Economic aspects of common health and fertility problems for the individual pig producer: an overview[1]

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SUMMARY *The income margin in modern pig farming is generally narrow. Controlling the cost of production, therefore, is of great importance. Improving health and fertility can play a major role in this context. In this paper three interrelated issues are discussed from a farm management point of view: (1) the financial losses of common health and fertility problems, (2) the costs and benefits of disease control, and (3) the decision to replace individual sows in case of poor health and/or reduced productive performance. Priorities for further research in the field of animal health economics are also discussed.*

1. INTRODUCTION

With respect to the economic aspects of diseases and disease control in pig farming, attention is often focused on diseases such as swine fever and foot-and-mouth disease. Especially in major exporting countries, such as the Netherlands and Denmark, outbreaks of these highly contagious diseases are properly feared. When leading to foreign trade restrictions, a fall in prices due to a temporary oversupply in the domestic market can cause tremendous losses in farmers' income. This also financially injures farms not directly affected by the disease (8, 10). Eradication and prevention of these diseases, therefore, is a matter of joint interest, reaching beyond the scope of the individual farm. Successful control requires a regional, national or even an international approach.

Besides these rarely occurring diseases, there are a number of health and fertility problems that are generally present but vary greatly in degree of frequency and severity across farms. Often the individual farmer can do much to control these problems (24). Identifying their economic impact is not a simple task, because their effects: a) are not always obvious and pronounced; b) are influenced by other management factors such as hygiene and nutrition; c) have a temporal dimension which adds to the complexity of evaluating their impacts at different stages in time; and d) often manifest themselves in a complex with other diseases (22). Farmers, therefore, can easily underestimate the economic impacts of these problems, especially when they become accustomed to the presence of such problems.

In this paper the economics of these ubiquitous health and fertility problems will be discussed. Three interrelated issues are addressed from a farm management point of view: (1) the financial losses they cause, (2) the costs and benefits of disease control, and (3) the decision to replace individual sows in case of poor health and/or reduced productive performance.

2. FINANCIAL LOSSES OF COMMON HEALTH AND FERTILITY PROBLEMS

The calculation of the losses is, in itself, not very important but it can help to provide a better overall view of the impact of diseases and can contribute in estimating the extent of the losses which can be prevented. This is particularly

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the case if the variance between farms is indicated, in addition to the losses in the average situation. Three questions should be answered for an economic characterisation of the actual situation:

1. To what extent does the disease in its various forms occur?
2. What are the quantitative and qualitative effects on production, mortality, etc. expressed in physical terms?
3. How can these physical effects be expressed in financial terms?

The accuracy of economic calculations highly depends on the availability and usefulness of the underlying data. In pig farming, almost no accurate data on the incidence rate and the physical effects of diseases is available in the literature. Kliebenstein *et al.* (15) published what is probably the most coherent data-set, based on a Mail-In-Record programme for Missouri swine breeding and fattening farms. Scours and pneumonia were found to cause 40 to 50% of all health problems, while crushing/trauma was the major cause of death, accounting for 30 to 35% of the total. Pneumonia and rhinitis were the single most important diseases from the standpoint of health expenses, accounting for 14% and 10% of the total, respectively. No information was provided on physical effects (other than mortality), nor on the duration and severity of the problems. Miller and Kliebenstein (17), nevertheless, used the same data-set to estimate the losses of Transmissible Gastroenteritis (TGE) assuming a 17.5% decrease in feed efficiency for surviving baby pigs and a temporary 10% loss in body weight for weaned pigs. Based on these assumptions the losses for producers who had the disease on their farms were calculated to $1.50 per hog sold. This equals about 15% of the average return earned above total production costs.
In other studies, Muirhead (20) quantified the net losses of Acute Rhinitis and of infectious infertility for a 100-sow farm in England to be £5440 and £3213, respectively. Windsor and Simmons (32) investigated the spread and economic significance of swine dysentery on British fattening farms and found that the costs of an increased feed conversion ratio, which are less obvious, may be more than four times the cost of medication. Hunneman (12) quantified the economic impact of *Haemophilus pleuropneumoniae* on Dutch fattening farms. Seropositive farms were found to have increased veterinary fees and a 1% higher mortality rate, together causing a total loss of approximately Dfl. 3.25 per hog sold, which equals about 20% of typical income. Daily weight gain of the hogs was not affected. Stein and Leman (26) calculated a loss due to Porcine Parvovirus (PPV) of $4 to $16 per gilt in herds were gilts were infected. Morrison and Joo (19) found the net opportunity cost due to PPV in a 130-sow farrow-to-finish operation in Minnesota to be $7260, or $55.85 per head.

