining their impacts at different stages in time, and (4) often manifest themselves in a complex with other diseases. This may help explain why the outcome of calculations often differs so much, even for similar farm and price conditions (Schepers and

Dijkhuizen, 1991).

Mathematical Modelling in Animal Health Economics

Models are an essential tool in the understanding of Animal Health Economics. Mathematical models are especially useful in this context and are commonly defined as a set of equations to describe or simulate an interrelated part (system) of the real world (Hillier and Lieberman, 1989). More specifically, a system in this context can be described as a set of related components (e.g. animal, farm, national economy) which exist within some defined boundary and react as a whole to internal and external stimuli (e.g. diseases, prices). Placing of the boundary is considered the key-issue in defining and structuring any system, and should depend primarily on the function the model has to fulfil (Dent and Blackie, 1979).

Basically, two different modelling approaches are to be considered: a positive approach and a normative approach. The positive approach can best be indicated as a description of relevant processes and characteristics by statistical/epidemiological data analysis (the so-called empirical modelling). In Animal Health Economics greater attention is being paid to the normative approach which uses computer simulation techniques (the so-called mechanistic modelling). Computer simulation is a method for analyzing a problem by creating a simplified mathematical model of the system under consideration which can then be manipulated by input modification. It is especially attractive where real-life experimentation would be either impossible, costly, or disruptive (e.g. with highly contagious diseases), and to explore strategies that are not yet applied. Special attention has to be paid to the correspondence between model and reality to obtain meaningful results for real-world situations.

During computer simulation, usually six interrelated steps are being considered: (1) define the system and objectives for modelling, (2) gather the data and specify relations relevant to the model, (3) construct the model, (4) validate the model, (5) carry out a sensitivity analysis, and (6) use the model to provide the results.

A clear description of the system, and statement of the reasons why the system simulation work is being carried out, is an essential first step. The system under consideration, the nature of the problems to be solved, the relevant data and relations available (step 2), and in what degree of detail answers are required, highly determine the type of model to be used. Different types of models are available (France and Thornley, 1984), and applied in the field of Animal Health Economics (Dijkhuizen, 1988). A first choice to be made is that between static and dynamic models. A static model does not contain time as a variable, and, therefore, cannot simulate the behaviour of a system over time as opposed to a dynamic model. A model that makes definite predictions for quantities (such as milk production and liveweight) is called deterministic. A stochastic model, on the other hand, contains probability distributions which deal with uncertainty in the behaviour of a system (i.e., disease occurrence, price level). Probability distributions offer the possibility to include random elements. With random elements, repeated runs of the model ('replicates') are necessary to provide insight into the spread in outcome. A final difference to consider concerns optimization versus simulation. An optimization model determines the optimum solution given the objective function and restrictions, whereas a simulation model calculates the effects of pre-defined sets of input variables (scenarios, strategies).

Constructing the model itself (third step) is usually a multistage procedure. Three different approaches are to be considered: (1) the bottom-up approach, beginning with the components of the model at the lowest level of organization and melding them together without any aggregation, (2) the top-down approach, which begins with a simple representation of the entire system and is complete when the resolution of the model is sufficient to satisfy the objectives, and (3) the prototyping approach, representing an iterative compromise between the first two alternatives. Development under the prototype approach begins with simple modelling of single sub-systems. The process of development proceeds by formulating more sophisticated representations of the most important sub-systems and aggregating, deleting or ignoring sub-systems of lesser importance. Because of its flexibility, the prototyping approach is especially favourable for models of large and complex systems, such as livestock farming.

Validation is considered a very important but difficult (fourth) step in the entire modelling procedure. The key-issue here is to judge whether or not the model mimics the real system sufficiently enough to fulfil the purposes for which it has been developed. A distinction is being made between internal and external validation. Internal validation is a continuous process throughout the entire development stage of the model, ensuring that each equation or part of the model has a logical and correct basis. External validation refers to the comparison of the model's performance against the performance of the real system. This may include the sensitivity analysis (fifth step) in which the values of relevant parameters are systematically varied over some range of interest to determine their impact on the results. Good knowledge of sensitive parameters should be available and entered into the model. If not available, sensitivity analysis can help to set priorities for further research. In this way a valuable interaction between system modelling and field data analysis is possible. System modelling may be used to quantify the significant gaps in veterinary knowledge, while knowledge obtained from field data research increases the realness of economic models. This interaction is considered fundamental to the study of disease and disease control. If completed and accepted, the model can be used (sixth step) for providing the final answers to the questions for which it has been built.

