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Resource allocation for animal health research

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Abstract

Animal health management has changed from first-aid approaches towards planned prevention. To optimize health input at the farm level, various economic models can be used. At the sector level, however, both indirect effects and uncertain time dimensions tend to blur results of such modelling. In addition, health management is in its effects increasingly complementary to other sources of technological progress in animal production. Health management is particularly dependent on health research. Therefore, the question how to allocate research funds is crucial. Solving this problem is only to a limited extent possible via economic modelling techniques. The reason for this conclusion is that animal production has developed into system in which health and production measures are intertwined. These changes are largely scientifically-based and the research system also has become more of an integrated system. As a result, health research cannot be looked at as an independent factor in health control. Hence, the costs and benefits are hard to allocate to research and research funding.

Keywords: health management, economic modelling

Introduction

Both progress in animal production and more efficient animal production are stimulated by research in related fields such as housing, breeding, nutrition, grassland management and animal health. Health management programmes have become more important as a means of preventing losses. Dijkhuizen (1988) recently pointed out that current veterinary services to individual farms are changing from the traditional first-aid or fire-brigade approach, towards protection via planned prevention and control programmes.

In Dijkhuizen's view, the basic principle for determining the optimal level of protection at the farm-level is the equi-marginal principle: protective measures should be increased to a level at which the cost of additional input equals the returns from additional output. The output is the reduction achieved in the losses caused by animal diseases.

It is, however, difficult to assess the input-output relationships of health programmes, because the effects of a single disease:
(a) are not always obvious and pronounced;
(b) interact with other factors, such as nutrition and housing;
(c) possess a temporal dimension, which adds to the complexity of evaluating their impacts, and
(d) often manifest themselves as part of a complex of diseases (Dijkhuizen, 1988).

Dijkhuizen (1988) has discussed various economic models that can be used to optimize 'health' inputs. Sensitivity analyses can be used to assess the economic importance of knowledge of health control. Dijkhuizen (1988) and also Renkema & Dijkhuizen (1984) have applied such modelling to animal losses for decision-making at the farm level. For the management of the farm, the programmes and the levels of protection that can be applied are given. At this level the indirect effects also have limited importance. Health control at farm level differs from animal health protection at the sectoral level. The relationship with animal health research merits separate discussion.

The models discussed by Dijkhuizen (1988) (partial budgeting, cost-benefit analysis, linear programming, dynamic programming, Markov chains, systems simulation) seem, at first glance, also valid for making decisions on resource allocation in national health programmes, if definite programmes are distinguishable. At this level the economic assessments are more complicated because of indirect effects; for instance, those causing improvements on existing programmes. Furthermore, health programmes must be adapted to other technological developments in animal production.

The last-mentioned factor is most important in making decisions on resource allocation for public research on animal health. Improving the effectiveness of animal health programmes greatly depends on health-related research. In turn, health-related research is most effective if it takes account of developments in control at farm level and its implications at the sector level. It is the farming community that applies improvements in health control programmes together with other new technologies. In this article we argue that the questions 'how much should be spent on animal health related research' and 'by what criteria should funds be allocated' must be answered by considering two aspects, specifically: modern developments in animal production systems in which health control and productivity management are intertwined and the management of agricultural research systems.

We will discuss the second issue by exploring the use of estimates of losses incurred from diseases to decide how to allocate funds for animal health research; and the costs and benefits involved in maintaining a public system for research on animal health.

The economics of disease control in modern production systems

When setting priorities, agricultural research has traditionally taken the demand from the farming sector into account. The relationship between research programmes and production can be denoted as 'applied research' or 'problem-solving research'. In order to explain this mechanism, agricultural economists have elaborated the so-called induced-innovation theory. According to this theory, research programmes are to supply new technology in response to the farmers' needs. Shifts in relative costs and prices induce farmers to search for technical alternatives to economize on scarce factors of production and to solve problems. Scientists and science administrators respond by making new technology available and by properly allocating research funds (Hayami & Ruttan, 1985). Applying this theory to animal health control we have first, at the farm level, the demand for veterinary service. This demand can be derived from its marginal revenue function in the farm which, in turn, is a function of losses incurred from disease. For such direct effects we can, at the individual farm, deal with veterinary service as a variable (non-factor) cost. Health control programmes exceed the farm level and the demand for improved health control cannot be derived solely by aggregating individual demands for new health technologies. An assessment of the economic significance of improving the technology of health thus has to rely on macro-analysis too. This would imply an estimation of the cost-effectiveness of health-related research. In principle, this method is feasible if the effects of health control can be assessed, i.e. if this factor can be looked at independently. There are two reasons, however, to cast doubts on the applicability of this approach. The first reason is that health research is not independent of other research relating to the animal production system and that the effects of such research are difficult to disentangle. The second reason can be derived from the evolutionary theory on technological change, which suggests that technology adjustment has a momentum of its own (Nelson & Winter (1977), Elster (1983) and Rutten (1989)). Below, we give a few examples and their application to animal health to illustrate this second point.

