Economic Analysis of Livestock Trials

by

Eric W. Crawford

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SPECIAL NOTE FOR ISRA-MSU REPRINTS

In 1982 the faculty and staff of the Department of Agricultural Economics at Michigan State University (MSU) began the first phase of a planned 10 to 15 year project to collaborate with the Senegal Agricultural Research Institute (ISRA, Institut Sénégalais de Recherches Agricoles) in the reorganization and reorientation of its research programs. The Senegal Agricultural Research and Planning Project (Contract 685-0223-C-00-1064-00), has been financed by the U.S. Agency for International Development, Dakar, Senegal.

As part of this project MSU managed the Master's degree programs for 21 ISRA scientists at 10 U.S. universities in 10 different fields, including agricultural economics, agricultural engineering, soil science, animal science, rural sociology, biometrics and computer science. Ten MSU researchers, on long-term assignment with ISRA's Department of Production Systems Research (PSR, Département de Recherches sur les Systémes de Production et le Transfert de Technologies en Milieu Rural) or with the Macro-Economic Analysis Bureau (BAME, Bureau d'Analyses Macro-Economiques) have undertaken research in collaboration with ISRA scientists on the distribution of agricultural inputs, cereals marketing, food security, farm-level production strategies and agricultural research and extension. MSU faculty have also advised junior ISRA scientists on research in the areas of animal traction, livestock systems and farmer groups.

Additional MSU faculty members from the Department of Agricultural Economics, Sociology, Animal Science and the College of Veterinary Medicine have served as short-term consultants and professional advisors to several ISRA research programs.

The project has organized several short-term, in-country training programs in farming systems research, agronomic research at the farm-level and field-level livestock research. Special training and assistance has also been provided to expand the use of micro-computers in agricultural research, to improve English language skills, and to establish a documentation and publications program for PSR Department and BAME researchers.

Research publications from this collaborative project have been available only in French. Consequently, their distribution has been limited principally to West Africa.

In order to make relevant information available to a broader international audience, MSU and ISRA agreed in 1986 to publish selected reports as joint ISRA-MSU International Development Paper Reprints. These reports provide data and insights on critical issues in agricultural development which are common throughout Africa and the Third World. Most of the reprints in this series have been professionally edited for clarity; maps, figures and tables have been redrawn according to a standard format. All reprints are available in both French and English. A list of available reprints is provided at the end of this report. Readers interested in topics covered in the reports are encouraged to submit comments directly to the respective authors, or to Dr. R. James Bingen, Associate Director, Senegal Agricultural Research and Planning Project, Department of Agricultural Economics, Michigan State University, East Lansing, MI 48824-1039.

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ECONOMIC ANALYSIS OF LIVESTOCK TRIALS

by

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1988

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ECONOMIC ANALYSIS OF LIVESTOCK TRIALS[1]

Eric W. Crawford

INTRODUCTION

The reorientation of research programs at I.S.R.A. and the emphasis currently placed on applied research reinforce the role and importance of on-farm trials. These trials, whether managed by farmers or by researchers, are performed with the objective of developing improved technology or production practices.

The purpose of this paper is to present methods for the economic analysis of livestock trials. There is less literature on this subject than on the economic analysis of agronomic trials (see, for example, Perrin, et al.). There are certain important differences between livestock and agronomic trials, and the techniques of economic analysis must be modified to take these into account.

According to Landais (1986a), livestock trials can be grouped into several categories:

1) orientation or diagnostic trials;
2) trials for perfecting improved production practices;
3) trials for adapting improved production practices;
4) demonstration trials (at the pre-extension stage).

The subject of these trials most often concerns feeding, animal behavior, and therapeutic or preventive veterinary interventions.

Compared with agronomic trials, livestock trials have certain characteristics which exert a direct impact on the methods of economic analysis to be adopted. Among the characteristics mentioned in the literature (Landais, 1986a; Bernsten, Fitzhugh, and Knipscheer; Gryseels and Anderson), the following points should be noted:

1. Due to the length of the biological cycles of animals, the effect of treatments must be observed over a relatively long period. This is especially true for large species in general, and for the impact on reproductive

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[1]Some material in this paper is drawn from Crawford and Kamuanga (1986).

performance in particular. The lengthy biological cycle has two consequences of note:

a. It increases the duration and thus the cost of the trials, as well as the probability of losing a portion of the experimental population through deaths or sales. As a result, it is difficult to obtain a balanced experimental design with a sufficient number of animals in each category. Given the complexity of analyzing unbalanced multifactorial designs, in practice trials are often limited to single-factor designs.

b. A multi-year analysis is often called for, which requires a more complicated methodology.

2. It is rare, in livestock trials, that progressively increasing levels of a treatment are tested. Most often a single level of treatment is compared to a control group. A so-called "marginal" economic analysis is thus less relevant than the partial budget method, where two options are compared (usually the existing practice and an improved option). Feeding and therapeutic trials are the exception to the rule, inasmuch as they typically do involve increasing doses or periods of treatment.

