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Valuation Method of Livestock Loss: Farm Level

by Ignacio Benito Amaro

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VALUATION METHOD OF LIVESTOCK LOSS: FARM LEVEL

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Abstract

This paper lays the foundations for a correct valuation of the effects of livestock diseases. It is essential to have a correct quantification to take dimension of the problem. An erroneous quantification of the magnitudes relevant to the problem, both of the intervention and of the disease, may conduct to erroneous guidelines of importance to combat the problem. An erroneous public policy may be expensive for both society and producers. Thus, it's essential to start with the correct valuations when conducting the policy analysis to be followed.

It is concluded that the internal rate of return (IRR) of the activity in study is the best available rate to use when it is needed to estimate at farm level. In regards to the methodology to quantify the losses at farm level, the approaches of price differentials and cash flow both are equally usable. Which one to use depends on the information available, processing capacity and objective of the analysis.

JEL Code: Q1, D2, D4

Key Word: Disease losses, livestock disease, price differentials.

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Valuation method of livestock loss: farm level

I. Introduction

In the livestock sector, an important source of income loss to the producers are the livestock diseases. To know which is the value of these losses allows the producer and policymakers to observe what is the length of the problem. With better understanding of the problem, it is able to evaluate the best possible strategies to combat the diseases.

This paper lays the foundations for a correct valuation of the effects of livestock diseases. It's essential have a correct quantification of the problem to take dimension of what it implies. An erroneous quantification of the magnitudes relevant to the problem, both the intervention and also the disease, may conduct to erroneous guidelines of importance to combat the problem. An erroneous public policy may be expensive for both the society and producers. Thus, it's essential to start with the correct valuations when conducting the policy analysis to be followed.

Otte and Chilonda (2000) define the effect of the livestock disease as a reduction in the efficiency with which the inputs/resources are converted into outputs/products. In others words, a disease decreases productivity.

In current literature, different ways of evaluating these issues can be observed. Rushton et al (1999) claim that the cost of losing an animal to a disease as the market value of that animal, since this should reflect the expected future income of that animal. However, they added that if the animal could be sold after death, there is the possibility that it has a salvage value.

Rushton et al (1999), also, consider that an animal slaughtered due to disease is likely to have a lower value than if it were slaughtered at the time the producer had planned. However, slaughtering sick animals will reduce mortality rates and increase income, which can make productivity appear to increase. This is because the methods presented are based on budget and a gross margin analysis.

Rushton et al (1999) consider that a disease is likely to have an effect on the surviving animals. This will usually affect the performance of the animals in terms of: a) fertility; b) delay in reaching maturity (for reproduction or sale); c) decreased production of milk, eggs, wool, etc.; d) decreased draught power available; e) decreased weight of fattened or culled animals.

Various authors have presented different ways to value the losses due to a disease. To exemplify the different approaches used, example applied to beef and dairy cattle are used.

Bellows et al (2002) conducted a review of the literature and found out the cost of infertility. Generally, it has been defined to include the cost of replacing cull animals and the costs of labor, medicines or veterinary services included in the treatment and/or prevention of the disease that caused the cull.

Cabrera (2012) defined the value of the productive issues, these can be used to give value to the losses due to livestock diseases. The value of a new pregnancy in his model was defined as the difference between the value of the newly pregnant cow and the value of the non-pregnant cow, for a cow with similar characteristics. The cost of a pregnancy loss was defined as the difference between the value of the pregnant cow and the value of the non-pregnant cow, for a cow with similar characteristics.

Reichel et al (2013) conducted a review of literature on neospora caninum where they analyzed how losses due to a diseases had been valuated. In regards to abortions, they found out that in dairy cattle the costs of abortion are the costs of replacing the aborting cow with one of similar characteristics and an equal productive situation. While in beef cattle, they found that the costs of abortion represented the loss of the calf, plus the cost of replacing the cow that aborted with one of similar characteristics and the same productive situation. In the latter case, it could be said that by adding the replacement cost to the cost of the lost calf, a double charge would be incurred.

Campero (2002) used in his paper the price of the calf at weaning to valuate the losses due to reproductive infectious diseases. Those diseases reduced the percentage of pregnancies. Therefore, pregnancy losses were valued as a weaned calf. Thus he was overestimating the losses value. He was accounting, at the time of the loss and the time the animal was sold, value that was never generated.

Alvear Uvidia et al (2018) in their paper (in which they valuated losses due to Brucelosis) considered the cost of maintenance from birth until the disease was detected, the loss of milk, the recovery of positive livestock sales, and even included the cost of insemination. It could be said that they incurred in a double charge. This was said because they added the cost incurred until the moment of loss with loss of profit. These were the two ways to valuate the same thing.

Finally, in regards to dairy, Vissio et al (2015) showed how to valuate losses due to lower milk production. They consider losses as a result of the amount milk that was not produced and the price of milk.

After having looked at various ways to value disease losses. With the intention of having a correct valuation, two methodologies were proposed. The first one was inspired by the concept of hedonic prices. It consisted on comparing animals with similar characteristics, where the existence of a certain attribute was the difference. This attribute is the one that was related to the disease. The other methodology was the cash flow approach.

This paper doesn't seek to obtain the optimal control strategies. It is intentioned to be used as a tool for a correct valuation of losses due to disease. Many disease control methods could be compared, but to start with an incorrect loss valuation, leads to an incorrect result. For this reason, the present paper did seek to lay the foundation for a discussion on which was the correct way to valuate the losses at farm level in order to obtain the true measure of the diseases. In this way, with a correct valuation, the next step can be taken, which is to search for the optimal strategies or compare among several strategies.

II. Methods

Price differential method

This method is based on the comparison on animals where the difference is the presence of a certain attribute. Certainly, for those who know about the term hedonic prices, this method could be familiar. The proposed method was inspired by the concept of hedonic prices.

The hedonic price approach was theoretically supported by Lancaster (1966), Rosen (1974), and Ladd & Martin (1976). In them, a good was perceived as a set of characteristics

intrinsic to it, and it was the price for these characteristics as a whole, that made up for the price of the goods.

This approach assumes that a certain good Z could be decomposed into a vector of n measurable characteristics: $Z = (z_1, z_2, z_3, \dots, z_n)$ where z_i is the quantity of characteristic i that the good possessed. In the market, buyers purchase goods based on the characteristics they possess. The price can be rewritten $P(Z) = p(z_1, z_2, z_3, \dots, z_n)$. This is because the buyers will purchase the set of characteristics and not the good itself.

