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A NEW APPROACH TO INTEGRATE RISK ANALYSIS AND ECONOMICS

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L'analyse de risque est un domaine d'intérêt croissant dans la profession vétérinaire, en particulier quand elle se fait dans le respect du commerce international des animaux et des produits d'origine animale. Le principal résultat de cette analyse est la notion de "risque acceptable". Les décideurs doivent juger si une chance d'importation du virus de 1, dans plusieurs milliers de tonnes ou durant des centaines d'années d'importation, est acceptable ou non. Dans ce papier, il est soutenu que pour la plupart des décideurs, un tel résultat est trop difficile à interpréter et une décision est très dure à prendre dans ce cas là. Par conséquent, il est suggéré d'apporter une approche courante de l'analyse de risque en la combinant à une analyse économique. Cela permettrait de convertir le concept de "risque acceptable" en une sorte de valeur monétaire. Les effets économiques inclus sont, d'une part, les bénéfices apportés aux consommateurs qui achètent actuellement le produit et le profit (s'il existe) obtenu par ceux qui importent et commercialisent le produit. D'autre part, il y a des pertes associées lorsque l'introduction du virus cause une épizootie de la maladie. Ces pertes entraînent des coûts directs des animaux affectés et des mesures de contrôle mais également, des coûts indirects à travers les exportations interdites, au moins pour la majorité des pays exportateurs. Dans ce papier, la structure de base d'une telle approche - intégrant les résultats de la théorie de protection, de l'analyse de l'offre et la demande et les critères de choix spécifiques afin de classer les options alternatives - est présentée, discutée et illustrée par un exemple simple.

INTRODUCTION

Decisions in real life have to be made under conditions of uncertainty, which means that there is imperfect knowledge about the various input factors included and/or about the outcome of possible actions. In the area of Animal Health Economics increasing efforts are being made to quantify the costs and benefits of measures to control disease and reduce the risk of occurrence. Various techniques are available to help perform this kind of analysis, ranging from simple partial budgeting, to decision-tree analysis and stochastic computer simulation and optimisation (Dijkhuizen and Morris, 1997). These techniques differ considerably in complexity, but have in common that they all can convert risks for and consequences of disease into costs and benefits, and hence into money values. Money values are easy to interpret by decision makers (e.g. farmers and government officials).

The major outcome of most risk analyses, at least those with respect to import/export and trade issues, is what is called 'acceptable risk' (Morley, 1993). The decision maker(s) must decide whether a chance of virus import of one in so many thousands of tonnes of animal products or in hundreds of years of imports is acceptable or not. Such an outcome is for most decision makers too difficult to interpret and decide upon, if possible at all. In our view, therefore, the current approach of risk analysis should be brought one step further, and combined with economic analyses. That would make it possible to convert the concept of 'acceptable risk' into some sort of money value. Economic effects to be included are, on the one hand, the benefits (i.e., utility) to consumers who actually buy the product and the profit (if any) made by those who import and trade the product under consideration. On the other hand, there are losses involved when the virus introduction causes an outbreak of the disease. These losses include direct costs, e.g. affected animals and control measures, but may also include indirect losses through export bans, at least for major exporting countries (Berentsen et al., 1992).

The type of economic analysis that is able to quantify these benefits and costs is based on welfare theory and demand/supply analysis. Moreover, specific choice criteria (such as expected monetary value and stochastic efficiency criteria) are needed to discriminate between the - uncertain - outcomes. In this paper the basic principles of such an approach will be presented and illustrated with an example.

THE CONCEPT OF DEMAND AND SUPPLY TO MEASURE WELFARE EFFECTS

It is common practice (and an invaluable aid to comprehension) to express demand and supply schedules in graphical form, with prices on the vertical axis and quantity on the other. Such a graph is called the 'scissors graph' because of its shape; most demand curves slope downwards from left to right - more of the commodity is demanded as price falls - whereas supply curves slope upwards from left to right - more is supplied as price rises. Where the two curves cross is the equilibrium price at which demand and supply are in balance.

