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Research Article

Costs And Benefits of the Improvement of Biosecurity on Pig and Broiler Farms

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Abstract

The control of the risk factors of animal diseases should be considered as the primary safeguard in livestock farms to prevent the introduction and circulation of pathogens, which can lead to severe productive and economic consequences. Livestock producers perceptions about the costs of biosecurity measures are critical to their willingness to take steps for improving it. There is still limited information about the direct benefits that biosecurity improvements can bring to farms productivity, while the additional costs of the biosecurity measures can be more easily calculated. In this study, 22 broiler houses in Cyprus and Greece and 35 pig farms in Italy and France were considered to calculate the costs and benefits of measures taken for improving the level of biosecurity. The effects of the increased productivity in pig farms is sufficient to more than offset the costs of the biosecurity measures. On pig finishing farms a 3% increase both in the feed conversion rate and daily weight gain is enough to balance the additional costs of biosecurity measures. In broiler farms the technical performances need to improve further to compensate for the extra costs of biosecurity.

Keywords: Biosecurity; Broiler farms; Economics; Pig Farms

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Introduction

Farmers often have considered prophylactic antimicrobial treatments as an easier, cheaper and less-labour-intensive way to prevent diseases than therapeutic treatments or investments in infrastructure or disinfection of the farm [1]. In the past antimicrobials were considered to be a guarantee to maintain productive performances, as their use was driven by the objective to prevent diseases and promote production growth. As the excessive use of antimicrobials contributes to antimicrobial resistance, a more accurate and therapeutic use is recommended and many innovative practices are put in place to prevent any use of antimicrobials on livestock farms.

In order to reduce the use of antimicrobials in pig and broiler farms it is important to implement biosecurity measures to prevent pathogens from entering the farms or avoid the spread of the pathogens within the farm premises. Both external and internal biosecurity measures contribute to this objective [2]. The level of biosecurity determines the risks that diseases may emerge among the animals present on the farm. Several surveys show that still many farms have a negative attitude towards biosecurity and are unaware of the effectiveness and economic benefits of adopting biosecurity measures [3]. There is a clear need to raise farmers' awareness with regards to the economic benefits yielded from implementing biosecurity measures [4]. The higher farmers perceive the costs of biosecurity measures the less likely they are to adopt these measures [5].

The adoption of enhanced biosecurity levels requires that producers accept additional costs which however may not always generate enough direct and immediate benefits [6]. Information about perceived benefits and costs of biosecurity and farm characteristics is therefore needed to identify how measures to promote the adoption of biosecurity could be targeted [7]. A research on 20 broiler farms showed that with a series of interventions related to the improvement of biosecurity and preventive vaccinations the average daily gain (ADG) increased, the feed coversion rate (FCR) decreased, but mortality rates slightly increased [8]. According to this study the costs of the interventions are paid off by the improvement of the technical performance of the broiler farms. Another study showed that improving specific biosecurity and welfare parameters on pig fattening farms can lead to decreased antimicrobial use, as less pathogens are able to enter the farm. Reducing AMU in livestock is a priority for controlling the emergence and spread of antimicrobial resistance [9]. To do so in a sustainable and pragmatic manner, a good understanding of the factors that determine the need for AMU is crucial. A multiblock approach can be of help in the analysis when the goal is to summarize and compare the effects of several (groups of seemingly related) factors. In doing so, it was shown that internal biosecurity and micro-climate conditions influence AMU the most among pig and veal calf farms [10]. The improvement of external biosecurity was linked to the number of weaned piglets per sow per year: a 10 point higher external biosecurity score resulted in 0.2 more piglets per sow [11].

From this overview it becomes clear that the implementation of biosecurity measures can often generate clear benefits in terms of an

improvement of the technical performances of pig and broiler farms and finally reduce the use of antimicrobials. In this paper the costs and benefits of biosecurity [12] measures in pig farms in Italy and in broiler farms in Cyprus and Greece were analysed. After a short overview of the methodology and a description of the samples of the selected farms the results of this analyis are be presented.