The present article's aim is to use the price paid for a specific attribute. This attribute is the one that affects the disease that is being valuated, everything else remains constant. When this is done, the opportunity cost of having the animal by possessing the attribute was gotten. The equation of the loss for disease represented in the x-ésimo attribute ($loss_x$) would be:

$$Loss_x = p(z_1 = \bar{z_1}, \dots, z_x = 1, \dots, z_n = \overline{z_n}) - p(z_1 = \bar{z_1}, \dots, z_x = 0, \dots, z_n = \overline{z_n})$$

Where z_x is the attribute that affects the disease. This attribute takes value 1 if the animal was healthy and 0 if the animal was sick. The rest of the attributes (z) take constant values ($\bar{z}$).

Following the basic postulates for applied welfare economics by Harberger (1971):

a) The competitive demand price for a given unit measures the value of that unit to the demander.

b) The competitive supply price for a given unit measures the value of that unit to the supplier.

c) When evaluating the net benefits or costs from a given action, the costs and benefits accruing to each member of the relevant group should normally be added without regard to the individuals to whom they accrue.

Based on these postulates, one could claim that at least in the aggregate, the price is a very good approximation of the producer's valuation. Even so that, some producers go to the market and sell their livestock. Thus the market price represents the minimum value that the

animal represents for producers. This makes market prices be a very good approximation to estimate the value of loss for disease.

Cash Flow Method

This method is based on estimating the cash flow that is lost because the goal is not reached, or an extra cost had to be spent in order to achieve the goal. When the loss is due to the goal not being reached it could be estimated in two ways. The first one consists on estimating the present value from the cost incurred before the loss (capitalized at the time of the loss). The mathematical expression is:

$$Loss = \sum_{t=0}^{i} (Cost_t - Income_t) * (1 + r)^t$$

Where: $Income_t$ is the income obtained in a period t; $Cost_t$ is the cost incurred in a period t; r is the discount rate; i is the number of periods the animal lives on the farm.

The second one, consists on estimating the present value of the lost profit (discounted at time of loss). The mathematical expression is:

$$Loss = \sum_{t=0}^{i} \frac{Income_t - Cost_t}{(1 + r)^t}$$

Where: $Income_t$ is the income expected to be obtained in a period t that will not be obtained; $Cost_t$ is the cost expected to be incurred in a period t that will not be incurred; r is the discount rate; i is the number of periods left to finish the productive cycle.

If the IRR of the productive project in this value chain is used to discount cash flows, the estimated losses in both forms should be the same. The cost incurred must consider the loss in value of the assets involve in the production.

When the loss is due to an extra cost had to be spent in order to achieve the goal, the mathematical expression is:

$$Loss = PR_0 - \frac{PR_1}{(1 + r)^i} + \sum_{t=0}^{i} \frac{Cost_t}{(1 + r)^t}$$

Where: $Cost_t$is the cost incurred in period t; PR_0 is the value of the animal that should have completed its productive stage at the expected time; PR_1 is the value of the animal at the end of its productive stage that required extra time; r is the discount rate; i is the number of extra periods that the animal must be in production.

Discount Rate Estimation

The discount rate is a fundamental issue to be able to valuate losses, giving a correct value over time. For this reason, it is important to give a real value so that estimations are as realistic as possible. Therefore, here the internal rate of return (IRR) of the productive activity under study is proposed as the discount rate. The equation for the IRR is:

$$0 = \sum_{t=0}^{i} \frac{Income_t}{(1+r)^i} - \frac{Cost_t}{(1+r)^t}$$

Where: $Cost_t$ is the cost that is expected to be incurred in period t; $Income_t$ is the income that is expected to be obtained in period t; i is the number of periods that the animals live in this productive stage on the farm.

When the IRR is proposed, the idea is to use a rate that the producer expects to obtain implicitly from incurring the cost of production to achieve the final production goal. For this reason, the IRR will be the best rate to use. The others rates that could be used are the rates at which it can be financed or at which it could invest the cash.

To see the methods applied in dairy and beef cattle you can go to the annexes

III. Discussion

The main concept behind these methodologies is that: the animal during each productive cycle of its life, accumulates value until the moment in which this is obtained. This concept is included in both proposed methods.

The time when the accumulated value is obtained under normal conditions is the farm's target time. Believing that this moment is the right time to value the loss is a common mistake. In this article and its annexes, when the different methodologies have been presented, not only has a way to quantify the losses been presented, but also it has been

presented at which time the loss should be valued. This is because the moment in which the productive cycle ends under normal conditions, it may differ from the moment in which the loss becomes effective.

When losses on a production cycle are accrued to internalize them as production costs, they must be valued at the end of the production cycle. In the case that a disease control method is evaluated, losses should be valued at the same time that the investment in control should be made.

So far, common problems on both methodologies have been discussed. Now it is time to discuss the particularities of each methodology. The following discussion begins with the price differential approach then switches to the cash flow approach.

The price differential approach consists on contrasting the market prices of the livestock with similar characteristics, with only one attribute between them being different. This attribute, being the solely responsible for the actual differential in price, and so the one that reveals its value.

This approach, since working with the market prices, is based on marginal values. The act of working with marginal values is very relevant. This is because these values show the indifference between selling or not the animal for sellers and the indifference between buying or not for buyers. Therefore, variations in marginal values affect the allocation of productive resources, affecting production levels.

After analyzing and discussing the issues with this methodology, a link to cash flow can be established. This link consists of using the cash flow to construct the values of the animals for the producers and then using it to obtain the value from the loss with the price differentials. This can be useful in cases when producers believe that the market price does not represent the true value of their livestock. For this reason, the value of the animal is built with the expected cash flow from the animals. the equation for cash flow is:

$$animal\ value = \sum_{i=0}^{t} \left(\frac{Income_i}{(1+r)^i} * Pp_i - \frac{Cost_i}{(1+r)^i} \right)$$

Where: t is the number of periods the animal is expected to produce on the farm; $Income_i$ is the income obtained by the animal in period i; $Cost_i$ is the cost incurred in period i; r is the discount rate; Pp_i is the probability that the animal obtain incomes in period i.

Regarding the cash flow methodology, it works on average values. The advantage is that it allows working on the values that producers really do hope to obtain. The problem with this methodology is the large amount of information required to make the estimations and the sensitivity to parameter variations. Changes in the flow of income and costs or changes in the discount rate can generate different values for the same loss. In the effort to try to contemplate heterogeneous production systems, erroneous production models are built and therefore erroneous valuations of losses.

An issue that affects both methods is the variation of the prices over time. The value of the losses varies each time the relevant prices change. Throughout the year, the value of the loss may show seasonality if the price of the livestock shows it. It could also be that the disease, instead of generating a loss, may generate a profit if the price relationship encourages the trade of sick animals and at the replacement. Furthermore, the cash flow approach is also influenced by variations in inputs prices.