In the following paragraphs this type of modelling is worked out on three levels of decision making in Animal Health Economics: the animal, herd, and national level.

Modelling the Economics of Replacement Decisions at the Animal Level

Animal health and production control decisions at the animal level all include replacement as one of the alternatives. Usually, these decisions are based on economic considerations: animals are culled not because they are no longer able to produce in a biological sense, but because replacement animals are expected to yield more profit. The income potential of the replacement animal cannot be realized as long as the available animal is kept in the herd, and, therefore, can be interpreted as the opportunity cost of postponed replacement (Renkema and Stelwagen, 1979; Dijkhuizen et al., 1986). So, the net revenue of not only the animals present in the herd but rather the net revenues of the present and all subsequent replacement animals, are to be maximized.

Dynamic programming is considered the most appropriate technique for determining the optimum replacement decisions in livestock. It allows non-linear relationships, genetic improvement, seasonal variation and variation in expected performance of both the present and all subsequent replacement animals to be included. In the Netherlands, extensive research has been carried out to apply this technique to cows (Van Arendonk, 1985) and sows (Huirne, 1990). Decisions were optimized for animals that differ in age, productive capacity, and reproductive status. Major outcome of the research is an economic index - called Retention Pay-Off (RPO) - that enables ranking of individuals within the herd on their expected future profitability: the higher the RPO, the more valuable the animal. A value below zero means that replacement is the most profitable choice. Results show that selection on insufficient productive capacity, apart from any disease, should be significantly stronger in cows than in sows. The key-factor here is the repeatability of performance across parities, which is much higher for milk production than for litter size. Reproductive performance, on the other hand, is economically far more important in sows than in cows. Costs of a one-day delay in conception, for instance, reduces annual sow income by about 1% against 0.1 to 0.3% in cows. So, culling on reproductive failure should be significantly stronger in sows than in cows. This means that fewer number of breedings are allowed before the RPO-index falls below zero and replacement becomes the more profitable option.

Having the RPO-index available in this way, about half of the decisions for replacement in dairy cattle and sows can be directly supported. Moreover, the outcome can provide some indirect help with decisions on treatment or culling in the case of health problems. This is because its value represents the maximum amount that should be spent in trying to keep the animal in the herd. Decisions on whether or not to treat for abomasal displacement in cows, for instance, has been worked out in this way, using the decision tree modelling techniques (Breukink and Dijkhuizen, 1982). Surgical treatment involving laparotomy turned out not to be profitable, unless the cow's productive capacity exceeds the average of the herd. Research is underway to include other health problems in the dynamic programming approach. Mastitis in dairy cattle is the first to be considered (Houben et al., 1991), commonly recognized as the cause of considerable losses in many countries.

When considering health problems, however, not all relevant aspects are to be expressed quantitatively. More qualitative aspects also play a role in the farmer's decision-making process, e.g. with respect to leg weakness, udder quality and body constitution.

These qualitative aspects, however, cannot be included directly in the dynamic programming approach. Therefore, research was started to develop a hybrid decision support system combining the dynamic programming approach with expert system features (Huirne et al., 1991). Expert systems are a modelling representation of the human reasoning process, using expert knowledge to attain high levels of performance in a narrow problem area (Turban, 1988). They typically represent knowledge symbolically, and examine and explain their reasoning process. Huirne et al. (1991) entered rules of thumb derived from veterinary experts into the system, making it possible to re-calculate the initial RPO-value for the specific - more qualitative - health status of the animals under consideration. For that, it is also possible to include the farmer's subjective weights on specific deviations and problems. Results are promising so far, which justifies increased research input in this particular area.

Modelling the Economics of Veterinary Services at the Farm Level

Controlling the cost of production is becoming increasingly important in modern livestock farming. Improving animal health and fertility can play a major role in this context. Total losses caused by health and fertility problems in Dutch dairy cattle, for instance, are currently estimated to average about Dfl. 500 per cow per year (Dijkhuizen, 1990). This is almost 10% of the gross production value and 40 to 50% of income for a typical farmer. Differences between farms are estimated to be of the same magnitude.