Materials and Methods

Study design

In order to estimate the costs and benefits of biosecurity an economic analysis has been made of measures taken by pig farmers in Italy and by broiler farmers in Greece and Cyprus. Based on a risk assessment carried out with a specific risk analysis tool [13]. strengths and weaknesses of the biosecurity condition for each farm have been identified on each farm. This assessment generated tailor-made health plans which have been proposed and discussed with each farmer. The needs for change in management to mitigate risks and routes for improvement have been agreed between the farmer and veterinarian. For each of the farms tailor made health plans have been formulated and implemented [14].

For the broiler farms two production cycles before and two cycles after the implementation of the health plans have been taken into account. For the pig farms a comparison has been made between the baseline data in year 1 with the results in year 2, when the biosecurity measures have been completed.

Partial budgeting approach

In order to estimate the technical and economic impact of the biosecurity measures for the pig and broiler farms data protocols have been designed. The objective of these data protocols was to collect information about the baseline condition of the farms before they would have implemented the tailor made health plans. Data concerning the technical performances (average daily growth, feed conversion rate, mortality, etc.), and revenues and costs broken down by the main cost items such as feed costs, veterinarian and medicine costs and other variable costs of the farms, were collected. Particular attention has been dedicated to information concerning the costs and the use of antimicrobials. For all farms involved in the analysis the collected data allowed to calculate the technical and economic efficiency before undertaking measures to improve the level of biosecurity of the farms.

To establish the technical and economic effect of the health plans a partial budgeting approach has been used. Partial budgeting is a planning and decision-making framework used to compare the costs and benefits of alternatives faced by a farm business. It focuses on the changes in income and expenses that would result from implementing a specific alternative [15] Partial budgeting is regularly used to compare alternative production practices in agriculture with limited data. To assess the effect of the health plans information has been collected concerning the change of the technical efficiency parameters, the number and costs of treatments with antimicrobials and the costs of the biosecurity measures. With the partial budgeting methodology these data have been used to estimate the impact of the health plans on the overall production costs and on the income of the pig an broiler farms. The biosecurity measures may change fixed costs (capital and labour) and variable costs as well as revenues, due to changes in output prices. Technical performance parameters may change due to the introduction of the measures (e.g. feed conversion rate (FCR), piglets weaned per sow, mortality rates, average daily gain (ADG), etc.). A simulation of the change in investments, operational costs and revenues and of the technical performance parameters on the ex-ante baseline scenarios allows for an assessment of the costs and benefits of the proposed innovations for each type of farm.

Samples of pig and broiler farms

Selection of broiler farms

Twenty two poultry houses were recruited to participate in this study in Cyprus, and Greece. Selection of farms is described in detail by [16]. Farms in principal, were selected on the use of antimicrobials in their recent history. Each poultry house was based on a different farm, except in Greece where some poultry houses were from the same farm. These poultry houses had different management and antimicrobial histories and thus were handled as independent houses and economic results as shown in (Table 1).

	Cyprus	Greece
Number of houses	7	15
Number of chicks per house	17,036	17,573
Average age at slaughter (days)	42 ± 2.2	44 ± 4.4
Average weight at slaughter (kg)	2.4 ± 0.2	2.5 ± 0.2
Average mortality (%)	2.6% ± 1.6	5.5% ± 1.9

Table 1: Characteristics of samples of broiler houses.

Selection of pig farms

In Italy fifteen pig finishing farms were recruited to participate in the study. The finishing farms produce pigs sold for slaughter at a live weight above 160 kg, as they are destined for the production of "Prosciutto di Parma", which requires the use of fresh hams obtained from heavy pigs. Farm size is in average 2,900 pig places, ranging from a minimum of 1,000 to a maximum of more than 8,000 places. Slaughter pigs are raised from a starting weight of 33 kilograms, which is the average weight of rearing pigs purchased from specialized rearing or farrow to rearing pig farms. Given the high final weight and lower daily weight gain compared to northern European genetics, less than two fattening cycles are concluded per year as shown in (Table 2).

No. of farms	15
Farms size (No. places)	2,900
Pigs placed (No.)	2,660
Starting weight (kg)	33.3
Final weight (kg l.w.)	167.4
Mortality rate (%)	4.7

Table 2: Characteristics of sample of pig finishing farms in Italy.

Results

Biosecurity measures

A variety of biosecurity measures have been taken by each farmer contained in the specific tailor made health plans. Examples are frequent and recorded use of disinfection, placement of appropriate points for the collection of all daily mortalities and culls, build a separate and closed entry room for each shed, placement of hand sanitizers at the entrance of each shed on the farm and systematic use of a water acidifier at specific points in the growth cycle. The operating and investment costs of each of these measures have been collected.