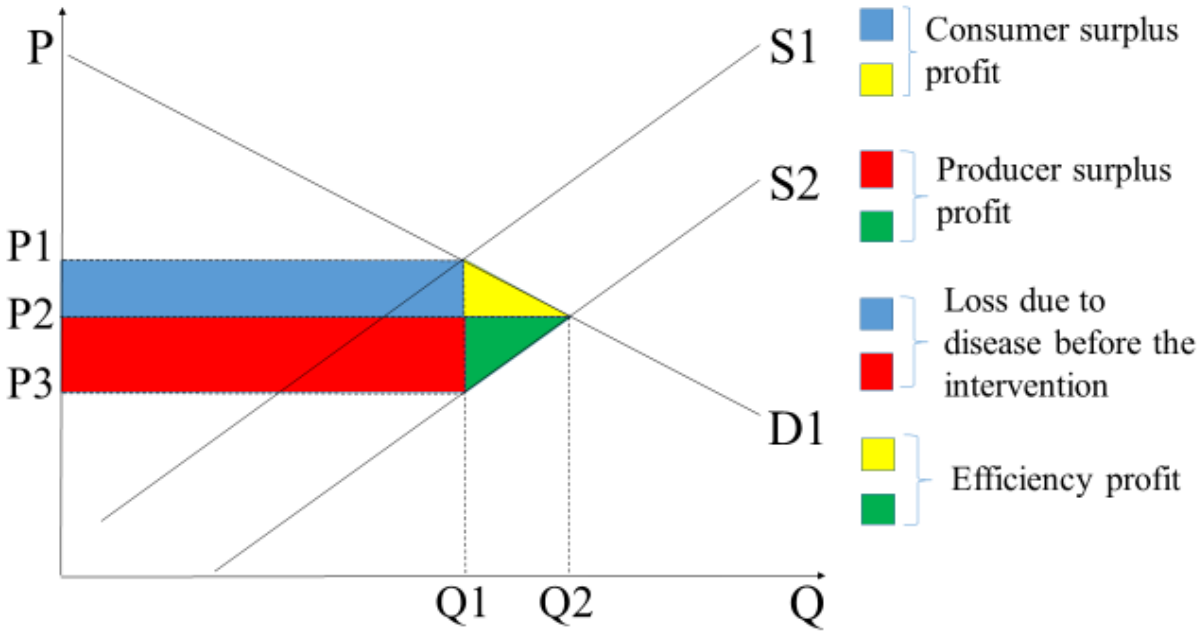
Another important issue is the difference between a loss due to a disease and loss due to mismanagement of the farm. It must be taken into account that it is one thing to a loss due to diseases and other to have a loss due to mismanagement (such as insufficient number of animals to trade, financial problems, the lack of control, etc.)

It is very important to clarify that on this article the objective is to obtain the true value of the losses due to diseases regardless of the inefficiencies from the producer. It could happen that the inefficiencies increase the value of the loss in some others decreases it. Therefore, this article remains important by seeking to obtain the true value from a disease by isolating it from issues of management actually not related to loss.

The methodologies proposed here provide a tool that allows estimating values at the producer levels, making it possible to know the internalized cost of a disease by producers in the aggregate. At this point, it is necessary to know that a disease that generates losses at the producer level generates a displacement of supply. This can be seen in graph 2 where the

surplus generated by a displacement of supply due to the disease is shown. The supply curve without a disease is S2 and with a disease is S1.

Graph 2. Analysis of producer losses due to displacement of supply



Source: Myself

The total area (red, green, light blue and yellow) is the loss of social welfare due to the existence of a disease. The difference between P1 and P3 for the Q1 units produced is nothing more than the losses generated by sick animals. Therefore, this a-priori value is known since it is the estimation of losses per animal with the proposed methodologies (methods of price differentials and cash flow).

Although $P3$ is unknown, it can be roughly estimated because the value of the loss per sick animal is known ($Loss$). Consequently, knowing the quantity of animals/kilograms lost due to the disease (Q_e), the quantity traded in total (Q_1) and the market price ($P1$) it is simple to obtain the estimated value of $P3$. Therefore, $P3$ is:

$$P3 = P1 - (1 + r)^h * Loss * \frac{Q_e}{Q_1}$$

Where: r is the discount rate; h is the number of periods between the time when the loss is internalized and the moment when the investment is made to avoid the loss.

The intuition behind this is that, in general, loss due to disease is internalized as a cost of production. Then the equilibrium price is partly explained by the disease and, as shown in the graph 2, the total loss from the disease is internalized as a constant cost per head/kilogram.

The maximum value that producers can be charged for controlling the disease without reducing the incentive to produce is known. This maximum cost, which it will name Cm is:

$$Cm = (1 + r)^h * Loss * \frac{Q_e}{Q_1}$$

It can be seen that this value Cm is the difference between P_1 and P_3 in value of the moment in which the disease should be controlled. This is because it must not be forgotten that P_1 and P_3 are in values at the time of achievement of the productive objective. It can be concluded that: if the cost of disease control is equal to the present value of the difference between P_1 and P_3, the production does not change; if the cost is higher, the production goes down; If the cost is lower, the production increases.

So far, the methods with their scope, extent and limitations have been discussed. Now it's time to review literature and how it handles the different issues, analyzing both successes and errors. For this discussion, the articles presented in the introduction are used. The different quantifications of the problems that producers have encounter are observed.

In one of the cases presented in Rushton et al (1999), the slaughtering of sick animals reduces mortality rates and increases the extraction rate, which could appear as if the production increases. This is due to the methods they mention at the farm level, these models are based on gross margin and budgets. With these methods very assiduously the effects of the management and the effect of the disease overlap. Using these methodologies makes it difficult to obtain a pure quantification of the effects of the disease.

To clarify the difference between the approaches, an example is being given. Suppose a producer has 100 cows for breeding, where he normally gets 85 calves per year. A disease appears and causes 30 cows to abort. The producers decide to select all the cows that aborted and commercialize them. With this methodology one can see that this year the profit increases

as the author claims from the sale of those 30 cows that aborted. This suggests that the gain was higher, when in reality it was a health liquidation.

Continuing the example, the following situation could occur: producers sell the 30 aborted cows and the 15 dry cows, and replace them with 45 pregnant cows. Therefore, that year he obtains 100 calves. The loss due to disease of comparing a regular year with the one where the disease occurs, is attributed to the replacement of the whole lot and the gains for the 100 calves produced.

It can be seen as in the assembly of the gross margin or budget, due to the way in which these methodologies are constructed, that it is very difficult to separate the effects of the disease from the management effect. The value of the loss due to disease with the methodology proposed in this article is the cost of replacing the 30 cows that abort with 30 cows with similar characteristics using the price differential approach.

In Bellows et al (2002) it is observed that in the valuations, the costs of infertility have been generally defined to include the cost of the replacement of the animal culled and any labor, drug, or veterinary service expenses included in treatment and/or prevention. Here the loss is oversized. The loss due to infertility, with the methodology of price differentials, is only the price difference of replacing the sick animal with a healthy one. While the cost incurred in treatment and/or prevention are part of the production cost.