3. The animal as an individual often represents the experimental repetition, yet it is difficult to assemble homogeneous sample groups. Animals are genetically more heterogeneous than plants. The age and the stage of physiological development also vary from animal to animal. The mobility of animals makes it difficult to monitor and/or control non-experimental factors related to the physical environment. The combination of all these factors increases the residual variance of the trial, and reduces the chances for obtaining statistically significant results.

4. The analysis is also made more complex in the case of trials where the herd (or the experimental sample group), rather than the individual animal, represents the repetition. Determining the effects of the experimental treatment requires detailed and careful monitoring, in order to comprehend the complex pattern of interactions among the different factors affecting herd productivity (herding practices, feeding, health status, etc.). Simulation models are sometimes used to estimate the impact of a treatment when direct observation of impact is not possible.

5. The role of non-marketed inputs and outputs is more important for livestock systems than for cropping systems. Inputs include pasture land,

labor (including children), and agricultural by-products; outputs include manure, hides and skins, animal labor, etc. The monetary valuation of these factors is complex, yet necessary for the purpose of economic analysis. Taking into account the social value of animals is even more difficult.[2]

The general objective of the economic analysis of livestock trials is to determine the economic return and the feasibility of a treatment, from the point of the view of the producer, in order to contribute to the formulation of recommendations which he can adopt. Given that costs as well as benefits are taken into account, the "best" treatment in the economic sense is not necessarily the one which achieves the greatest physical impact. The analysis also makes it possible to identify the optimal combination of elements in the technical package and/or the best level of utilization of the treatment in question.

Since the objective is to formulate recommendations, it is necessary to evaluate profitability from the producer's point of view (financial return), which requires using existing prices, including any taxes or subsidies. Thus we are not concerned here with an analysis at the level of the national economy (economic return), which would instead require using prices prevailing in the international market, free of taxes and subsidies. (This approach is nonetheless entirely valid when the objective is to evaluate economic return.)

The economic analysis or interpretation of livestock trials can be performed using various methods. In this paper we will present one method which is often used, without suggesting that it is perfectly adapted to all situations requiring economic analysis. (For a more detailed presentation of this method as applied to agronomic trials, see the CIMMYT manual by Perrin, et al.)

GENERAL METHOD

In summary, the method includes the following stages:

1. Preparation of a partial budget for each treatment. This stage includes, in turn, the following sub-stages:

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[2]On these points, see the Ch. Ly presentation.

a. Calculation of the economic benefit (gross benefit) corresponding to the different treatments incorporated into the trial. For veterinary interventions, the principal economic benefit consists of the reduction in the value of losses which can be attributed to a therapeutic intervention.

b. Enumeration of the different inputs used and estimation of their value. This makes it possible to estimate variable costs.

c. Calculation of the net benefit (equal to the gross benefit less the value of the inputs used, excepting capital) for each treatment.

2. Identification of the "dominated" treatments, which are of no economic interest.

3. Calculation of the marginal rate of return (MRR) for each "undominated" treatment, in other words the ratio (as a percentage) of the additional net benefit to the additional costs resulting from the adoption of increasing levels of inputs. This is in effect a measure of what the livestock producer gains in terms of net income when he spends progressively higher amounts on production inputs.

4. Identification of the most promising treatment, from among all the "undominated" treatments, taking into account the means at the disposal of the producer, as well as any objectives not yet considered in the analysis. In theory, this is the treatment which will be proposed to producers by the development organization, and submitted to further trials and pre-extension tests.

ANALYTICAL CONCEPTS AND CHOICE CRITERIA

There are two key concepts underlying the analysis presented here, as follows:

1. **Partial Budget Approach.** Partial budgets indicate the net gain attributable to switching from current practices to recommended practices. Cost or return elements which remain the same are not included in the analysis. The classic structure of the partial budget is as follows:

Additional benefits, which include:

- the additional value of production
- the decrease in costs

Additional costs, which include:

- additional costs
- any decrease in the value of production

Net gain = additional benefits - additional costs

For example, weight gain achieved by animals due to the purchase of various food supplements can be compared to traditional grazing practices. In this simple example, it is unlikely that there would be any "decrease in costs" or "decrease in the value of production."

2. **Marginal Analysis.** In trials which incorporate several treatments with different levels of inputs (and thus different levels of cost), the increase in cost and in income obtained by moving from one combination to another is studied. It is possible to identify thereby the point at which a given increase in production costs no longer yields an equal or greater increase in income. (Major investments or radical changes in the production system are better analyzed by other methods such as capital budgeting or whole-farm budgeting. Nonetheless, the principle of marginal analysis is fundamental in economics.)

In general, the treatments incorporated into the trial are evaluated with respect to the following criteria:

Profitability. Net income received is compared to the funds invested. The rate of return is compared either to a target rate which is assumed to be acceptable to producers, or to rates observed in empirical studies of the economic activities of farm households.