Figure 1 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 Q_s, while consumers demand Q_d, with the difference (Q_s-Q_d) being exported. When export bans are in effect, a new equilibrium will arise at a lower price and influencing the welfare of both producers and consumers. The losses to 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 is fixed and the supply curve will be steep. With disease outbreaks that do not last long, therefore, the vertical supply curve (S') can be used to quantify the losses in producers' income. Actual losses to the producers are reduced by any compensation paid by the government. Consumers gain from the drop in price; their gain is indicated by the increase in consumer surplus

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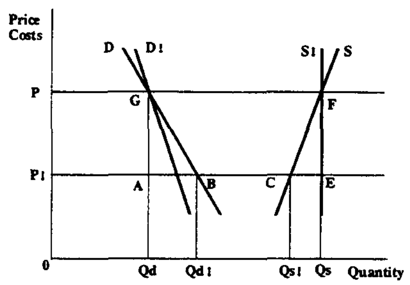

Figure 1. : Market situation for a country exporting a product

(area PGBP'). From the alternative demand curve (D') it can be concluded that the slope of the curve (i.e., the price elasticity of demand) influences the increase in consumer surplus. Not only is it possible to identify the net effects on producers and consumers respectively, but also to summarise the consequences for a society as a whole (ie, for people irrespective of whether they are producers, consumers or both).

Within the theory of welfare economics, however, 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. It is, therefore, recommended to report both the separate effects for producers and consumers, and their equally-weighed total, leaving policymakers the opportunity to apply their own weights.

Based on this theoretical concept it is possible to quantify the potential benefits and losses of trade risks for individual country and market conditions, related to the introduction of contagious animal disease virus. For the Netherlands, a modelling approach has been developed to quantify these economic effects related to outbreaks of Foot-and-Mouth disease (Berentsen et al., 1992; Jalvingh et al., 1997) . Results show that the indirect effects through trade disruptions are easily 7 to 10 times as high as the direct costs from destroyed animals and other disease control costs. The modelling approach is general and could also be applied to other countries and disease conditions.

Some argue that because of current GATT and WTO regulations such economics effects of trade disruptions should not be taken into account in risk analyses because every citizen of a country has the right to import unless the trade is likely to introduce disease. Such a firm standpoint, however, would implicitely ask for a zero-risk approach with respect to imports, which is not acceptable to the authorities either.

CRITERIA TO CHOOSE AMONG ALTERNATIVES

Expected monetary value

Once the economic effects have been quantified and included in the risk analysis for a specific import of livestock and/or livestock products, a choice criterion is required to choose among the decision alternatives. One such criterion is the expected monetary value (EMV), defined as the summation of the possible levels of outcome within an alternative multiplied by their probabilities. If there are m possible states for the j^{th} action with the i^{th} s-tate denoted $_i$, having outcome O_{ij} and probability P_i, then the expected monetary value is given by: $EMV(O_j) = P_1O_{1j} + P_2O_{2j} + ... + P_mO_{mj} = P_iO_{ij}$. To support decisions in this area, therefore, appropriate (although often subjective) probability estimates for the relevant variables under consideration should be included. The EMV criterion, however, does not always lead to a good advice, as shown in the following - simplified - example. Suppose that a choice has to be made between two acts, i.e., to import (a_1) and not to import (a_2) a product from a specific country. No import is the current situation and defined to have a zero payoff. The payoffs of the two options are expected to differ according to whether or not an outbreak of the disease under consideration will occur. These 'states of nature' can be no outbreak, minor outbreak or severe outbreak for a specified time frame, with an estimated (subjective) probability of 0.80, 0.15, and 0.05 respectively. Benefits and losses are calculated according to the producer and consumer surplus approach, explained before, and summarised in Table I.

Table I
Payoff matrix for two import options (1000 US$)

State of nature (Θ_i)	$P(\Theta_i)$	Import (a_1)	No import (a_2)
No outbreak (Θ_1)	0.80	750	0
Minor Outbreak (Θ_2)	0.15	-100	0
Severe outbreak (Θ_3)	0.05	-5000	0
Expected monetary values (EMV)		335	0

When taking into account the expected monetary value to compare the alternatives, import (a_1) is the preferred option. This choice holds for so-called risk-neutral decision makers, i.e., decision makers who implicitly put an equal weight on one dollar above or below the expected outcome. Most people, however, tend to be risk averse, i.e., consider a relatively big loss as a more than proportional threat. With respect to the example in Table 1, this means that they put a higher weight on each dollar loss with a severe outbreak than on each dollar involved with no outbreaks. That may lead to a different choice, making the decision in Table I a classical example of risky choice.

Stochastic efficiency criteria

One of the most widely applied models for studying decision making under risk is the subjective expected utility (SEU) model (Hardaker et al., 1997). Using the model, actions are ordered according to the beliefs and risk attitude of the decision maker. Each money value is assigned a utility value (ie, preference), according to a personalized, arbitrarily scaled utility function. The utility values for each possible outcome of an action are weighed by their (subjective) probability and summed across outcomes. The resulting expected utility is a preference index for that action. Actions are ranked according to their levels of expected utility with the highest value being preferred.