Although worthwhile in themselves, these published calculations do not provide a comprehensive view of the total economic impact of the diseases at the farm level. Another way to estimate this total impact is to analyse differences in productive performance across farms. The 20% of Dutch swine breeding herds with the best performances, for instance, raise more than 21.5 pigs per sow per year, while the 20% with the poorest results do not exceed 15.5. Assuming an average net economic value (i.e. gross return minus variable costs) of Dfl. 80 for each extra pig raised, such a difference corresponds to Dfl. 460 per sow per year. Even when the more extreme values at both sides of the variation in herd data are not taken into account, the difference still equals slightly more than 20% of gross return, and about 120% of net return on labour and management on a typical farm (Appendix 1, page 123). Arkes *et al.* (1) found that 50% of these differences could be related to the number of litters per sow per year, 25% to the number of pigs born alive, and 25% to pig mortality.

Feed conversion efficiency, daily weight gain and mortality rate are, from an economic point of view, the most important production performance factors on pig fattening farms, accounting for about 65% of the differences in income between farms (1). Economic weights for one unit of deviation in these parameters can easily be derived from data as given in Appendix 2. An increase in the feed conversion ratio of 0.1, for instance, increases feed consumption by 8.5 kg per hog sold and therefore reduces income by Dfl. 4.25 per head. Again leaving out the best and poorest performing Dutch farms, the remaining differences cause a calculated total difference in income of Dfl. 32 per hog sold, as shown in Table 1. Such a difference equals 10% of gross return and even more than 200% of net return on labour and management on a typical fattening farm (Appendix 2, page 124).

Table 1. Economic impact of differences in productive performances on Dutch pig fattening farms.

trait	20% of worst farms	20% of best farms	herd differences physical	herd differences financial[1]
feed conversion effic.[2]	> 3.3	< 2.9	0.4	17
daily weight gain (gr)	< 610	> 730	120	11
mortality rate (%)	> 3.6	< 1.3	2.3	4

[1] Dfl. per hog sold
[2] kg feed per kg weight gain

It is not known, however, what portion of these differences is directly related to health and fertility problems in a strict sense, either on swine breeding herds or on pig fattening farms. Assuming these problems are responsible for about half of the difference would imply an impact equal to 10% of gross return in swine breeding herds and 5% on pig fattening farms. Such values are not unlikely when compared with dairy cattle, in which the total impact was calculated to be about 10% of gross return (3). The resulting impact on farmers' net returns on labour and management differ considerably according to the normal ratio between earned income and gross return, and would equal 40 to 50% on typical dairy farms, 60% on swine breeding herds and even 100% on pig fattening farms (Appendix 1 and 2). There is reason, then, to expect that considerable economic improvement can be achieved, especially for pig farms with higher than average losses.

3. COSTS AND BENEFITS OF DISEASE CONTROL

Current veterinary services to individual farms are changing from the so-called first-aid-practice or fire-brigade approach (18) to planned prevention and control programmes. The application of these planned services is rarely an all-or-nothing affair. Usually several programmes are available, each of them offering a different degree of improvement. The basic economic principle for determining the optimal input level of such services is the equimarginal principle: the input should be increased up to the level where the cost of an additional unit of input equals the added return associated with it.