Risks. In addition to the level of profitability of a new technology, attention must be paid to its sensitivity to environmental events. This means taking account of factors such as the stability of the treatment's impact, the impact achieved in poor years, etc.

Feasibility. It is of fundamental importance to know whether the new technology is compatible with the farmer's current production system. To what degree is the adoption of a technology (even a very profitable technology) limited by the means available to the producer, for example the level of funds which can be raised for investment, cash reserves, family labor, the availability of water and pasturage, etc.? It should not be assumed that the constraints posed by the farmer's limited resources can always be overcome.

DATA REQUIRED FOR THE ANALYSIS

1. Each trial for which an economic analysis is planned must include a control (zero treatment and/or existing livestock practices). Otherwise, it will be impossible to determine what appeal adopting the new technology will have for the producer.

2. It is important to know the quantity and price of all inputs used in the different treatments, whether they are furnished by the producer himself from his own supplies, purchased in the market, or obtained with credit. This category includes inputs such as medicine, veterinary services, forage, agricultural by-products, purchased feed concentrates, family or outside labor, as well as the expense of using any agricultural equipment.

3. The quantity and price of everything produced must also be calculated, whatever the eventual use (sale, storage, consumption). Frequently by-products (manure, hides and skins, etc.) must also be taken into account.

4. The same is true of the target rate of return, defined as the minimum rate of return deemed necessary for a given technology to be adopted by producers.

EVALUATION OF COST AND INCOME

Problems in calculating quantities and prices may arise. There are several principles which come into play, as follows:

1. **Product prices.** For products which are normally marketed, we use the sale price at the producer level, in other words the official price or the price charged at the local market, less the cost of transportation and the expense of marketing incurred by the producer. For products intended for home consumption, we use the purchase price, including the cost of transportation and any other expenses involved in bringing the product to the producer. Using the official producer price is appropriate only when (a) this is the actual price received by the producer, (b) the purpose is to get an idea of what the official price represents in terms of net income, or (c) no other valid estimate of the true price is available.

2. The very same questions arise with respect to **evaluating the cost of inputs**, especially in the case of inputs which are not purchased. It is equally important here to apply prices which take into account both the purchase cost and the cost of transportation between the point of purchase and the place of use, especially when bulky products are involved (straw, molasses, etc.).

For inputs which are not purchased (forage, agricultural by-products), the general principle is to value each factor in terms of "opportunity cost," in other words the price which the producer would have paid if he had purchased the factor. This requires a good working knowledge of the prices charged in local markets.

3. **Labor.** Labor often represents a very significant portion of production costs, thus it is an essential element of the analysis. However, the amount of labor involved is often difficult to estimate on the basis of livestock trials, given their small scope and the special requirements of trial management.

It is even more difficult to estimate the value of family labor. The classic approach is to evaluate its "opportunity cost," in other words "the wage which could be earned in off-farm employment, or the value of the time if spent on another farm enterprise, or the value which the worker places on leisure" (Perrin, et al., p. 8).

In practical terms, this approach is difficult to apply.[3] Sometimes family labor is valued in terms of the wage paid for hired labor. Another solution is to not deduct the opportunity costs of family labor, but instead to calculate the net income per family work unit. Finally, family labor can be valued by using the average return obtained by the producer for all of his

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[3]First of all, it is nearly impossible to determine the value of leisure (which is subjective). Secondly, using the market wage poses three problems (among others), namely: (a) in principle, wages vary according to the task, the season, and the status of the worker, yet data on these variations are rarely available; (b) if few people in a region work outside the farm it is not logical to assume that this is in fact an option available to everyone; and (c) even if off-farm work is potentially available, in general a producer is willing to work on his farm at a rate of return lower than the wages paid for outside work. All of these factors suggest that often the wages paid for off-farm labor represent an overestimate of the opportunity cost of family labor. Thus one is obliged to discount the observed wage rate by a more or less arbitrary factor.

agricultural activities, based on the assumption that if he did not spend time on a given activity, he would spend his time on another agricultural activity (rather than on a non-agricultural activity). This is the approach adopted by the I.S.R.A./Djibélor production systems research team; based on survey data, they estimated the average return in agriculture at 500 CFA francs per day of work.

4. Finally, the **target rate of return** is not easy to estimate. We will return to this subject later.

STAGES OF THE ANALYSIS

To illustrate the principal stages, we will make use of a trial involving the treatment of respiratory diseases affecting small ruminants in the Sine-Saloum region (Faugère, et al.). Two other trials will be presented as examples: 1) a trial on control of bovine trypanosomiasis in the Ivory Coast (Landais, 1986b), and 2) results drawn from trials on sheep fattening in Senegal (Diallo, Calvet, Denis).

Construction of the Partial Budget

In the small ruminants trial, two categories of respiratory disease were identified:

-- the **"plague syndrome,"** which includes "all pathological cases where the respiratory symptoms are associated with digestive symptoms (diarrhea)" (Faugère, et al., p. 1).