Veterinarians try to anticipate herd health control by changing their services to individual farms from the so-called first-aid practice or fire-brigade approach into planned prevention and control programs, in which farm advisory visits play a central role (Noordhuizen, 1984). Throughout the world, several field trials were carried out to investigate the economic attractiveness of such programs. Very few of these trials, however, were properly designed for a sound economic analysis. Such an analysis requires data from both the 'with' and 'without' situation. This may be realized in two ways: data from 'before' (b) and 'after' (a) application of the program, collected on farms participating in the program (P) as well as on comparable control farms (C). When available, these data make it possible to estimate the causal effects of the program more precisely, i.e., $(P_a\text{-}P_b) - (C_a\text{-}C_b)$, especially when particular herds with obvious health problems take part in the program.

In the Netherlands, the field trial the most appropriate for economic analysis was carried out on dairy farms from 1974/75 to 1976/77 (Sol et al., 1984). A total of 30 program farms and 31 control farms were included, none of them showing specific herd health problems. In the preparatory year (1974/75), the two groups showed no large differences in economic results. After two years of program application statistically significant improvements were found, both regarding fertility (calving interval) and replacement due to reproductive failure and ill health. Regarding udder health (i.e., cell count) no significant effect was found. The average increase in gross returns minus feed cost per cow turned out to be Dfl. 460 in the program group, which is Dfl. 176 more than in the control group. Additional veterinary costs per cow were estimated to average Dfl. 35 at most, indicating this herd health program to be a sound investment. The latter conclusion was further confirmed by the finding that the program effect had soon disappeared after the experiment was finished (Hogeveen et al., 1992). It seems to be profitable, therefore, to apply such programs to farmers on a more than temporary base.

To really optimize this type of input on farms according to the equimarginal principle mentioned before, much more detailed information is required. Actually, the current single-point type of results need to be extended to include a wide range of possible contents and frequencies for the various programs and/or measures. To provide this kind of information by field trials only will not be feasible, i.e., it is too costly and time-consuming. Computer simulation, therefore, is considered an appropriate alternative.

Experiences in this respect were gained with a stochastic simulation model, using random numbers, primarily designed to explore and evaluate management strategies on reproduction and replacement in dairy cattle (Dijkhuizen et al., 1987). In the model, cows are individually generated according to a set of predetermined herd characteristics. After an initial herd has been generated (year 0), changes in the herd can be followed at 20-day intervals over 15 years. For each strategy under consideration, 20 runs of calculations are carried out to obtain statistically reliable results. Each run is to be conceived as a separate herd or farm. Once available, the possibilities for experiments are extensive. For typical Dutch farms with Black-and-White cows it was found that a 20% increase in both the calving rate after first insemination, and the oestrus detection rate has a relatively small effect on income: 2 to 3% of net return on labour and management. Where herd health and management programs in the field are still restricted to fertility, a broadening of the content is desirable and necessary from an economic point of view. Improving the herd's production level (e.g. by reducing health problems) has a much bigger effect on income. But also the farmer's insemination and culling strategy should be taken into account. Fertility performance indicators can strongly be improved while income is decreased, as shown with a strategy in which the maximum allowable number of inseminations per cow is reduced. The advantage of a shorter calving interval is outweighed then by the negative effects of increased herd turnover and replacement. A shorter calving interval, therefore, should be achieved by improved herd fertility management rather than by increased culling of cows that fail to conceive.

With these kind of structured experiments, computer simulation can help to set priorities in herd health and management programs (Marsh et al., 1987). By entering farm-specific data into the model, it is possible to explore strategies tailored to individual farm conditions (King and Dijkhuizen, 1988). Research is underway and should be further extended to make such models available for use in the field suitable for running on the personal computer (Jalvingh et al., 1992).

Increasing efforts are also being made to model farms within a production chain as a whole. The various participants in such chains can all have their own specific goals and interests, which does not have to be optimal for the chain as a whole. This possible conflict becomes more important where consumers put an increasing demand on product quality, food safety, and animal welfare. More than ever, therefore, insight is desired into the possibilities for and economic consequences of optimising the animal production chain as a whole. Within this context, animal disease control is also considered a major aspect of common interest.