Broiler houses

The differences between the two pre and post cycles are very small in the CYP/GR group of broiler houses. There are no relevant differences between the average weight and age at sale or slaughter between the two groups (Table 3).

Cycle	Number of chicks placed	N. broiler sold to SH	Average weight at sale (gr)	Average age at slaughter (days)
Pre	17,459	16,517	2,381	44.4
Post	17,142	16,339	2,463	43.3
% var	-1.81	-1,08	3.44	-2.5

Table 3: Farm size, weight and age at slaughter.

For the purpose of this study of high interest are the differences between the pre- and post- intervention cycles. In the CYP/GR group of farms the number of treatments with antibiotics and the total days of antibiotic use declined between the pre and post condition by respectively 13.0% and 21.2%. A first important result of this analysis is that on broiler farms that are rather high users of antibiotics a significant reduction of their use can be obtained by means of the implementation of biosecurity measures even within a relatively short period as shown in (Table 4).

	ADG (g)	FCR (kg feed/kg lwt)	Total cost of antibiotics (€) per cycle	Number of treatments per cycle	Total days AB use in the cycle
pre	53.87	1.664	413	2.41	6.05
post	55.71	1.652	325	2.10	4.77
% difference	3.41	-0.72	-21.26	-13.01	-21.22

Table 4: Productive performances and use of antibiotics per cycle.

The question posed is to which extent the biosecurity measures have an impact on the costs and revenues of the farms. In the table below a comparison is made between the production costs of broiler meat before and after the implementation of biosecurity measures as shown in (Table 5).

	Pre intervention		Post intervention	
	€ct/kg live weight	€ct/broiler/cycle	€ct/kg live weight	€ct/broiler/cycle
Total costs	86,88	206,86	86,52	206,00
Purchase of day old chicks	13,44	32,00	13,47	32,08
Feed	54,00	128,57	53,75	127,97
Other variable costs	11,65	27,74	11,68	27,81
Antibiotics	0,99	2,36	0,80	1,90
Labour	1,50	3,57	1,50	3,58
Buildings	4,70	11,19	4,71	11,22
Overhead	0,60	1,43	0,60	1,43

Table 5: Production costs of broiler meat before and after biosecurity measures in CYP/GR.

Different contrasting effects of the biosecurity measures have been seen in the comparison:

1. The cost of antibiotics declines from 2.36 €ct per broiler to 1.90 €ct per broiler
2. The slight improvement of the feed conversion rate reduces the production costs further by 0.23%

Without taking into account the costs of the biosecurity measures at the balance the overall effect of the implementation of the biosecurity measures causes a reduction of the production costs of 0.41% of broiler meat.

As some measures were already in place, a limited number of measures have been taken such as for example the placing of hand sanitizers at the entrance of each shed, systematic use of a water acidifier at specific points of the growth cycle, frequent use of disinfection spraying of the immediate area outside each shed's entrance, cleaning and disinfection of water storage tanks on the farm as well as the water pipes and retraining of farm workers on the key aspects of biosecurity. The costs of the above mentioned measures are about 4.08 €cts per broiler or 1.71 €cts per kg liveweight. This would increase the production costs by 1.75%. It is clear that the increase of the productive performances needs to improve further in order to cover the extra costs of biosecurity measures as shown in.

Pig farms

Comparing the data collected from the sample of Italian fattening farms during the two farm visits shows a slight increase in production in year 2 due to the higher number of pigs sold and the increase in the final weight of slaughter pigs. Instead, no significant differences were found in the average purchase weight of rearing pigs as shown in (Table 6).

IT	No. rearing pig purchased	Starting weight (kg)	No. slaughter pigs sold	Slaughter live weight (kg)
Pre	2,660	33.3	2,531	167.4
Post	2,785	33.4	2,651	176.8
% var	4.7	0.5	4.7	5.6

Table 6: Rearing pigs purchased and slaughter pigs sold by finishing pig farms (Italy).

After the implementation of the health plans on the finishing farms an improvement in daily weight gain was detected in year 2 (ex-post situation), resulting in nine days reduction of the finishing period despite the higher final weight. Also the feed efficiency (FCR) turns out to be better, although there were no significant changes in the genetic type of pigs bred and in the feed rations adopted between the baseline year and the year 2. The significant reduction of the use of antimicrobials did not affect the mortality rate, which remained the same as shown in (Table 7).