-- **"specific respiratory disease,"** where only respiratory symptoms are identified.

The trial was performed on a sample of herds suffering from respiratory disease in (1) the rural community of Kaymor, and (2) the PRODELOV project zone (Kaolack and Gossas Departments). For each animal considered sick, an agent recorded the symptoms manifested. The treatment consisted of an injection of oxytetracycline (ND PFIZER Long Action Terramycine, 1 ml per 10 kg live weight) on the day when the agent first observed the sickness, followed by repeated injections every three days until the animal either got well or died. For the experimental group in Kaymor, the intervention is

considered to be **early** (less than 7 days between the appearance of the first pathological case in the herd and the first therapeutic intervention); for the PRODELOV experimental group, the intervention is considered to be **late** (an average of 12-15 days between the first appearance of disease and the first treatment). The control group was composed of different herds in the rural community of Kaymor in which respiratory disease occurred, but in which the animals received no treatment.

Thus the economic analysis consists of evaluating three strategies of treatment:

-- strategy 0 = no treatment
-- strategy 1 = early intervention
-- strategy 2 = late intervention

The impact of these strategies was observed in three situations: (a) plague syndrome among goats; (b) specific respiratory disease among goats; and (c) specific respiratory disease among sheep.

The technical results of the trial are presented in table 1, and the economic results in table 2.

1. **Calculation of the gross benefit per treatment.** For this trial, the gross benefit (GB_S), called the "gain in gross benefit" by Faugère, et al., is obtained by applying the following formula (Faugère, et al., p. 10):[4]

$$GB_S = P_a \times 10 \times (M_0 - M_S) \qquad \text{(for strategy s)}$$

where P_a = 6,000 CFA francs, the average sale price of an animal
10 = size of the standard herd
M_0 = mortality rate in the control group
M_S = mortality rate in the group treated for strategy s

Even though the impact of the treatments was measured according to two parameters (morbidity rate, mortality rate), only the economic value of the decrease in the mortality rate is incorporated into the calculation of the GB_S. The profit consists of the reduction in losses, which is the classic situation for any health intervention.

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[4]The equivalence between the terminology used by Faugère, et al., and by us is as follows:

Faugère, et al.:	Us:
gain in gross product	gross benefit
marginal variation	additional net benefit

TABLE 1

COMPARISON OF THE EFFECTIVENESS OF THREE THERAPEUTIC STRATEGIES USING LONG ACTION TERRAMYCINE (ND PFIZER) TO CONTROL RESPIRATORY DISEASE IN SMALL RUMINANTS

Species	Disease	Strategy	Morbidity		Mortality		Number of Treatments Per Sick Animal
			Rate (%)	Variation w.r.t. Strategy 0 (%)	Rate (%)	Variation w.r.t. Strategy 0 (%)	
Goats	Plague	0	35.2	--	17.8	--	0.00
	Syndrome	1	23.1	-34.4***	6.6	-62.9***	1.63
		2	59.1	+67.9***	15.8 NS	NS	1.78
Goats	Specific	0	31.0	--	3.8	--	0.00
	Respiratory	1	13.9	-55.2***	1.3	-65.8***	1.50
	Disease	2	17.0	-45.2***	0.7	-81.6***	1.78
Sheep	Specific	0	36.8	--	15.8	--	0.00
	Respiratory	1	15.2	-58.7**	2.2	-86.1***	1.73
	Disease	2	34.0 NS	NS	2.0	-87.3***	2.02

Source: Faugère, et al.

[a]Strategy 0 = no therapeutic treatment
Strategy 1 = early therapeutic treatment
Strategy 2 = late therapeutic treatment

[b]NS = variation not significant
** = significant to 1 percent
*** = significant to 0.1 percent

TABLE 2

RATE OF RETURN ON COSTS INVOLVED IN THREE THERAPEUTIC STRATEGIES USING LONG ACTION TERRAMYCINE (ND PFIZER) TO CONTROL RESPIRATORY DISEASE IN SMALL RUMINANTS

Case	Strategy[a]	Gross Benefit[b]	Costs	Net Benefit[c]	Dominated[d]	Additional Net Benefit[e]	Additional Costs	Marginal Rate of Return (%)[f]
Goats	1	6,720	753	5,967	no	5,967	753	792
Plague	0	0	0	0	no	--	--	--
Syndrome	2	1,200	2,104	-904	yes	(-904)	(2,104)	(-43)
Goats	2	1,860	605	1,255	no	172	188	91
S.R.D.[g]	1	1,500	417	1,083	no	1,083	417	260
	0	0	0	0	--	--	--	--
Sheep	1	8,160	526	7,634	no	7,634	526	1,451
S.R.D.	2	8,280	1,374	6,906	yes	(6,906)	(1,374)	(503)
	0	0	0	0	--	--	--	--

Source: Adapted from Faugère, et al.