In such planned veterinary services, farm advisory visits play a central role. Muirhead (21) suggests the following activities should be included in pig farm visits: clinical examinations, discussions and record evaluations, special topic presentations, and the report. For commercial herds of typical size (Appendix 1 and 2) 25 hourly visits a year seems to be a reasonable schedule, implying additional costs for the farmer of about Dfl. 4000 per year (16). This implies costs of Dfl. 28.50 per sow for breeding herds and Dfl. 1.10 per hog sold in finishing operations, which equal 1.3% and 0.4% of total production cost respectively. Extra costs for special treatments and measures do not necessarily occur, and should be calculated separately in each individual case.

To determine the benefits of planned veterinary services, two different research approaches can be considered: a normative and a positive approach (13, 24). A normative approach is intended to predict the effects based on existing knowledge about the veterinary aspects of the health and fertility problems involved and about the farms which are supposed to apply the programme. This knowledge may be derived from pure veterinary research and field data, and should at least clarify whether or not the minor improvements in physical performance needed to compensate the additional cost of pig advisory visits are likely to occur.

To gain a more comprehensive insight, it is preferable to construct a formal mathematical model which describes the herd's state of health and productivity, enabling a simulation of the effects of various preventive and control measures. Modelling necessitates specification of the required relationship in detail, often clearly revealing lacunae in knowledge. Instructive and successful applications in pig farming were carried out by Van Arendonk and Renkema (30), who developed a stochastic simulation model to determine the possible effects of different management policies on the financial losses caused by TGE, and by Parson *et al.* (23), who recently used a decision tree analysis for the assessment of the benefits of a vaccination programme against PPV. In both studies a sensitivity analysis could easily be carried out to indicate the economic impact of unknown and uncertain input data on the final results.

A positive approach can best be described as a direct evaluation of any health programme actually carried out. For a sound analysis, physical and economic data from both the 'with' and 'without' situation should be available. This may be realised in two ways: data from 'before' (b) and 'after' (a) application of the programme collected on farms participating in the programme (P) as well as on comparable control farms (C). When available, these data make it possible to estimate the causal effects of the programme more precisely, i.e. $(P_a\text{-}P_b)\text{-}(C_a\text{-}C_b)$, especially when particular herds with obvious health and fertility problems take part in the programme. Experience with a broad preventive health progamme in dairy cattle has shown that collection of data in the 'without' situation should be made concisely to avoid interfering with the programme and underestimating its effects (25). Even when all this is properly realised, however, the effects of the programme are not always easy to determine because of the tremendous variations that exist irrespective of the programme. In the study by Sol and Renkema (25), for example, the effect of the dairy programme on total farm income could easily be determined. After two years of programme application the income per cow had risen Dfl. 170 more in the programme group than in the control group. This equals about 8% of the initial situation. The effects on income of improvements in individual parameters, such as calving interval and forced replacements due to disease, could not be determined accurately from the collected data. In such a case it is possible to fall back on a normative approach. With the help of models, in which irrelevant disturbing influences can be eliminated, it is possible to determine which effects on income are to be expected from an improvement in individual health and fertility parameters (6). This emphasises how a positive and a normative approach can complement each other.

Kingston (14) recently applied a combined positive and normative approach to pig farming. Farms in the programme, however, could only be compared with national averages and emergency service clients, without knowing the degree of similarity of the groups before the programme started. Therefore, the precise role of the preventive medicine scheme in the improvements could not be established. It was concluded, however, that the benefits would at least exceed the cost, which accounted for only 0.15% of output.

4. THE DECISION TO REPLACE INDIVIDUAL SOWS

Even with the most successful herd health programmes it will be impossible to eliminate and prevent all health and fertility problems in swine breeding herds. Therefore, farmers must frequently take decisions about whether to retain individual sows with poor health and/or reduced productive performance, or to cull them. From an economic point of view, these decisions must be based on future expectations: the expected extra costs of retention (i.e. veterinary treatment and affected productivity) must be weighed against the future income lost in the case of replacement. The expected future income, called the Retention-Pay-Off (RPO) in this paper, is an economic index which makes it possible to rank sows within the herd on future profitability. The higher the RPO, the more valuable the sow. It also represents the maximum amount that should be spent trying to return a sow to her previous level of performance in case of reproductive failure or health problems. A value below zero means that even for completely healthy sows, replacement is the most profitable choice. The RPO, therefore, can be used as a management guide in culling decisions.