Modelling the Economics of National Disease Control Programs

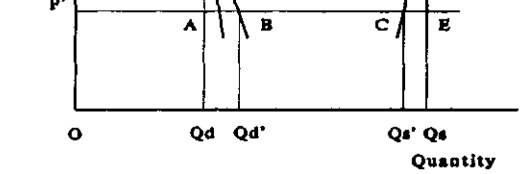
Outbreaks of contagious animal diseases are understandably feared, especially in major exporting countries such as the Netherlands. Control of this type of disease goes beyond the range of influence of the individual farmer, and needs to be carried out at the national or even international level. Current control strategies differ between countries as well as between diseases on (1) whether or not routine vaccination is applied to prevent this type of disease, and (2) what eradication measures are taken if a certain disease does occur, e.g. vaccination policies versus stamping-out of infected animals and/or herds.

Decisions on what strategy is best to apply are highly subject to uncertain conditions, especially with respect to the risk of outbreaks and foreign trade restrictions. To make economically sound decisions, therefore, an integrated modelling approach is required that simulates the effects of different conditions and scenarios considering (1) the spread of the disease, (2) the direct cost of prevention and eradication, and (3) the indirect effects due to export bans. Published work in this field is scarce and hardly goes beyond the first two stages (Houben and Dijkhuizen, 1990; Van der Kamp et al., 1990). Therefore, research was started to develop a method for quantifying and including the indirect losses of export bans (Berentsen et al., 1990).

The basic principle for determining the indirect effects due to export bans is illustrated in Figure 1. This figure shows the supply curve (S) and the demand curve (D) for a country exporting a certain product. At the basic price level P, producers supply amount Qs while consumers demand amount Qd, with the difference (Qs-Qd) being exported. When export bans occur, a new equilibrium will arise at a lower price level, influencing the welfare of both producers and consumers.

Assuming producers strive for maximum profits in competitive markets, the supply curve (S) is the same as the rising part of the so-called marginal cost curve, indicating the costs of an additional unit of output. The return to fixed inputs, therefore, is formed by the gross returns (quantity times price) minus the variable costs (the area under the supply curve), and is commonly called producer surplus. Consequently, the losses for the producers due to a drop in price from P to P' is the reduction in producer surplus (area PFCP'). In the short term, a large part of the costs are fixed and the supply curve will be steep. With short-lived disease outbreaks, therefore, the vertical supply curve (S') can be used to quantify the losses in producers income. Actual losses for the producers are reduced by any compensation paid by the government.

Consumers gain from a drop in price, indicated by the increase in consumer surplus (area PGBP'). The consumer surplus is defined as the difference between the willingness to pay for a certain quantity and the amount actually paid, in Figure 1 illustrated by the area under the demand curve and above the price line. From the alternative demand curve (D') it can be concluded that the slope of the curve (i.e., the price elasticity of demand) is not very important for the calculation of an increase in consumer surplus.



Figuur 1. The market situation for a country exporting a product.

Within the theory of welfare economics, there is discussion about the aggregation of benefits and costs at the national level (Just et al., 1982). Simple aggregation of these effects presumes an equal weight of benefits and costs for each group and individual which is usually not the case. From an investigation of EC dairy policy in the years 1980 to 1987, for instance, it emerged that one guilder of producer income was considered about twice the weight of one guilder of consumer income (Oskam, 1988). It is, therefore, recommendable to report both the separate effects and their equally weighted total, leaving policy makers the opportunity to include their own weights.

The basic principle for determining the indirect losses of export bans has recently been worked out for and applied to Foot-and-Mouth (FMD) disease, focusing on the decision whether or not to stop annual vaccination of cattle (Berentsen et al., 1990). The various export markets for meat and breeding cattle were described by the volume of export, the level of consumption, the price elasticity of demand, and the transport costs per unit of product. For the domestic market, the import and the price of the products were specified. Some countries (such as the USA, Japan and South Korea) do not accept meat from countries with an annual FMD-vaccination scheme. As a result, the price paid for meat on these FMD-free markets was assumed to be about 10% higher than on other markets. In calculating the indirect effects, it was also necessary to specify what reactions to expect in importing countries in case of an FMD-outbreak in the Netherlands. Moreover, possibilities to temporarily increase export to other markets as well as the storage behaviour of traders had to be specified. Results showed that the indirect losses, indeed, are many times greater than the direct costs, although they did not influence the economic ranking of the various strategies in this case. Strategies without annual vaccination were found to be the most preferable for the Netherlands anyway, which findings support the decision of the European Community to cease vaccination against Foot-and-Mouth disease from January 1, 1992.