Utility functions, however, are not easy to elicit (if possible at all). Moreover, they relate primarily to a situation where there is one decision maker whose preferences are to be used in the analysis and who also bears the consequences of the choice. Often more than one person will be involved in any decision and/or affected by the consequences, as is the case with import/export and trade issues. Stochastic efficiency criteria are proposed as a useful alternative for this type of situations. Stochastic efficiency rules satisfy the axioms of the expected utility model but do not require precise measurement of risk preferences. They are implemented by pairwise comparisons of cumulative distribution functions of outcomes (y) resulting from different actions. However, as opposed to the complete ordering achieved when risk preferences are precisely known, they may only provide a partial ordering. The most simple stochastic dominance criterion, for instance, called first-degree stochastic dominance and which holds for all decision makers who prefer more to less, requires that the cumulative probability function of the preferred alternative must never lie above the dominated alternative. This criterion, therefore, is not able to discriminate between the two options presented in Table 1. Stochastic dominance with respect to a function (SDRF) is a more promising one and allows for flexibility in reflecting preferences, but also requires more detailed information on those preferences. Formally stated, SDRF establishes necessary and sufficient conditions under which the cumulative function F(y) is preferred to the cumulative function G(y) by all decision makers whose risk attitude lies anywhere between specified lower and upper bounds. The method is flexible enough to include and investigate the impact of any specified value (King and Robison, 1984). This criterion shows that the more risk-averse decision makers should give preference to 'no import' in Table I. PC-software has become available to perform the stochastic efficiency analyses (Goh et al., 1989).

FINAL REMARKS

Risk and uncertainty are undoubtedly important factors in animal health management. Advice and modelling that are to support decisions in this area, therefore, should include appropriate (subjective) probability estimates for the relevant variables under consideration. Decision analysis is considered a worthwhile approach for ensuring that farmers get advice and make decisions which are consistent with (a) their personal beliefs about the risks and uncertainties surrounding the decision, and (b) their preferences for the possible outcomes. It can also help to provide a more rational basis for decision making in the public domain, and to determine the economic value of additional information to reduce and/or predict the risks and uncertainties. A good risky decision, however, does not guarantee a good outcome. That would only be possible with perfect foresight (ie, in the absence of uncertainty). It does assure, however, that the decision made is the best possible one given the available information. Appropriate decision criteria are considered a major component of a risky decision problem The most widely used expected monetary value criterion does not always tell the whole story, as shown in the - simplified - example in this paper. Utility functions make it possible to provide the most comprehensive approach, including a trade-off between the average outcome and variance, but will not always be easy to carry out and apply in actual field advice. Stochastic dominance criteria are commonly considered promising tools in this type of analysis. User-friendly software has become available to make the application of this type of advanced criteria much easier and accessible. In this way it becomes possible to transform current outcome of risk analyses (ie, 'acceptable risk') into values that are easier to interpret and to compare.

REFERENCES

Berentsen, P.B.M., Dijkhuizen, A.A., Oskam, A.J., 1992. A dynamic model for cost-benefit analyses of Foot-and-Mouth disease control strategies. Preventive Veterinary Medicine, 12, 229-245.

Dijkhuizen, A.A., Morris, R.S., 1997. Animal Health Economics: principles and applications. The Postgraduate Foundation Publisher, University of Sydney, 305 pp.

Goh, S., Shih, C.C., Cochran, M.J., Raskin, R., 1989. A generalized stochastic dominance program for the IBM PC. Southern Journal of Agricultural Economics: 175-182.

Hardaker, J.B., Huirne, R.B.M., Anderson, J.R., 1997. Coping with risk in agriculture. CAB International, Oxford, 235 pp.

Jalvingh, A.W., Nielen, M., Meuwissen, M.P.M., Dijkhuizen, A.A., Morris, R.S., 1997. Economic evaluation of Foot-and-Mouth disease control strategies using spatial and stochastic simulation. Proceedings ISVEE (in press).

King, R.P., Robison, L.J., 1984. Risk efficiency models. In: Barry, P.J. (ed.): Risk management in agriculture. Iowa State University Press, Ames, p. 68-81.

Morley, R.S., 1993 (Coordinator). Risk analysis, animal health and trade. OIE Scientific and Technical Review, vol. 12, no 4, December 1993, Paris.