	ADG (kg/day)	Mortality (%)	FCR (kg feed/kg l.w.)	Finishing period (days)	DDDvet finishers
Pre	0.675	4.8	3.56	196	22.7
Post	0.758	4.8	3.43	187	7.6
% var	12.3	0.0	-3.4	-4.6	-66.4

Table 7: Productive performances and use of antibiotics in finishing pig farms (Italy).

Economic impact of the health plans on pig farms in Italy

The following analysis aims to evaluate the potential effect on production costs of biosecurity measures adopted by the three types of pig farms. Costs change determined by the innovation is assessed considering as benchmark the average cost in the pre-intervention condition (baseline scenario). The comparison with the post-intervention scenario takes into account only the costs of the adoption of the specific health plans and biosecurity measures, keeping unchanged all other variables (eg prices of inputs). Clearly, these extra costs can be offset only by the improvement of farms productivity and efficiency and by the reduction of the expense for antimicrobial products. The hypothesis adopted is that the change in productivity and efficiency indicators detected in the second farms visits is due to the improvement of the farms biosecurity level.

Although this hypothesis cannot be tested (many factors other than biosecurity can change productivity parameters), this type of analysis can still provide an indication about how much the animal performances need to improve to compensate for the additional costs of biosecurity.

Finishing pig farms

The following biosecurity measures have been considered for the finishing pig farms: known health status of purchased breeding pigs coming from farms free of specific diseases (Specific Pathogen Free farms), provision of adequate filter zones (hygiene lock) at the entrance of pig houses where farm workers and visitors can change clothes and footwear and disinfect hands and shoes with strict separation between dirty and clean area, purchase of a carcass cooled storage dedicated to the collection of dead pigs physically separated from animal facilities (placed in the dirty area of the farm), provision of specific gloves, clothing and footwear to personnel in charge of removing and transferring dead animals into the carcass storage cell and the adoption of a specific protocol for the cleaning and disinfection of the equipment after their use and of the room where it is stored and use of compartment specific veterinary equipment (i.e. needles).With regards to the investment on buildings (preparation of filter zones) and for the purchase of equipment (carcass cooled storage), a total amount of 24,000 € and a ten-year depreciation period were considered. The purchase of breeding pigs from farms free of specific pathologies entails an additional cost of 3 € per head. The annual management and consumables items costs have been valued at 1,700 €. If productivity (ADG) and feed conversion rate (FCR) would remain the same, all the measures to strengthen the farm biosecurity level would lead to a 2% cost increase compared to the baseline scenario, corresponding to 5 €/pig sold. Assuming the same mortality rate (found unchanged in second round of surveys), the higher costs of biosecurity would be balanced by about a 3% increase of the daily weight gain (+40 grams) and by a reduction of the same amount of feed efficiency rate (-60 grams of feed per kilogram of live weight produced). This is because the increase of daily weight gain would entail higher number of pigs sold per year, while the higher feed conversion rate, at constant feed prices, would result in a lower feed cost per head as shown in (Table 8).

According to the data collected at the second farm visit the increase in productivity (ADG and FCR) and the reduction of medical products and feed costs (calculated at constant prices) more than offsets the extra costs of biosecurity, resulting in a 2.2% overall decrease of total production costs per pig and per live weight sold. In absolute values, the decrease corresponds to 5.46 € per head as shown in (Table 9).

	PRE (1st visit)	POST (FCR=-3% ADG=+3%)	POST (2nd visit)
ADG (kg/day)	0.675	0.695	0.758
FCR (kg feed/kg l.w.)	3.56	3.45	3.43
Mortality (%)	4.8	4.8	4.8
Finishing period (days)	199	193	177
Pigs sold per place (No.)	1.75	1.80	1.95
Pigs sold per year (No.)	2.531	2.603	2.826

Table 8: Finishing pig farms productive performances before and after biosecurity measures.