Analysing the crucial role of the semi-conductur in micro-electronics, Dosi (1984) has drawn attention to the existence of so-called technological trajectories. Technological trajectories are the result of processes of 'normal' problem-solving activities using generally accepted models or technological paradigms (a technological paradigm is 'a model' and 'a pattern' for solving a given technological problem, based on selected material technologies). This suggests a close relationship between science and economic strategies. Key technologies often become surrounded by a web of innovations and applications in divergent fields. Taking the farm tractor as a case study, Sahal (1979; 1981) hypothesized that technological innovation originates in accumulated practical experience (learning by doing). An example of a technological trend by which animal health and other technologies were integrated is artificial insemination (AI). AI originated from attempts to combat bovine venereal infections. Over a period of about three decades, AI became the basis for modern breeding strategies of almost all animal populations in the developed world. This development resulted from normal problem-solving in policies for selecting for improved livestock. In addition, as a breeding technique, AI provided the basis for many other developments, such as embryo transfer, in vitro fertilization, rDNA techniques, cloning etc. Productivity growth in farming in general can also be explained by applying the evolutionary theory of technical change. Growth and production processes that occur closer to their potential levels of efficiency are better 'understood' scientifically, because of the accumulated experience involved. According to de Wit et al. (1987) 'high yielding' production can also be better controlled and managed than 'lower yielding' production. De Wit's statement is based on the experience that the number of fixed operations increases with increasing yields and that concomitantly the number of variable operations diminishes. As a result, many inputs become less of a variable cost element, and more of a complementary cost element. Applying technological trajectories thus means that some inputs gradually lose their variable cost character and hence their usage becomes less determined by their costs and their rewards become less determined by their scarcities than is the case for variable inputs. Applying this theory to animal production results in factors of production such as animal health control increasingly representing complementary cost elements. In other words, given the farmer's decision to rear and keep animals (in a certain place, at a certain time), health control is, according to this view, to be seen more as a fixed cost than as a variable cost. In such a situation it is still feasible to vary levels of protection or to select between systems of protection. Decision-making on these choices can be based on economic models as listed by Dijkhuizen (1988). But it is hard to see how these models can apply to the decisions on allocating resources for health research. Health research funding is not only in accordance with losses incurred from disease, but also depends on market developments and on the future of technological trends. There is ample evidence that considerable opportunity for boosting animal production efficiency still exists (DSA, 1986). In this development, disease control will be increasingly integrated into recording data on growth and production, individualized feeding, environmental conditions and genetic improvement parameters. Reproduction technology will probably have a particularly strong impact on health control. Oestrus detection devices, for instance, will enable farmers to rebreed animals faster, make speedier and more effective culling decisions, and improve the efficiency of techniques such as embryo transfer. The combination of information on production records, feed intake, vaccination profiles, breeding data, conception data, number of offspring, types and dates of diseases, costs of medicine and treatment, therapeutic or preventive, will provide health profiles for individual animals, farm herds and the national herd (OTA, 1986).

A highly productive herd demands healthy animals. Therefore, diagnostic tests play an important role in health technology trends. These should enable farmers to see which animal is at risk, in subclinical condition or ill. In addition, health control will increasingly aim at the enhancement of resistance to health-disturbing factors. Thirdly, health conditions are likely to become more directly related to quality characteristics of the end-products in a particular market and marketing system. Quality characteristics not only refer to physical aspects of milk or meats etc., but could increasingly be related to quarantees and treatments.

In sum, health programmes will be fully integrated with other developments. Future developments in animal production will involve fine-tuning various control programmes and measures. Developments in health control will probably keep in step with other advances in technology. This implies that applied research will reflect on-farm developments and will concentrate on problems encountered in the modern farm. This being so, imbalances in public resource allocation to various branches of animal production research must be avoided. In other words, in practice, resource allocation for applied research (including health research) is subject to the goal of maintaining and gradually improving production efficiency. Of course, breakthroughs in research can give rise to considerable readjustment of research funds. Moreover, research management should provide opportunities for serendipity.