Suppose, for example, a reproductive disease that causes abortions, for which animals are vaccinated before mating. 100 animals are vaccinated, 5 of which have abortions. The cost of the vaccine should not be included in the loss of having to replace the 5 animals that had abortions. This given that when replacing them, the production continues to be 100 calves. The cost of one dose of the vaccine against the disease is implicit in the cost of calf production.

But what if this is not considered? The loss is oversized in the cost of the vaccine; the oversize here is a fixed amount. What about the cost of the calf? With increases in the number of abortions, the cost of the calf will decrease. This is because, with 5 abortions, if the cost of the vaccine is attributed to the loss due to abortion, the cost of vaccinating 95 animals is divided by 100 animals. In the case of 20 abortions, the cost of vaccinating 80 animals is

divided by 100 animals. It can be seen here how the cost attribution error means that as more abortions happen, the cost of producing a calf is reduced.

Cabrera (2012) shows a good example of how to value the loss. He uses a complex model to obtain this loss. The value of a new pregnant cow within the formulation of their models is defined as the difference between the value of a newly pregnant cow and the value of a new non-pregnant cow with similar characteristics. The cost of a loss on pregnancies is defined as the difference in the value of a pregnant cow and the value of a non-pregnant cow with similar characteristics. It can be seen that there are no differences with the price differentials approach.

In Reichel et al (2013) it is observed that in the dairy herd the loss estimated is the same one proposed by the present article. While in beef cattle the abortion loss is considered as the cost of the aborted calf added to the difference between the value of the animal culled and its replacement. Here it is observed that they incurred in a double imputation, because the replacement price includes the value of the calf that the replacement-cow will have. Likewise, the option to value an abortion based on the price of a calf, would require that these values consider the value of time, the cost not incurred, and the probabilities that the calf will actually be born.

Campero (2002) in his article uses the value of the calf at weaning to valuate the losses due to infectious diseases of reproduction that reduce the percentage of pregnancies. For which on loss due to pregnancy problems, this author gives the value of feeder calf. When this valuation is made, an overestimation on the value of the loss is being made. This is because there is a record from a value that was never generated between the time when the loss occurs and the time of weaning of the calf (expected time of sale of the aborted animal). During the period of time between an abortion and the weaning, there are costs that were never incurred and also these long period of time carries a great value, these issues must be considered.

Alvear Uvidia et al (2018) consider to valuate the loss as the cost incurred in: feed from birth until the disease is detected, the loss of milk, the salvage value of the positive animal and the cost incurred in the insemination of the animal. In their article it can be said that he incurred a double charge due to the fact that the costs incurred in the animal before the disease became effective and the loss of profits are two ways of valuing the same thing. But also, they incurred in the mistake of not carrying the cash flows to a moment in the time.

Finally, in dairy, the case of Vissio et al (2015) who value the losses due to a lower milk production as the result of the liters of milk lost and the price of a liter of milk. In this case, the methodology is correct, it can be added also, to take into consideration the time value.

IV. Conclusion

The motivation to create this article came from knowing that in the livestock sector, a major source of income loss is due to livestock diseases. Therefore, being able to know the value of these losses allows producers and/or policy makers to understand the actual dimensions of the problem. With a deeper understanding of the problem a better assessment of possible strategies to combat the disease can be made.

The first conclusion that can be drawn from this article is that the IRR of the productive link under study is the best available discount rate to use when estimating. This is due to the fact that the IRR is the rate that producers implicitly expect to obtain from incurring the necessary cost to achieve the production objective.

As for the methodologies to quantify losses, both are good. It is concluded that in a farm where there are exhaustive records and there is a lot of information on costs, income and other parameters of the agribusiness, the best methodology in terms of the accuracy of what the producer faces is the cash flow one.

In cases where, the farm lacks from this amount of information and there isn't an actual need to make such complex analyzes, or even where the problem is to be analyzed based on the opportunity cost of the animal, it is possible to choose and use the price differential approach. The results will be similar between both methodologies, but the cost of obtaining the values in processing time and the amount of information required is less with the latter approach.

When the value from producer losses want to be seen at an aggregate level, in cases where it's wanted to do an incentive analysis or quantify losses to do research and/or make a policy, it is recommended to use the price differentials approach whenever it is possible. This is because it represents the marginal values of the loss, these being the values that really affect the allocation of resources. Furthermore, this approach is also much simpler.

It can be concluded that the tools mentioned and developed in this article provide with the necessary instruments to make a correct valuation of losses due to diseases. The valuations made with these methodologies can be used to obtain the optimal strategies and/or compare between control strategies.

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Annexes: Applied methods

In cattle, the application of these methodologies to value losses can be seen at different steps in the value chain. This value chain begins with mating and ends with the steers that go to slaughterhouse. In this study, three types of producers are considered for the beef chain (breeders, rearers, and fatteners). In dairy, this is considered as a breeding alternative in the beef chain. Rearing and fattening is the same in both.

The aforementioned division allows a correct valuation considering the expected goal for each type of producer. The breeder wants to obtain as many calves as possible, his business goal is that each cow has a calf and that at weaning it has the highest possible weight. The definition used for the breeding activity ranges from the mating of the cow till the weaning of the calf.

The dairy farmer's goal is to get as much milk as possible during the milking season. The dairy producer’s cycle runs from the end of the last milking season to the end of a new milking season.

The goal of the rearers is for cattle to grow after weaning and then sell it to the fatteners or breeders. Here the objective is that the cattle reaches the necessary development so that in the next stage they achieve the expected goal. Finally, the fatteners, they feed the cattle so that it fattens and sell it to the slaughterhouse.

Each productive situation can be approached from different sides, or even combine these methods to improve the valuation of the problem. Next, various situations are presented where there are different ways of estimating economic losses due to livestock diseases.

Breeding

It begins with mating the cattle (the confirmation of pregnancies), abortion, birth of dead calves, or a dead calf a few days after the birth. The issues presented are valued with the same method, although the values used may vary. It then continues with a dead calf within a few days from birth and weaning. Next, the loss valuation of a cow in any productive state. The case in which the calve arrives at weaning with a lower weight than expected is valued. Breeding bulls are valued for their ability to mate.

In regards to the discount rate to use, as mentioned above, the use of the IRR is recommended. The IRR of the breeding activity is the rate by which the subtraction between the present value of the cost incurred (from mating to weaning of the calf) with the present value of the expected income (weaned calf) is equal to zero. The equation to estimate the IRR is:

$$0 = \frac{PEC_n}{(1+r)^s} + \frac{Incomes_i}{(1+r)^i} - PEC_0 - \sum_{t=0}^{i} \frac{costs_t}{(1+r)^t}$$

Where: PEC_0 is the price of an empty cow/heifer at the time of initial mating; PEC_n is the price of the empty cow/heifer at the time of the next mating; $Incomes_i$ are the expected incomes from the sold calves; i is the number of periods that the cycle lasts (it can be days, weeks, months); n is the number of periods from the initial mating to the next mating.