To quantify the RPO index for sows of different age and productive performance, an economic replacement model was developed within an electronic spreadsheet programme for the microcomputer, described elsewhere in more detail (7). The logic of the model is based on the same criterion as that already applied to dairy cattle (5, 28, 29). The model runs with default values, but allows the user to enter other data for all the variables considered. Therefore, it can easily be adjusted to individual farm conditions worldwide. Parity-specific input data are used for feeder pig sales (born alive and raised), feed cost, probability of premature disposal, and slaughter value of the sows.

Some results from the model for typical Dutch swine herds are presented in Table 2. A longer herd life is especially profitable for the better producing sows, as would

Table 2. Retention Pay-Off index for sows at weaning (Dfl.)

parity	pigs born alive	% productivity in previous (max 3) parities				
number	per parity[1]	50%	75%	100%	125%	150%
1	9.4	59	130	201	272	342
2	10.1	—	92	202	311	421
3	10.6	—	51	170	289	407
5	11.0	—	—	98	208	319
7	10.8	—	—	38	136	233
9	10.6	—	—	7	69	130

[1] Parity-specific avarages in the herd (= 100%)

be expected. For a second parity sow that produces 50% more than other sows in the herd of the same parity, for instance, the expected advantage of retention over replacement is Dfl. 421 (Table 2). In other words, Dfl. 421 is the maximum amount that should be spent trying to return this sow to her previous level of performance in case of reproductive failure or health problems. It is also shown in Table 2 that sows with an average production level (100%) have an economic optimal lifespan of 10 parities. The advantage of their retention over replacement after 9 parities, however, is only Dfl. 7, which closely agrees with results recently obtained by dynamic programming (11). The optimal time of culling for low producing sows is at a younger age, although strong selection pressure in the earlier parities is not economically worthwhile. Even first parity sows that produce 50% below average should be retained. The key factor here is the low repeatability of litter size used to predict the future performance of the sows (31).

As the RPO index is calculated in the model at the average time after weaning when sows conceive in the herd, an extra delay in conception will decrease the RPO, since the sow concerned will have more open — unproductive — days. The smaller the initial RPO, the sooner it falls below zero, making replacement more profitable than another breeding. By relating the initial value of the RPO index and the calculated financial loss of a delay in conception, calculated by the model for the typical herd under consideration to be Dfl. 3.30 per open day, the model gives an indication of the maximum allowable number of breedings in case of failure to conceive. Two options are considered: (1) an optimistic breeding outlook, assuming normal probabilities of conceiving in future parities of the sow (repeatability of 0), and (2) a pessimistic breeding outlook, assuming recurrent problems in future parities (repeatability of 1). Some of the results are presented in Table 3.

Table 3. Maximum allowable number of breedings (at 21-day intervals).

	% productivity in previous (max 3) parities (100% = average)									
	50%	75%	100%	125%	150%	50%	75%	100%	125%	150%
parity number	optimistic breeding outlook					pessimistic breeding outlook				
1	1	2	3	4	5	1	1	1	2	2
2	—	2	3	5	7	—	1	1	2	2
3	—	1	3	5	6	—	1	1	2	2
5	—	—	2	3	5	—	—	1	2	2
7	—	—	1	2	4	—	—	1	1	2
9	—	—	1	1	2	—	—	1	1	2

As shown in Table 3, results differ considerably among the options considered, especially for the higher producing sows. Under the optimistic breeding outlook, average producing sows in the first three parities can be allowed at least 3 breedings before replacement becomes more profitable. However, if fertility problems are also expected in their future parities (pessimistic breeding outlook) no re-breeding is economically worthwhile. Veterinarians and other livestock specialists, therefore, can help to improve the farmer's decisions and income by making accurate prognoses about the expected repeatability of fertility problems when sows fail to conceive.