[a]Strategy 0 = no treatment; Strategy 1 = early treatment; Strategy 2 = late treatment. The strategies are presented in decreasing order of net benefit.

[b]Called "gain in gross product" by Faugère, et al. Equal to the value (in CFA francs) of the drop in the mortality rate resulting from the adoption of strategy s, as compared with the control group.

[c]Net benefit = gross benefit - costs, in CFA francs.

[d]A treatment is said to be "dominated" when there is at least one option presenting a greater net benefit at lower or equal cost.

[e]The additional net benefit for an undominated strategy is calculated in relation to the net

[f]MRR = (additional net benefit)/(additional costs), expressed as a percentage.

[g]S.R.D. = specific respiratory disease.

2. It should be pointed out that the calculation of the gross benefit described above includes the calculation of both the physical impact of the treatment (drop in mortality) and the value of this impact in monetary terms. In general, contrary to what was done in our example, **the calculation of the producer price** (i.e., the price from the perspective of the producer) is performed by subtracting all costs incurred by the producer for processing (for example, for converting milk into butter), transportation, storage, and marketing, from the price which he receives (for example, at the local market, taking into account both the period and the form of sale). If a product usually intended for home consumption is to be valued (for example, milk or meat in a traditional pastoral system), the purchase price of the product is used, rather than the sale price.

3. **Calculation of costs associated with the treatment.** This calculation requires (a) making a list of the categories of variable costs, (b) determining the quantities of factors utilized in each category, and (c) setting the price (or opportunity cost) associated with each factor. For this particular trial, only the cost of the product is involved. The variable costs for each treatment are determined by applying the following equation (Faugère, et al., p. 10):

$$VC_s = C \times 10 \times MB_s \times D \times I_s$$

where C = 80 CFA francs, the price of one milliliter of the antibiotic used

10 = the size of the standard herd

MB_s = the morbidity rate in the group treated for strategy s

D = 2.5: the average number of milliliters of antibiotic used per injection

I_s = the average number of injections per sick animal

In the case of plague syndrome among goats, by using the figures in table 1, the cost of strategy 1 can be calculated as follows:

$VC_1 = 80 \times 10 \times 0.231 \times 2.5 \times 1.63 = 753$ CFA francs (table 2)

No extra labor is required of the herder; transportation expenses for agents

and other costs associated with the extension program are not incorporated, since these are not paid by the herders.[5]

4. **Calculation of the net benefit**, which is the gross benefit less the value of all variable costs (both monetary and non-monetary). We have already pointed out that the treatment with the highest net benefit is not necessarily the one which has the greatest physical impact. In table 2, in the case of sheep S.R.D., the gross benefit of strategy 2 is higher than for strategy 1, but the net benefit is lower. Furthermore, as we shall see later, the "best" treatment (from the economic point of view) is not necessarily the one with the highest net benefit.

IDENTIFICATION OF DOMINATED TREATMENTS

In CIMMYT terminology, a treatment is said to be "dominated" when there is at least one option that offers a greater net benefit at an equal or lesser cost. Thus a treatment is "undominated" when no other option exists offering a greater net benefit at an equal or lesser cost. The terms "superior" and inferior" can be substituted for "undominated" and "dominated." Dominated treatments can be identified with either graphic or numerical analysis. In our illustrative trial, superior and inferior treatments can be identified by reading table 2, where for each case the treatments are ranked in decreasing order according to the net benefit corresponding to each treatment. The dominated treatments have higher variable costs than do the treatments which are ranked higher in terms of net benefit. For example, in the case of sheep S.R.D., strategy 2 is profitable in comparison with strategy 0, but clearly inferior to strategy 1, since it shows both a lower net benefit and higher costs.

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[5]On the other hand, these costs would have to be incorporated into any analysis of the economic value of a project to control respiratory disease in small ruminants.

Analysis of Profitability

Calculation of the Marginal Rate of Return

The marginal rates of return (MRRs) are first calculated for all **undominated** (or superior) treatments, then compared with the target rate in order to identify satisfactory treatments. (Dominated or inferior treatments are no longer included in the analysis since they are of no economic interest.) The MRR is calculated as indicated in table 2: the increase in variable costs attributable to moving from one option to another more expensive option is compared to the corresponding increase in net benefit. Thus the MRR is the ratio of the additional net benefit to the additional variable costs, expressed as a percentage. In the case of goat S.R.D., we see that the MRR obtained by moving from treatment 0 to treatment 1 is higher than the MRR obtained by moving from 1 to 2, and that it is not the treatment with the highest net benefit (strategy 2) which results in the highest MRR, but rather treatment 1.

The advantage of marginal analysis should be noted at this point. In the case of goat S.R.D., if we calculate the **average** rate of return for treatment 2 compared to treatment 0, the result is (1,255 - 0)/(605) = 207%. But this conceals the fact that the rate of return on the initial expenditure of 417 CFA francs (corresponding to the application of strategy 1) is 260%, whereas the rate of return on the additional expenditure of 188 CFA francs (corresponding to the application of the late strategy (2)) is only 91%. Thus an expenditure which appears attractive on the basis of an average or overall analysis turns out to be considerably less attractive on the basis of the marginal analysis.