Losses in mating, abortion, birth of dead calves, or the death calf a few days from birth

Mating is a crucial time in the breeder's operations, because it is when the bulls must mate the cows that produces the calves on which the operation is supported. Once the pregnancy is confirmed, it is important that the cow/heifer successfully delivers the calf. The proposal is to valuate with the same methodologies, the period between the beginning of the mating and the first days of the calf's life. This is because the problems are the same.

The valuation is carried out in the period between the confirmation of the pregnancy and the first days of the calf's life. It is proposed to valuate the losses due to non-mating at the moment in which the producer knows the results of the mating period. This is because it is at this moment that losses due to non-mating are incorporated.

If the price differential approach is used, the opportunity cost of a non-pregnancy is the option to sell the cow as open cattle or as feeder cattle. The option to sell as open cattle is to be expected for heifers, but there is likely no market for open cows.

The difference between the value of the pregnant animal and the value of the same non-pregnant animal is the value of economic losses. The cost from the feeding period between the beginning of the mating and the moment that it is confirmed, the losses due to non-pregnancies are already included in the value differential. Therefore, it should not be

considered again in the cost, or a double charge will be made. Only price differentials are used in this methodology.

Another option for valuing losses which requires more data, is the cash flow approach. Here, as in the price differential approach the option of trying to re-mate the animal or fatten it exists.

The value from the losses in case of fattening is the difference between the value of the pregnant animal and the cash flow of the fattening the non-pregnant animal. The fattening cash flow is the present value difference between the animal sold already fat and the cost incurred on fattening it. The cash flow equation for the fat animal is:

$$Present\ value\ of\ the\ fat\ animal = \frac{Income}{(1+r)^i} - \sum_{t=0}^{i} \frac{Cost_t}{(1+r)^t}$$

Where: $Cost_t$ is the cost incurred during the period t; $Income$ is the income from the sale of the animal; r is the discount rate; i is the number of periods that the fattening lasts. With PCP representing the price of the pregnant heifer/cow, the value of the loss equation is:

$$Loss = PCP - \frac{Income}{(1+r)^i} + \sum_{t=0}^{i} \frac{Cost_t}{(1+r)^t}$$

The present value of the losses when evaluating the case in which the animals try to get pregnant again, is the present value incurred until the animal finally becomes pregnant and reaches a productive situation similar to the one it had at the time the loss occurred. Given that the time when the animal becomes pregnant is unknown, it is necessary to estimate the probability that it will become pregnant and reach a productive situation similar to the one it had at the time of loss. Cash flow in this case is the sum in present value of the expected cost incurred until the animal becomes pregnant and reaches a productive situation similar to the one it had at the time of the loss. The equation is:

$$Loss = \sum_{i=1}^{\infty} \left[\left(\sum_{j=1}^{i} \left(\frac{Cost_j}{(1+r)^j} \right) + PCP_0 - \frac{PCP_i}{(1+r)^i} \right) * \prod_{j=1}^{i-1} (1 - PPH_j) * PPH_i \right]$$

Where: $Cost_j$ is the cost incurred during period j; PCP_0 is the value of the pregnant animal at expected time; PCP_i is the value of the pregnant animal at period i; r is the discount rate; PPH_i is the probability of pregnancies from mating in period i.

PCP_0 y PVP_i can be the market prices or the value the producer gives to it. The inclusion of these values is to account for the losses at the moment the animal becomes pregnant. It is considered that there is a difference in price when the animal becomes pregnant at first attempt as in one that requires more attempts.

The analysis so far starts from the assumption that the producer wants to try indefinitely to get the cow pregnant, but this does not actually happen. The equation can be modified to incorporate that, instead of trying to impregnate the cow indefinitely, she has n chances. After n opportunities, the non-pregnant animal is sold at market price(PF_n).

$$Loss = \sum_{i=1}^{n}\left[\left(\sum_{j=1}^{i}\left(\frac{Cost_j}{(1+r)^j}\right)+PCP_0-\frac{PCP_i}{(1+r)^i}\right)*\prod_{j=1}^{i-1}(1-PPH_j)*PPH_i\right] + \prod_{j=1}^{n}(1-PPH_j)*PF_n$$

Another alternative is to obtain the present value of the loss profit. The value from the loss is the difference between the present value of the income from calves sold that is expected to be obtain and the present value of the cost that was not incurred. Income should be corrected for the true probability that the calf could reach weaning. The loss equation is:

$$Loss = \frac{Income}{(1+r)^i}*Pd-\sum_{t=0}^{i}\frac{Cost_t}{(1+r)^t}+\frac{PCE_m}{(1+r)^m}-PCE_l$$

Where: $Income$ is the expected income from the calf sold at weaning; $Cost_t$ is the cost incurred in the period t; r is the discount rate; i is the number of periods between when the loss occurs and weaning; Pd is the normal percentage of calf weaning per cow/heifers mated; PCE_l is the value of the empty animal at the time of the loss; PVS_m is the value of the empty animal at the time of the next mating; m is the number of periods between the confirmation of a pregnancy and the next mating.

Loss due to death of calves between the first days of life and weaning

In this case, if the calf has a market price, this value is given. To do this, the cost of weaning the animal and putting it in conditions for sale must be incorporated, reducing the loss.

Another alternative is to consider the use of price differentials, where the difference between the price of the cow-calf pair and the price of an empty cow can be used. This difference is the value that the market puts on the calf in a cow-calf pair. In this case, the calf may be working as a sign of the cow's productive capacity. This may cause the value of the calf to be overestimated because it incorporates the value of the cow as its mother. For this reason, when valuing calf value with this methodology, this must be taken into account.

The cash flow option is the present value of the revenues from the sale of the weaned calves minus the cost of feeding the calves for the remaining time until weaning. The loss is:

$$Loss = \frac{PI}{(1+r)^i} - \sum_{t=0}^{i} \frac{Cost_t}{(1+r)^t}$$

Where: PI is the price of the weaned calf; r is the discount rate; i is the number of periods between the calf's death and weaning; $Cost_t$ is the cost that would have been incurred in period t. Where a calf death salvage value exists, this should be incorporated reducing the loss.

Loss due to the death of cows in all their productive states

In this case, the loss occurs in an animal who possesses a market value. The value of the loss is the cost of replacing the sick animal with another with similar characteristics. This is true in many cases, but in the cow-calf pair situation it does not apply. For these animals, the death of a cow cannot be compared to buying a cow-calf pair because the buyer can only buy the combo.