The above considerations lead to the conclusion that, from the point of view of research funding, animal health programmes and disease control should be treated as productive factors. As regards resource allocation, therefore, health research is similar to the other R & D programmes such as breeding, housing, nutrition, etc.

The use of estimates of losses incurred from disease as a basis for allocating resources to health research programmes

The conclusion that health research is similar to other R & D programmes does not deny that if high losses were incurred from disease, research to help combat such diseases and their causes will be favoured. What it does mean, however, is that even for production systems that require wide-ranging measures of disease control, the process of biological innovation is dependent on factors over and above the costs of health programmes vis-à-vis the costs of other inputs.

When inputs are complementary, it is, of course, the minimum factor that causes marginal returns on other factors to abruptly diminish. Therefore, all other factors are, so to speak, grouped around the factor in the minority (in optimal ratios). Research thus is seen as a key element to enhance the productivity of that scarce factor. This is natural, because that factor will be important when observing a problem in livestock production. Animal health can be such a factor. Model simulations may then be used to search for gaps in veterinary and zootechnical knowledge (Dijkhuizen, 1988).

Decision-making by cost-benefit analysis proceeds in the following steps:

1. Estimate economic losses from animal diseases.
2. Define a research programme capable of control (and formulate alternative programmes).
3. Calculate the net present value of funds to be allocated.

Decision-making via this procedure presupposes quantitative assessments of priorities and posteriorities. This approach makes more sense if new R & D lines are being considered. New R & D lines, in this context, means totally new technological trends or paradigms. Such research, however, is by its very nature not predictable, at least not in terms of its practical implications.

Resource allocation involves deciding in advance which areas of research will be the most productive ones. But even at the applied level and within established technological paradigms, the results of research are frequently not predictable. Indirect losses resulting from disease outbreaks, whatever their cause, will normally outweigh any direct losses, for instance, because of loosing markets. Indirect costs are more difficult to assess than are direct costs. Hence, the validity of allocating research resources on the basis of predicted outcomes must be questioned. Fundamental research, by definition, should have the potential to spark off new technological trends. Estimates of indirect losses incurred from disease may provide the starting point for long-term resource allocation for such research.

Decision-making based on loss estimates would require three steps. Firstly, at least one 'best alternative' line of research must be formulated for the animal health research programme in question. Secondly, a minimum pay-back period must be defined. Animal health research tends to be prolonged, though it has long-term benefits as well. Thirdly, the extent to which expenditure on animal health research is for maintenance research or for research 'in the face of Malevolent Nature' must

Table 1. Overview of costs of veterinary research as a percentage of the costs of other livestock research and of production value, in 1974, 1979 and 1984.

	1974	1979	1984
A. Costs of veterinary research as a percentage of total research costs on animal production			
Cattle	0.24	0.28	0.22
Pigs	0.36	0.26	0.42
Poultry	0.25	0.24	0.42
B. Costs of breeding research as a percentage of total research costs on animal production			
Cattle	0.16	0.12	0.18
Pigs	0.21	0.15	0.13
Poultry	0.13	0.12	0.08
C. Costs of research on reproduction as a percentage of total research costs on animal production			
Cattle	0.10	0.03	0.05
Pigs	0.13	0.14	0.11
Poultry	0.07	0.03	0.02
D. A + C as a percentage of total research costs			
Cattle	0.34	0.31	0.27
Pigs	0.49	0.40	0.53
Poultry	0.32	0.27	0.36
E. Veterinary research in mln. Dfl.			
Cattle	3.75 (41)	9.09 (100)	7.90 (87)
Pigs	3.15 (89)	3.55 (100)	7.33 (206)
Poultry	1.89 (74)	2.54 (100)	3.56 (140)
F. Veterinary research as percentage of total production value (total production value (in mln. Dfl.) in brackets)			
Cattle	0.5 (7086)	0.9 (9987)	0.6 (13110)
Pigs	0.4 (3158)	0.9 (4108)	1.2 (5799)
Poultry	1.3 (1369)	1.5 (1682)	1.3 (2622)

Source: National Council for Agricultural Research, The Hague.

be balanced (Wise, 1984). If animal health research is treated as a negative benefit, namely as a necessary outlay for the benefit of other animal research, the result will be low rates of returns on animal health research proper, but very high returns for breeding research, housing, etc. According to Wise (1984), the only theoretical justification for using such cost-benefit ratios is if the 'research-to-forego-the-indirect-loss' represents the sole limiting factor ro research-related gains (Wise, 1984). Simulation models on the effectiveness of health control programmes, as suggested by Dijkhuizen (1988) and Noordhuizen et al. (1987), may yield new and better knowledge of limiting factors and interdependencies within animal production systems. Predictions of the overall effects of new research may be made using the new models. Yet, even then estimates of reduced disease loss may be dominated by innovations which occur — seemingly — spontaneously.