€/slaughter pig sold	PRE (1st visit)	POST (FCR=-3% ADG=+3%)	POST (2nd visit)
Rearing pig	78.31	81.46	81.46
Feed	110.90	107.57	107.13
Vet. and medicines	€ 1.88	1.83	1.69
Other costs	59.29	57.64	53.09
Depreciation	-	*1.03*	*0.95*
Other biosecurity costs	-	*0.65*	*0.60*
Total cost	**250,37**	**250,18**	**244,91**

Table 9: Finishing pig farms production costs before and after biosecurity measures.

Pig farms in France

For the 20 farrow-to-finish pig farms of the sample in France only economic and production data collected during the first visit are available. Simulation of the impact on production costs due to the implementation of biosecurity measures in these farms has been carried out considering the adoption of the following biosecurity measures: construction of new quarantine building for the replacement gilts, washing and disinfection protocol in post weaning units by defining presence of salmonella and check of colostrum intake of suckling piglets.

The cost of these measures has been calculated in 145 € per sow, and includes the depreciation of the investment (quarantine building), the disinfectant and washing material purchase cost, and the increased workload of the farm staff.Since these measures are all aimed at avoiding the introduction and containing of the circulation of viruses and bacterial infections in the breeding units, the objective of the simulation exercise was to define the new level of mortality in farrowing, weaning and post-weaning stages that can offset the higher costs due to the biosecurity measures.Excluding any reduction of suckling piglets and weaned pigs mortality, the adoption of the health plan would result in 4% increase of average production cost, implying an extra cost of 5.10 € per pig sold (4 €ct per kg live weight).To estimate how much the breeding efficiency should improve to balance the extra costs, in the simulation only the number of piglets born per litter was kept unchanged under the assumption that adoption of the health plan would not change the sows prolificacy at farrowing. Instead, the effect on production costs of a 2.4% reduction in mortality at farrowing (piglets born dead), 6% during lactation and 1% in post-weaning was simulated as shown in (Table 10).

This decrease in mortality rates would raise the number of slaughter pigs sold per sow from 28.5 to 31.9, resulting in the reduction of

	PRE	POST
Litter/sow/year (No.)	2.40	2.40
Pigs born per litter (No.)	16.36	16.36
Mortality at birth (%)	7.2	4.8 *(-2.4%)*
Pigs born alive per litter (No.)	15.18	15.58
Pre weaning mortality (%)	16.7	10.7 *(-6.0%)*
Pigs weaned per litter (No.)	12.65	13.92
Post weaning mortality (%)	3.6	2.6 *(-1.0%)*
Pigs reared per litter	12,19	13,55
Slaughter pig sold per sow/year (No)	28,53	31,88
Slaughter live weight (kg)	121	121

Table 10: Changes in mortality rates offsetting extra costs of biosecurity measures in farrow-to- finishing farms.

many average cost items, such as the cost of breeding herd feeding, labour, insurances, etc., that would compensate the extra cost of biosecurity measures. Clearly, any other productivity improvement that would lead to an equal target in terms of pigs sold per sow/year would yield the same result as shown in (Table 11).

€/pig sold	PRE	POST
Feed	84.01	82.54
Vet and medicines	4.79	4.39
Energy	3.69	3.45
Other costs	45.65	43.15
Health costs		4.60
Total cost	**138,14**	**138.13**

Table 11: Farrow to finish pig farms production costs in France before and after biosecurity measures.

Discussion

The enforcement of biosecurity on farms is an important measure to reduce economic losses from animal diseases, while preserving the public good of human health. Reducing the risks of animal diseases through the adoption of biosecurity measures involves a change in routine farm management and may require investments to adapt existing facilities and housing buildings to make them more suitable for preventing the introduction of pathogens from other farms (external biosecurity) or their spread among the animals of the same farm (internal biosecurity). Livestock producers perceptions about the costs of biosecurity are critical to their willingness to take steps for improving it [16]. Education and training are other factors influencing farmers' perceptions of biosecurity, as they reflect the degree of awareness that the benefits of high levels of biosecurity can offset the higher management and investments costs required. Several studies have indicated that biosecurity is highly profitable, as it acts as an insurance against the outbreaks of epidemics that can have severe economic impact for livestock farms [17]. In this study, 22 broiler farms in Cyprus and Greece and 35 pig farms in Italy and France were considered to calculate the costs and benefits related to measures taken for the improvement of the level of biosecurity. All twenty pig farms surveyed in France are farrow-to-finishing farms, while fifteen farms in Italy are specialized in the finishing stage of the productive cycle. The average costs per kilogram of live weight during the first farms visits has been considered as the baseline for assessing the increase of the production costs due to the implementation of the specific biosecurity measures actually adopted by the farms of the samples. As regards broiler farms, the biosecurity measures [18] concerned the improvement of disinfection practices in the areas surrounding the sheds, in the entrance areas to the poultry houses and in the sheds themselves, as well as equipment (feed silos, water pipes). Where necessary, a clear delimitation between the red, orange and green areas of the farms was also adopted, through marked traffic routes and the creation of filter zones and rooms at the entrance of each sheds. The biosecurity measures adopted by finishing farms involved various interventions, including the restructuring of the filter areas at the entrance to the pig houses, the provision to the staff of protective clothing (gloves, boots, coveralls and headgear), the installation at the farm exit point of cooled cells for the storage of dead animals and the delimitation of the farm orange zone with metal fences.