Here are two options. On the one hand, it is possible to value the cow for the price of the empty cow. On the other hand, the price of a cow-calf pair minus the value of a calf with the methodologies proposed in the section *Loss due to death of calves between the first days of life and weaning.*

Loss for less weight at weaning

During its short life, the calf may be affected or might have been born with a condition that causes the calf at weaning to be underweight, or to not in the expected condition for trading. The value of the loss is obtained from the difference between the income that would be received from selling the animal under normal conditions and the income that would actually be received.

Losses due to re-productive problems or the death of the Bulls

As for losses due to the bull's unproductiveness or death, an interesting discussion takes part. Bulls under normal conditions cover from 20 up to 40 cows, losing it at the time of mating implies important losses to the producer. To make a better estimation, it shouldn't be considered that the loss of a bull is the same before, during, or after the mating season (the producer discovers that the bull wasn't successful during mating season).

In case the delivering season is not controlled, the time that is equal to the mating season can be interpreted as the time when the majority of herd is in heat. This clarification is due to the fact that many producers don´t control the delivery of calves, with the bulls being with the herd all year round. However, although the bulls are with the herd all year-round, there is usually a time when most of the herd are in heat and mating. This moment is crucial, and the bull should not miss it, because the loss will be worse otherwise.

Losses due to productive problems or death of the Bulls: before the mating period

The least conflictive situation for the producer is the discovery that the bull cannot mate or is dead due to some disease. This has the same validity as discovering that the animal has a disease that it can transmit to the herd, and that is why the producer opts for the bull to not mate even though he can.

If the bull dies, an alternative to value the loss is the value of buying a new one with similar characteristics. The loss is equal to the value of replacing the dead bull. In cases where there is a salvage value for the dead bull, this should be incorporated reducing the loss. If this is discovered before the mating period, the cost of the loss is the difference between the cost of buying a new one and the income from selling the bull that is unable to mate.

It may happen that the bull valued (bull on which the loss occurs) has no market price. In these cases, the price from the lost bull must be elaborated. To construct price of the bull,

the hedonic price or cash flow approach must be used. Each bull has certain characteristics that are expected to pass on to its progeny. These characteristics can compare with the characteristics that another bulls transmits through the Expected Progeny Differences (EPD). The price of the bull can be obtained by adding the price differentials for each EPD. The methodology for estimating hedonic prices can be seen in Kerr (1984), Dhuyvetter et al (1996), Richards and Jeffrey (1996), and many others.

If the cash flow approach is used, the goal is to obtain the implicit value of the animal to the producer. This value is the difference between the present value of expected incomes and costs from the bull and its progeny during its life. The equation is:

$$Bull\ value = \sum_{t=0}^{i} \frac{Income_t}{(1+r)^t} - \frac{Cost_t}{(1+r)^t}$$

Where: $Income_t$ is the income expected to be obtained in a year t; $Cost_t$ is the cost expected to be incurred in a year t; r is the discount rate; i is the number of periods that the bull produces.

Losses due to productive problems or death of the Bulls: the mating period

In first instance the loss is similar to the case of loss before the mating period. If the bull dies, the loss is the price of buying a new one with similar characteristics. When the troubled bull cannot mate due to a disease, the loss is the difference between the sale price of the troubled bull and the purchase price of a new one with similar characteristics.

The difference with the loss before the mating period, between the moment the bull dies or has a problem that does not allow him to work until the moment he is replaced, a loss is incurred due to the herd not being covered. Due to the herd not being covered, the loss should not only be considered for the un-useful bull, but also for the cows that saw their mating deferred over this time.

In addition, there might be another loss: the discount on the price paid for the feeder lot due to less uniformity caused by mating problems. Unfortunately, this loss is difficult to value and is not considered in this document.

The loss that can certainly be valued, is the loss due to the days that the herd is not covered. It is necessary to refer technical data; cows are polyestrous with the estrous cycle on average at every 21 days. Cows that are not pregnant at the time of heat must wait an average of 21 days to re-enter heat. This data must be considered because of the days the bull did not cover, the herd must be fed though it is not mating. Therefore, the herd must be fed for the days that the bull not cover and include 21 extra days. These 21 extra days are due to the fact that the cow that was in heat and that should have become pregnant on the last day, must wait 21 days more until returning to heat and become pregnant. This value can be insignificant if the days of delay are few or very important if the days of delay are many.

The equation of bull loss in this stage is:

$$Loss = \sum_{j=0}^{i+21} \frac{Cost_j}{(1+r)^j} + \frac{PT}{(1+r)^i} - PR$$

Where: i is the number of days the herd is not covered; $Cost_j$is the cost incurred on day j; r is the discount rate; PT is the replacement price of the bull; PR is the salvage price of the affected or dead bull. Here due to the dynamic production it is understandable that there is a delay between the appearance of the loss and the replacement of the bull.

Losses due to productive problems or death of the Bulls: after the mating period

This one is the most interesting case, discovering after the mating the ineffectiveness of it, that causes many cows to remain unmated. In this case it does not make much sense to consider the option that the bull dies. For this reason, is it only appropriate to consider that it isn't effective because of the disease.

Here the loss occurs in two ways. On one hand, the difference between the price of the bull that cannot mate and the price of the replacing bull. On the other hand, the value of the non-pregnant cows. These losses due to non-pregnancies are the result of the number of cows that were not pregnant due to problems of the bull and the cost of the loss due to non-mating. To estimate these losses due to a non-mating per cow, the methodologies proposed in the section *Losses in mating, abortion, birth of dead calves, and dead calf a few days after birth* are used.

Dairy

In this chain value, the calf is a secondary product, the main product is milk. The productive cycle is between the end of the previous lactation (with the departure of a pregnant cow) and the end of the new lactation. Cash flow begins with the investment to be made in feeding and other expenses in the cow during the pre-lactation period (dry period). Then comes the income due to the calf and the milk produced and the costs incurred during this period (lactation period). This section assumes that the calf is weaned after a few days of life and sent to rearing. For this reason, the calf at an early age begins to be valued with the methodologies proposed for rearing.

Regarding the valuation of the problem of bulls, the methodologies to used are those proposed in the breeding section with adaptation to the dairy.

This section presents the valuations of: *Losses in mating and abortion; Loss from dead calves; Loss per dead cow in dry period; Loss from dead cow in lactation period; Loss due to production problems during the lactation period;*

As for the discount rate in dairy, this is similar to the one used in breeding, only income due to lactation should be incorporated. The IRR on dairy will be the rate where the net present value of the cash flow equals zero:

$$0 = \frac{PC_1}{(1+r)^i} - PC_0 + \sum_{j=k}^{i} \frac{Income\ milk\ j}{(1+r)^j} + \frac{PT}{(1+r)^k} - \sum_{t=0}^{i} \frac{Cost_t}{(1+r)^t}$$

Where: $Income\ milk\ j$ is the income from the sale of milk in period j; PT is the income from the sale of the calf at weaning; $Cost_t$ is the cost incurred during the period t; i is the number of periods from the end of the last lactation until the end of the new lactation; k is the moment when milking begins; PC_0 is the price of the pregnant cow at the end of the last lactation; PC_1 is the price of the best value alternative for the cow at the end of the current lactation. This price can be the price of the pregnant cow if the cow must be in the productive system or the price of the culling if the cow ends its productive life.