5. DISCUSSION

Gaining more insight into the economics of pig diseases at the farm level is of interest in so far as it can help to determine: (1) in what ways and to what extent the risk of occurrence can be diminished, how much loss is prevented, and what costs are required, and (2) how to limit the losses as much as possible if the problems do occur. To document the economic impact of the various possible strategies under field conditions, it is not feasible to use actual farm data as the only basis. The necessary experiments would be costly, and they would take years to complete. Simulation modelling has long been recognised as a comprehensive technique for this kind of evaluation (4). It has the ability to closely imitate real farm conditions, especially when the events and effects of decisions are involved in a stochastic manner, i.e. as random samples on appropriate probability distributions rather than as fixed values. Such an approach produces a spread in results over a series of calculations, which better reflects normal biological variability. Recent experiences with this kind of modelling in dairy cattle have been positive (9).

Economic modelling of disease and disease control in pigs has received much less attention than in dairy cattle, although the potential economic impact for a typical farm would justify the opposite situation. A major reason for this inconsistency may be the serious lack of accurate epidemiological data of the various health and fertility problems in pigs, including their impact on productive performances. During the last few years much effort has been put into designing and implementing integrated veterinary, zootechnical and economic record keeping systems (2, 27). In the future, systematic epidemiological and economic analysis of these data-bases should be given high priority. Knowledge obtained from this kind of research is necessary to increase reality of economic modelling, while model calculations can quantify the significance of remaining gaps in veterinary and zootechnical knowledge. In this way a valuable interaction between economic research, on the one hand, and veterinary and zootechnical research, on the other, is possible. This interaction is fundamental to the study of diseases and disease control at the farm level.

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APPENDIX 1. Typical results for commercial Dutch feeder pig producers

Herd size 140 sows - weaning at 30 days - 2.13 litters per sow per year - 10.3 pigs born alive per litter - mortality rate 15% - 8.7 pigs raised per litter - 18.5 pigs raised per sow per year.

GROSS RETURN (per sow per yaer)			
18.5 pigs at Dfl. 110*)	Dfl. 2035		
sow inventory	Dfl. 150		
			Dfl. 2.185
COSTS (per sow per year)			
feed: sow (incl. repl. gilts) 1250 kg à Dfl. 0.50, and piglets 18.5 x 30 kg à Dfl. 0.70	Dfl. 1014		
labour	Dfl. 475		
housing (deprec., interest and maintenance)	Dfl. 450		
health care	Dfl. 75		
interest (herd and feed stock)	Dfl. 55		
cost for transportation piglets	Dfl. 50		
others (artif. insem., water, electr., etc.)	Dfl. 155		
			Dfl. 2274
NET PROFIT (per sow per year)		-/-	Dfl. 89
NET RETURN ON LABOUR AND MANAGEMENT (per sow per year)			Dfl. 386
NET RETURN ON LABOUR AND MANAGEMENT (total herd per year)			Dfl. 54040

* Currently about Dfl. 75 only

APPENDIX 2. Typical results for commercial Dutch feeder pig finishers

Herd size 1450 hogs - 2.55 deliveries per year - mortality rate 2.3% - 3612 hogs sold per year - starting weight 23 kg - ending weight 108 kg - daily weight gain 680 gr - net fattening time 125 days.

GROSS RETURN (per hog sold)			
83.5 slaughter weight at Dfl. 3.60*			Dfl. 301
COSTS (per hog sold)			
purchase piglet	Dfl. 110		
feed: feed conversion 3.05 and 85 kg of weight gain make 259 kg of feed à Dfl. 0.50	Dfl. 130		
housing (deprec., interest and maintenance)	Dfl. 22		
labour	Dfl. 18		
interest (herd and feed stock)	Dfl. 5		
cost for transportation hogs	Dfl. 5		
health care	Dfl. 3		
others (water, electr., mortality, etc.)	Dfl. 11		Dfl. 304
NET PROFIT (per hog sold)		-/-	Dfl. 3
NETT RETURN ON LABOUR AND MANAGEMENT (per hog sold)			Dfl. 15
NET RETURN ON LABOUR AND MANAGEMENT (total herd per year)			Dfl. 54180

* Currently about Dfl. 3.00 only

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