For trials which compare a single treatment to the control situation, the marginal analysis is not applicable. In this case, it suffices to use the partial budget method, which compares only two options.

Choosing the Target Rate

What is the appropriate target rate of return? In principle, the producer, when evaluating a new option for investment (or for the purchase of

inputs), hopes to receive an equal or greater return than the return he would obtain by placing his capital in other investments.[6] Thus the target rate of return could be estimated in reference to the rates observed for the producer's other activities. Since such data are not always available, an alternative method based on the cost of capital, in other words the interest rate, is often used. A certain percentage representing the "risk premium" can also be added.

In the context of Senegal, 50% represents the minimum threshold. Indeed, a target rate of 100% seems more reasonable if we take into account the interest rates paid on money borrowed for purchasing food during the pre-harvest hungry season, which often corresponds to the period when producers' needs for agricultural inputs are most pronounced.

Choosing the Preferred Treatment

All treatments with MRRs equal to or greater than the target rate are satisfactory (again, these are undominated treatments). Among the satisfactory treatments, the final choice of the treatment to be recommended will be made by considering a number of factors. Very often the satisfactory treatment with the highest net benefit will be recommended, except in the case where the financial resources of the producer do not allow him to make the necessary expenditure. Thus, for a target rate of 100%, our illustrative trial would lead to the choice of treatment 1 in every case.

Variability and Risk Analyses

Up to this point, the risk factor has not been considered explicitly apart from including a "risk premium" in the target rate of return. However, it is important to consider not only the expected profit level but also its

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[6]It is important to incorporate the cost of capital, given the very limited availability of this resource. There are two ways to take the cost of capital into account: (1) the cost of capital is added to the costs of the other factors, then deducted from the gross benefit; or (2) the cost of capital is not added to the costs of the other factors, but the estimated "gross" rate of return is compared to the opportunity rate of return, represented by the target rate.

variability over time and space. This is a key factor, especially for producers unwilling or unable to incur deficits.

For trials which include multiple repetitions of each treatment, risk analysis may involve one or more simple calculations. We mention some of these here (for an illustration, see Crawford and Kamuanga):

1. The standard deviation of the net benefit for each treatment, calculated across all repetitions.

2. The "variability index," defined as the ratio of the standard deviation to the average net benefit, expressed as a percentage.

3. The identification of the minimum net benefit, which reflects the performance of the treatment under poor conditions.

4. To take into account the occurrence of unfavorable situations, we can also calculate the average net benefit obtained by a given treatment for the 25% of repetitions with the poorest results.

Unfortunately, livestock trials are characterized by a low number of repetitions for each treatment. Risk analysis must be performed in other ways, depending on the objectives of the trial.

In our illustrative trial, a decision analysis was performed from the producer's point of view. When the producer observes the appearance of respiratory symptoms in his herd, the issue is to determine "whether it is a problem of plague syndrome, in which case the prognosis is serious (mortality: 17.8%), or a problem of specific respiratory disease, in which case the prognosis is more favorable (mortality: 3.8%)" (Faugère, et al., p. 17). Thus the economic value of treating the animals is uncertain. In this case, expected economic values can be calculated, in other words average values weighted according to the probabilities of the two syndromes (goats: 0.6 for plague syndrome and 0.4 for specific respiratory disease). The results of this calculation are presented in table 3; they underscore the attractiveness of the early strategy. The expected net benefit is negative for the late strategy, which is explained by the fact that this strategy gives very poor results in the case of plague syndrome, which is encountered more often than S.R.D.

TABLE 3

EXPECTED ECONOMIC VALUES FOR TWO STRATEGIES FOR TREATING RESPIRATORY DISEASE IN GOATS

Item	Early Treatment Strategy		Late Treatment Strategy	
	Plague Syndrome	Specific Respiratory Disease	Plague Syndrome	Specific Respiratory Disease
Gross benefit	6,720	1,500	1,200	1,860
Probability	0.6	0.4	0.6	0.4
Expected gross benefit[a]	------ 4,632 ------		------ 1,464 ------	
Costs	753	417	2,104	605
Expected costs	-------- 619 ------		------ 1,504 ------	
Expected net benefit	------ 4,013 ------		-------- -40 ------	
Expected MRR (%)[b]	-------- 648 ------		----- negative ----	

Source: Adapted from Faugère, et al., pp. 16-18.

[a]The sum of gross benefit times probability for the two disease types, using treatment strategy s.

[b]Expected net benefit divided by expected costs, as a percentage.

Sensitivity Analysis

The analyses presented above are based on both empirical data and assumed parameters. It is important to ask how different the results would be if other figures were used. Would the choice of preferred treatment be different, for example, if the producer price or the variable costs were modified?