Losses in mating and abortion

The value of the loss with the price differential approach is the difference between the price of the pregnant cow/heifer and the price of a non-pregnant cow/heifer. The price of the non-pregnant cow/heifer can be the price of the open cow/heifer or of the animal to be fattened.

Another option to value this loss is to use the cash flow approach. Here the loss of cash flow due to non-pregnancy or abortion of the animal is used. The loss equation is:

$$Loss = \sum_{j=k}^{i} \frac{Incom\ Milk_j}{(1+r)^{j-d}} + \frac{PT}{(1+r)^{k-d}} - \sum_{t=d}^{i} \frac{Cost_t}{(1+r)^{t-d}} + \frac{PC_1}{(1+r)^{i-d}} - PCD_d$$

Where: $Incom\ Milk_j$ is the milk income in period j; PT is the income of the calf at weaning (when the calf is sent to rearing); $Cost_t$ is the cost incurred in the period t; r is the discount rate; i is the number of periods from the end of the last lactation until the end of the new lactation; k is the moment when the cow begins the milking period; d is the moment when the loss is revealed (detection of no pregnancy or abortion); PC_1 is the price of the best value alternative for the cow at the end of the current lactation; PCD_d is the value of the non-pregnant cow at the time of loss.

Another way of looking at the loss is the sum in present value of the cost incurred from the end of the last lactation to the moment the loss arises. Here, it is considered that the cow comes out pregnant from the last lactation to enter the new lactation (PCP_0). Therefore, the present value of the pregnant cow is considered a productive cost.

$$Loss = \sum_{t=0}^{d} Cost_t * (1+r)^t + PCP_0 * (1+r)^d - PCD_d$$

Loss from dead calves

In this case, if the calf has a market price, this value is used. The cash flow option is the difference between the income that would have been obtained from the selling the calf and the cost of keeping the calf during the remaining time until weaning. The loss is:

$$Loss = \frac{Pd}{(1+r)^i} - \sum_{t=0}^{i} \frac{Cost_t}{(1+r)^t}$$

Where: Pd is the calf Price; r is the discount rate; i is the number of periods between the calf's death and the time of weaning; $Cost_t$ are the costs incurred in the period t. In cases where there is a price for rescuing the dead animal, it must be incorporated reducing the loss.

Loss per dead cow in dry period

Here the losses are produced by an animal that has a market price. The loss is the cost of replacing the animal with another one of similar characteristics. The cash flow option is the sum of the expected income for the remainder of its life. The equations the loss is:

$$Loss = \sum_{t=0}^{i} \frac{IT_t + Incomes_t - Cost_t}{(1+r)^t} + IS_{i+1}$$

Where: IT_t is the expected income of the calf in year t; $Incomes_t$ are the expected income from the sale of milk in the year t; $Cost_t$ are the expected cost incurred in the year t; r is the discount rate; i is the number of years of productive life expected for the animals; IS_{i+1} is the salvage income expected at the end of its productive life. In cases where there is salvage value, it must be incorporated reducing the loss.

Loss from dead cow in lactation period

Regarding this period, if there is a market for lactating cows, the cost of the loss is the cost of replacing the animal with a cow with similar characteristics and in the same productive stage. It is important, if the replacement has a window of time between the death of the animal and the cow being replaced, this must be considered in the milk losses for this period. This window of time allows to understand why there may be difficulties in repositioning.

Another option is to consider the present value of the milk production not produced by the sick animal during the current lactation and the present value of the replacement cost of a pregnant female for the next lactation. The loss equation is:

$$Loss = \sum_{t=0}^{i} \frac{Income_t - Cost_t}{(1+r)^t} + \frac{PC_i}{(1+r)^i}$$

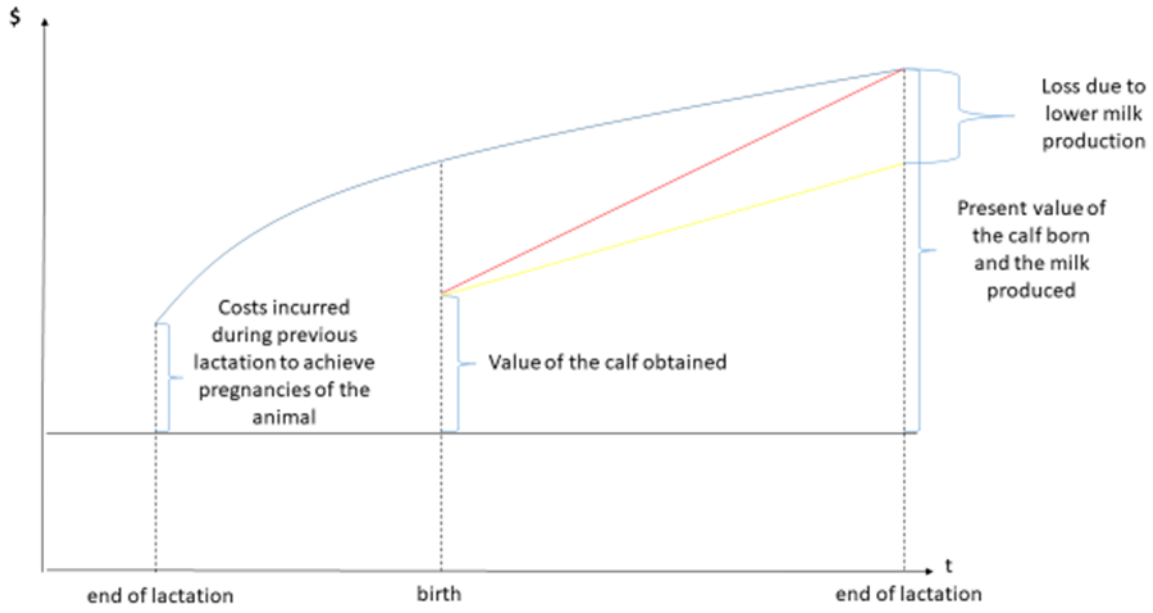
Where: PC_i is the price of a pregnant cow with characteristics similar to the deceased one; $Income_t$ is the income from the sale of milk in the period t; $Cost_t$ is the cost incurred in the period t; r is the discount rate; i is the number of periods from the moment of death of the animal until the moment when the current lactation ends. When the salvage value exists, this must be considered by reducing the loss.