A further integration of the EC towards one common market makes a coordinated policy against contagious animal diseases increasingly important. From Brussels, therefore, more strict demands are to be expected considering control and eradication of a wide range of diseases, starting with Aujeszky disease in swine, IBR in cattle and Newcastle disease in poultry (De Ruijter, 1991). To anticipate these demands, a modelling environment is desired in which 'what-if' scenarios can be performed to explore the epidemiological and economic effects of the various diseases and control strategies. This requires input flexibility regarding (1) the type and density of farming in the region or country under consideration, (2) the type of disease, (3) the prevention and control strategy to apply, (4) the extent and segmentation of export markets, including intervention possibilities, (5) the country-specific probabilities of trade restrictions, and (6) the various prices and demand/supply elasticities. A combined approach across countries would make it possible to examine the impact of a coordinated strategy within the EC as a whole. Increased effort is desired to develop and include in this approach possibilities for electronic identification and registration of individual animals. The system thus derived will be a flexible tool to support real-life policy making in an increasingly important area and, therefore, will get high priority within this new chair of Animal Health Economics.

Teaching activities in Animal Health Economics

A close relationship between research and teaching, as is the intention within academic studies, is considered extremely important for the quality of both. Related to the above-mentioned research activities, therefore, increasing efforts are made to develop and provide courses in Animal Health Economics.

A first and very short introduction into the field is included in a more general course in Agricultural Economics of 20 theoretical lectures, offered in the 4th year of the curriculum within the Veterinary Faculty in Utrecht. In this introduction, the basic economic framework of animal disease is presented and illustrated with some quantitative examples. In their 6th (and last) year, veterinary students get a further training in this field within small groups of 9 to 12 students. A 6-day economic course has been incorporated into an extensive training program in preventive medicine and herd health control. Theoretical principles are combined with practically-oriented case studies, using interactive computer models that focus on production, reproduction, and replacement economics in livestock.

A more theoretically-oriented and advanced course in Animal Health Economics has recently been made available at the Wageningen Agricultural University, including 24 theoretical lectures and six computer labs. The contents of this course are centered around the three interrelated research issues mentioned before: (1) quantifying the financial losses of disease, (2) optimizing treatment and/or control decisions, and (3) determining the profitability of preventive measures. Different economic modelling concepts and their applications are discussed and illustrated including partial budgeting, cost-benefit analysis, Markov chains, dynamic programming, Monte Carlo simulation, and expert systems. Both lecture notes and computer labs are available in English. The course is also open to qualified people from outside the University.

From these courses in the regular curricula, specific aspects are frequently made available for post-graduate training. Usually, this occurs within zootechnically- and/or epidemiologically-oriented courses. A specialized (international) post-graduate course in Animal Health Economics is also in the making to be initiated in Spring 1993. Finally, there is an increasing number of people from other (EC) countries interested in coming over for individual training in the underlying field. A proposal to establish (and fund) a European Training Center, closely related to the above-mentioned research and teaching activities, has recently been submitted to Brussels. Such a Center could also help to develop and share a more uniform approach in Animal Health Economics within the EC as a whole.

Exchange and Cooperation

By establishing this new (part-time) chair in Animal Health Economics, and with it a 4-year PhD-project, the Dutch Veterinary Service and the National Animal Health Committee emphasize their striving for an economically sound disease control policy. It is a real challenge - for all of us involved - to find a good working balance between the not always predictable and often time-stressed questions that come up from active policy making on the one hand, and the need for more long-term scheduled approaches in scientific studies on the other.

Scientific research is primarily an individualistic activity, but is difficult to perform without a stimulating environment of fellow researchers. It is a great privilege, therefore, that this new chair is made available within an active research group, covering various modelling activities in closely related areas. These activities center around the development and use of computerized management support. Our close cooperation and mutual exchange of methods and ideas have proven to be both pleasant and beneficial. All the more reason to continue.

Working in the field of Animal Health Economics asks for a multidisciplinary approach, including agricultural economics, animal science, informatics, operations research and veterinary epidemiology. The fact that such a multidisciplinary network of contacts and cooperation really exists (and works), makes the 'Dutch approach' unique in the world. The approach would be doomed to fail, however, if not embedded in a wider network of international contacts and cooperation. Providing the text of this public lecture in the English language is meant to stress the importance of such an international exchange.

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