Finally, farrow-to-finishing pig farms have been equipped with buildings dedicated to the quarantine of gilts and have adopted systems to verify the adequate colostrum intake of piglets and to control the presence of salmonella in the post-weaning sectors.During the second visits - which took place after the biosecurity measures were taken - the mortality rate, the feed conversion rate and the average daily weight gain were measured again. Information was also collected regarding the actual [19] costs incurred by the companies for the implementation of the biosecurity measures. The number of treatments and the number of days with antimicrobials use in the pre- and post situation were calculated in order to assess the actual reduction of their use. In the case of pig farms the Defined Daily Dose (DDD vet) was considered for assessing if the biosecurity measures had actually induced a reduction in the use of antimicrobial agents.

A partial budgeting approach has been implemented with unchanged prices of feed and other inputs and average labour cost in order to assess only the effects on total cost due to changes in productivity and to the additional costs of biosecurity measures [20]. Data collected in the second farm visits of farms reveal the reduction in the use of antimicrobials and the improvement of the productivity indexes by all the farms of the samples. On Cypriot and Greek broiler farms, an increase of more than 3% in average daily growth and a reduction of about 1% in the feed conversion ratio was found. For the same farms, there was a significant reduction in the use of antibiotics and in the cost per broiler sold related to veterinary services and medication. After the improvement of biosecurity the daily weight gain in the Italian finishing and farms was 12% higher compared to the results of the first survey. An improvement of the feed conversation rate of 4% was detected as well. An increase in the average daily weight gain entails more animals sold during the year, while improvement in feed conversion rate means less feed consumed per kilogram of meat produced. The effects of the increased productivity more than offsets the costs of the biosecurity measures, due to the decrease of all other cost items (feed, labour, fixed and overhead costs). The final result is lower total average costs.

The productive performances of the broiler farms in Greece and Cyprus would need to improve further in order to cover the extra costs, that are not fully offset by the reduction of the cost of medical treatments and by the slight increase in daily weight gain and feed efficiency demonstrated at least in the short term of this study which covered just two production cycles, of around 45 days, post biosecurity improvements carried out. It would be logical to postulate that further improvements in biological performance might be secured

over time. Clearly, these conclusions are based on the hypothesis that the improved farm productivity is due to the adoption of biosecurity measures taken by the farms in the samples. This assumption cannot be confirmed since the surveys were necessarily carried out in different years, so many other conditions may have intervened to influence the health status of the same farms. In this regard, more studies and tailoredtrials would be needed to examine how livestock performance can benefit from the adoption of specific biosecuritymeasures. Furthermore the margins for improving the health status of each farms is also highly variable, depending on the starting level of biosecurity and on the type of measure taken to improve it. In this study an analysis has been made to what extent the productivity indexes should improve to compensate the higher costs due to the implementation of specific biosecurity measures. This is an approach that all livestock producers should use to assess the minimum productivity targets they would need to achieve to at least break even the costs of any biosecurity improvement plan. In more general terms, this is a partial-budgeting approach, i.e., a planning and decision-making framework for comparing the costs and benefits of alternatives faced by a business operator. In the case of the Italian finishing pig farms a 3% increase both in the feed conversion rate and daily weight gain is enough to balance the additional costs. The same type of simulation could be carried out by considering the mortality rate, assuming that an improved health status ofthe farm in addition to a reduced antibiotic use would lead to fewer animal losses.

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