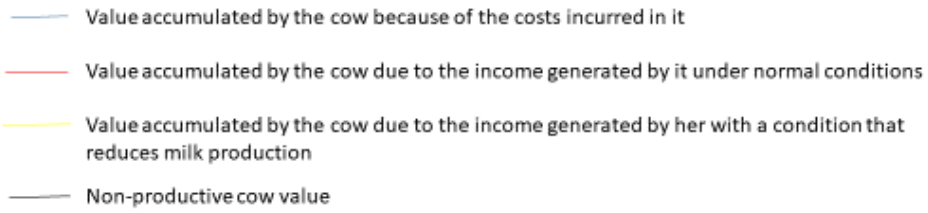
Loss due to production problems during the lactation period

In this section it is proposed to value this loss by adding the present value at the end of the current lactation of all the income losses during the milking period. This point in time is chosen because it is at this point that it is expected that under normal conditions the income and costs in present value will be equal.

Graph 1 shows the loss caused by a lower milk production through the gap that exists at the end of the current lactation between the income and costs in present value. This gap is the real loss for the producer due to lower milk production. The moment in which it is chosen to value the loss is the end of the lactation because it is the moment in which the producer implicitly expects that the income and the cost in present value are equal.

Graph 1. Value of milk production





Source: Myself

The loss equation is:

$$Loss = \sum_{j=a}^{i} PL * LNP_t * (1 + r)^{i-j}$$

Where: PL It is the price of the liter of milk paid to the producer; LNP_t is the liters that are not produced due to the disease; a is the moment when the disease begins to produce less milk; i is the number of periods from the end of the last lactation to the end of the current lactation.

Rearing and Fattening

In this section the situation of rearing and fattening are analyzed together. Although these are different links in the value chain, the losses and the valuation methodologies in both cases is the same.

In first instance, the rearing is defined. Rearing is the moment in the animal's life where its development is encouraged with the intention that in the future they may enter a higher stage. This higher stage of the animal for breeders is that young bulls and heifers enter mating. If the animals are destined for slaughter, the highest stage is entry to fattening. The rearing is considered a preliminary step in preparation for a higher stage (fattening or breeding).

Lastly, the case of fattening farms, producers whose objective is to ensure that the animals have an optimal weight and physical condition for slaughter market. The problems in rearing and fattening are: Death of the animal, Condition that prevents the animal from achieving its productive objective, and Condition postponing completion.

The proposed discount rate for rearing and fattening is the IRR. This is considered the best possible alternative. The equation for the IRR is:

$$0 = \frac{Income}{(1+r)^i} - PI - \sum_{t=0}^{i} \frac{Cost_t}{(1+r)^t}$$

Where: $Cost_t$ is the cost incurred in period t; PI is the purchase price of the animal at the time of purchase or when this stage was passed; $Income$ are the income that is expected to be obtained at the end of this productive stage; i is the number of periods that the animals live in this productive stage on the farm.

Death of the animal

When the death of the animal that was in rearing or fattening occurs, if there is a market price to replace the animal for one of equal to productive conditions, this value is given to the loss. It may happen that the animals have no market price, therefore the alternatives to value this loss will be discussed later.

The first option arises from seeing the cost incurred. The loss with this methodology is the present value of the cost incurred from the moment the animal enters this productive stage until the moment the animal dies.

The analysis begins with the first cost incurred, the purchase of the animals. If the producer in this productive link is the same person who produces in the previous productive link, it must be given the value that corresponds to the opportunity cost of the animal in the change of productive link. This value is the income that is obtained to sold the animal and/or the cost of purchase the cattle in the market. Due to market rigidities due to transaction cost and taxes, the price paid by the buyer is different from the price obtained by the seller, therefore, which price is used depends on the objective of the analysis.

The equation of the loss is:

$$Loss = PI * (1+r)^i + \sum_{t=0}^{i} Cost_t * (1+r)^t$$

Where: $Cost_t$ is the cost incurred in the period t; PI is the value of the animal when it was purchase or enter in this productive stage; r is the discount rate; i is the number of periods that the animal lives on the farm at this stage.

Another option is to look at the option that doesn't pay attention on costs, but does pay it to the lost profits due to the disease. The reasoning is the following, if the animal had not died, this in future time would have generated an income. This income was the purpose for which the animal was on the farm. Therefore, the loss is the present value of the income that was lost.

It must be considered that the animal died before the achieving the objective. There were production costs that were not incurred and these should be seen as a system gain that reduces the loss. The equation from the loss:

$$Loss = \frac{P_R}{(1+r)^i} - \sum_{t=0}^{i} \frac{Cost_t}{(1+r)^t}$$

Where: $Cost_t$ is the cost incurred in the period t; P_R is the value of the animal at the end of its productive stage; r is the discount rate; i is the number of periods left to finish the productive cycle. In cases where there is a salvage value, it must be incorporated reducing the loss.

The value of the animal at the end of its productive cycle varies depending on the specific case. In rearing heifers, it is when it becomes an open heifer, in young bulls when they can begin to mate, and in animals for fattening at the time it enters the fattening stage. These moments of completion of the rearing are expected to have a price in the market to be able to value them. In cases of fattening, the value is the price of fat cattle.

Conditions that prevent the animal from achieving its productive objective

The proposal to value this loss with the price differential approach is the difference between the expected income of the sold cattle at the end of their productive stage and the income that is actually obtained when selling them to another destination.

If the condition prevents the animal from obtaining a physical condition to achieve the productive goal, an alternative option is to sell the cull animal (usually destined for canning).

If the problem is that the animal is not suitable for breeding, there is the alternative of selling the cattle for fattening.

The moment that is proposed to value the loss is when the cattle would have been sold if the disease had not existed. If the sale of the animal with the disease occurs at a different time than when it was expected to be sold, the cash flows are valued at the present value of the time when it is expected to be sold. In cases when the cost overruns are incurred or costs are avoided, this must be included in the loss. In the first situation the loss is amplified (*Condition postponing completion*) and in the second case the loss is reduced.

Condition postponing completion

Here, the case where the animal differs in time its completion is analyzed. This causes extra costs to be incurred. The moment in which the loss becomes effective is when the animals should have finished their productive stage and did not do so due to the disease. This is the point at which the loss must be valued.

The proposal for valuing the loss is the difference between the expected value of selling the cattle at the expected time and the present value that is actually obtained from selling the cattle at a later date. The cost incurred during the overtime must be added to this loss. The loss equation is:

$$Loss = PR_0 - \frac{PR_1}{(1+r)^i} + \sum_{t=0}^{i} \frac{Cost_t}{(1+r)^t}$$

Where: $Cost_t$is the cost incurred in period t; PR_0 is the value of the animal that should have completed its productive stage at the expected time; PR_1 is the value of the animal at the end of its productive stage that required extra time; r is the discount rate; i is the number of extra periods that the animal must be in production.