In one type of sensitivity analysis, the break-even price or cost is calculated, in other words the threshold (in terms of price or cost) below which the treatment becomes unacceptable. For example, Faugère, et al., calculated the break-even price of the antibiotic used (the only cost element). C_S^* is the price at which net benefit equals zero; it is obtained by applying the following equation:

Gross benefit = costs

$$P_a \times 10 \times (M_0 - M_S) = C_S^* \times 10 \times MB_S \times D \times I_S$$

$$C_S^* = (P_a \times (M_0 - M_S))/(MB_S \times D \times I_S)$$

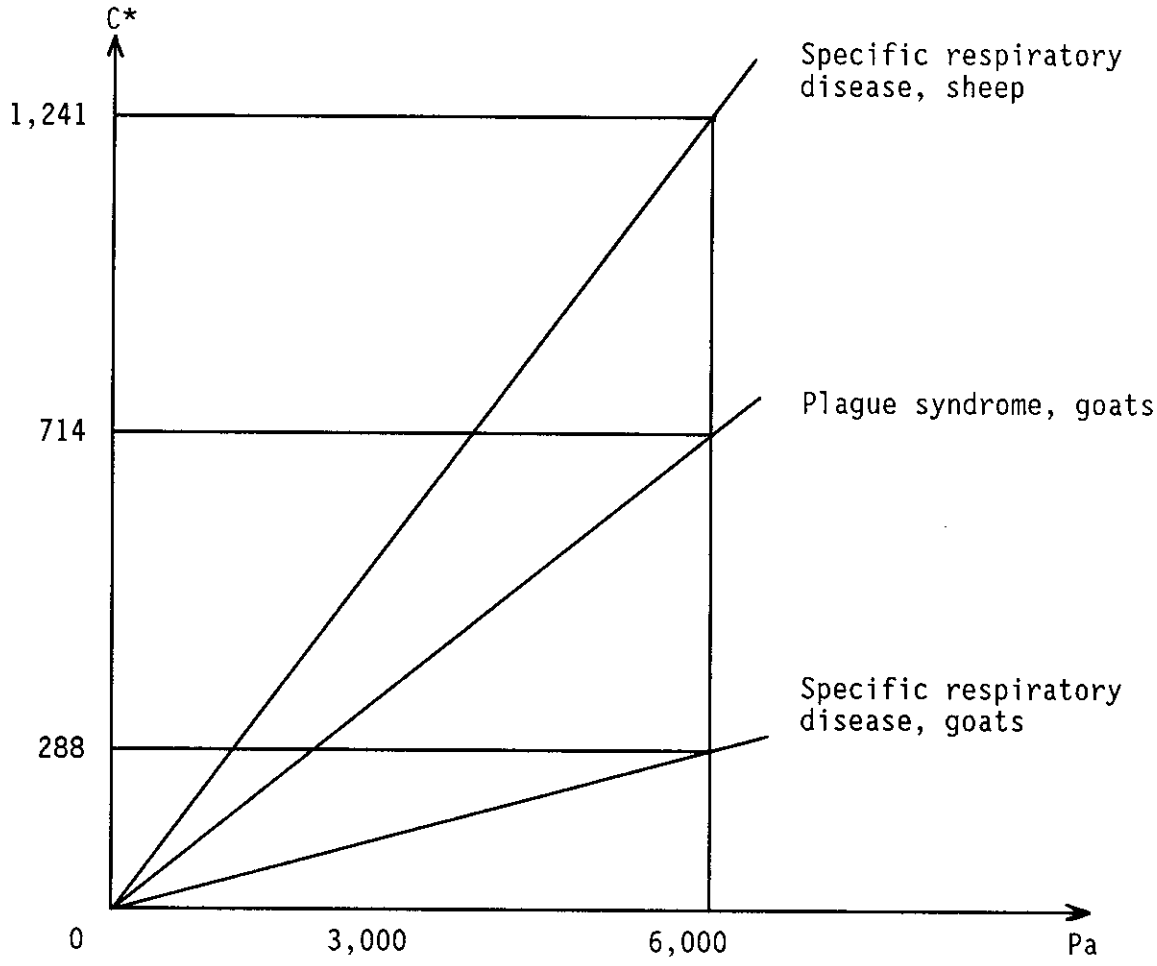
The value of C^* was calculated for the early strategy for each of the diseases studied. The results are presented in figure 1. If we assume an average price per animal of 6,000 CFA francs, the C^* values (in CFA francs/milliliter) come to 1,241 (sheep S.R.D.), 714 (goat plague syndrome), and 288 (goat S.R.D.). For the late treatment, the values come to 482 (sheep S.R.D.), 246 (goat S.R.D.), and 46 (goat plague syndrome). Except in the case of late treatment of goat plague syndrome, these values are substantially higher than the price paid by the herder (80 CFA francs/milliliter). So long as the cost of the antibiotic remains lower than its break-even cost, strategy s will be profitable. Using figure 1, one can also evaluate the impact of variations in animal prices on the profitability of the treatments.