To use empirical data on research outlays to analyse input-output relationships with regard to health research seems a blind alley. Analysis of historical data on the costs of expenditure on veterinary research in the Netherlands, reveals that there was considerable variation in the content of veterinary research and of breeding research. Bovine veterinary research had no unilinear trend upwards, whereas research for swine and poultry did (Table 1). However, the interpretation of such data is hazardous. No sharp distinction between research on reproduction and veterinary research can be made and although research outlays are more or less proportional to total value of production (at least for applied research), more fundamental research, such as biological research, is difficult to assign to livestock species. Besides, the effects of health control as a government service are partly included. If the expected indirect losses resulting from animal diseases are high, more money will typically be allocated for both applied and fundamental research. In addition, the data refer to publicly funded research and hence exclude privately financed research. It must therefore be concluded that there is insufficient basis for studying empirical data. We are left with the procedures and constituents to study how these enable priorities to be set. The institutional framework involved can be described, but the procedures are amenable for disclosing weighting procedures, etc. A major consideration seems that the research system should be kept in workable proportions.

Maintaining the research system

In the previous section the reasons why allocation on the basis of estimates of losses incurred from disease and cost-benefit analysis meets with fundamental difficulties were listed. It is true that more resources are likely to be spent on research if the expected costs of losses incurred from disease have increased, but it is hard to specify the direct relationship between observed problems and the research efforts. Normally, those research policies that have the potential to extend research along current lines in various fields are applied. For this reason, and because of the dynamics of the research system itself, it is virtually impossible to ascribe solutions for practical problems to research projects or even to research programmes.

Research expenditure necessarily has to be related to loss estimates in aggregates.

Such aggregates have a tendency to increase in size. It follows, then, that it is difficult to plan health research to uncover fundamental knowledge, for instance, on biological systems, that can form the starting point for new technological paradigms. Results that stimulate new paradigms are, at best, welcome spin-offs of existing lines of research.

In practice, managing a health research system draws on ex post performance. Those research units that have proven to be of high quality in the past should be adequately equipped and integrated in the wider agricultural research system in order to be able to meet the new challenges. Conversely, insufficient quality in the past may be due to the insufficient integration of good quality research units. Where research units have to operate below some minimum critical mass, or the performances of adjacent research units or disciplines in the system are inadequate, the research unit considered will be negatively affected. In other words, there is long-term benefit in maintaining the research system at an optimal level of activity. Finally, how, precisely, is research quality defined? The assessment of academic quality is highly subjective. Views on quality are undoubtedly strongly influenced by conventional wisdom.

How can research performance be anticipated? It would have been, for example, 'a prodigious feat to have anticipated an antibiotics industry, given Fleming's original paper' (Wise, 1984). It is impossible to foresee the effects if one line of animal production research would be stopped, whether it appears at first glance of minor importance or not.

Conclusions

Animal health research once found its rationale in reducing losses from disease on individual farms. Health research dealt only with a narrow aspect of animal production: preventing or curing disease.

Technical progress has put knowledge of biological systems and their management to the fore. Management means a search for the minimum of each input in animal production systems that allows the maximum effect of all other inputs. Research must be managed in compliance with this principle and resource allocation in animal health research is no exception.

Many means are needed to make the animal production system effective both at the farm level and in the research system. Research management deals with integration of research programmes, just as farm management is the linkage of many economic and physical factors. At both levels the harsh reality of more resources, better performance; fewer resources, poorer performance, holds. Allocating funds for animal health research on the basis of the economic effects of improved health conditions would imply an extremely intricate procedure as firstly, health improvement and other measures to increase productivity are very much intertwined. Modelling the effects of health research in effect requires the disentangling of changed input-output relationships. Secondly, research systems are becoming more of an integrated system of disciplines and of public and private R & D. Thirdly, health research is difficult to distinguish from health control and health control is closely linked with developments in the animal farming systems. For these reasons, the allocation of research funds on the basis of economic modelling is hardly possible.

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