Final Choice of Preferred Treatment

To summarize the analysis thus far, we first evaluated the profitability of all treatments in terms of net benefit and marginal rate of return. The satisfactory treatments were then identified by comparing the MRRs of all treatments to the target rate, taking into account the cost of capital and the risk factor. Next we examined the expected net benefit for each treatment,

Figure 1. Sensitivity Analysis of Break-Even Treatment Cost Compared to Average Animal Value, by Disease Category.

(TREATMENT 1)



C* = break-even cost of the treatment product (FCFA)

Pa = average animal value (FCFA)

taking into account the uncertainty of its impact. Finally, we compared the treatments again based on the results of the sensitivity analyses, in order to evaluate the relative performance of satisfactory treatments under different price and cost conditions.

Returning to the trial described by Faugère, et al., it turned out that the early treatment remained the best treatment no matter which criteria were applied. Obviously, other trials could give less clear results. In such a case, it would be up to the members of the research team to select the preferred treatment based on the results of these analyses as well as their knowledge of farmer or herder circumstances in the zone being studied. Sometimes the proper decision will be to program other livestock trials before issuing definitive recommendations. In that case, the economic analysis will have helped by providing better guidelines for future trials.

EXAMPLES OF ANALYSES OF OTHER TYPES OF TRIALS

Intensive Fattening Trials

Intensive fattening trials lend themselves best to marginal analysis when there are several treatments with increasing costs, as in the case of trials testing different feeding regimes. By way of example, we can examine the case of sheep fattening trials conducted at the National Laboratory for Livestock and Veterinary Research (Laboratoire National d'Elevage et de Recherches Vetérinaires: LNERV) in Dakar, using results drawn from Diallo, Calvet, and Denis. The trials involve various peanut hay- or shell-based diets which include various concentrates. The control group was fed on natural pasture with no supplements. After a 10-week period of fattening, the animals were sold through wholesale butchers in Dakar. The technical results are presented in table 4 and the results of the economic analysis in table 5. Figure 2 contains the net benefit and total cost values for each treatment.

Several observations should be made on these results:

1. We have taken into account both total costs and the total value of the carcass. This approach was used in order to incorporate the cost of capital invested in acquiring animals for fattening. The alternative approach, which compares the value of the weight gain to feeding costs only,

TABLE 4

RESULTS OF SHEEP FATTENING TRIALS, LNERV (SENEGAL), 1973-1976

Item	Treatment							
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7
1. Diet based on peanut hay (H) or shells (S)	Natural Pasture	H	H	S	S	S	S	S
2. DNM/FU[a]	--	100	100	110	110	120	125	150
3. Consumption index (FU/kg weight gain)	--	11.2	9.0	7.8	9.4	7.8	8.4	8.8
4. Initial live weight (kg)	25.5	26.6	27.4	26.0	28.6	29.4	36.1	29.1
5. Weight gain in 10 weeks (kg)	1.7	4.1	4.7	9.4	10.5	9.0	9.0	7.0
6. Weight of final carcass (kg)	13.3	16.5	17.3	19.1	20.3	19.9	24.3	18.7
7. Purchase price = 4 x 215 FCFA/kg	5,483	5,719	5,891	5,590	6,149	6,321	7,762	6,257
8. Total feeding costs (FCFA)	0	1,624	1,518	1,795	1,922	1,593	3,177	1,428
9. Total costs (FCFA) = 7 + 8	5,483	7,343	7,409	7,385	8,071	7,914	10,939	7,685
10. Gross benefit (wholesale butcher: 6 x 650 FCFA/kg)	8,645	10,725	11,245	12,415	13,195	12,935	15,795	12,155
11. Net benefit (FCFA) = 10 - 9	3,162	3,382	3,836	5,030	5,124	5,021	4,856	4,470

Source: Taken from Diallo, Calvet, and Denis.

[a]DNM/FU = digestible nitrogenous matter (grams)/forage unit.

TABLE 5

PROFITABILITY ANALYSIS FOR SHEEP FATTENING TRIALS CONDUCTED IN SENEGAL, 1973-1976

Treatment	Gross Benefit[a]	Costs[b]	Net Benefit	Dominated?[c]	Additional Net Benefit[d]	Additional Costs	Marginal Rate of Return[e]
	FCFA				FCFA		%
T_4	13,195	8,071	5,124	no	94		
686	14						
T_3	12,415	7,385	5,030	no	1,648	42	3,924
T_5	12,935	7,914	5,021	yes			
T_6	15,795	10,939	4,856	yes			
T_7	12,155	7,685	4,470	yes			
T_2	11,245	7,409	3,836	yes			
T_1	10,725	7,343	3,382	no	220	1,860	12
T_0	8,645	5,483	3,162	no	--	--	--

Source: Derived from table 4.

[a]Total value of carcass sold through wholesale butcher @ 650 FCFA/kg.

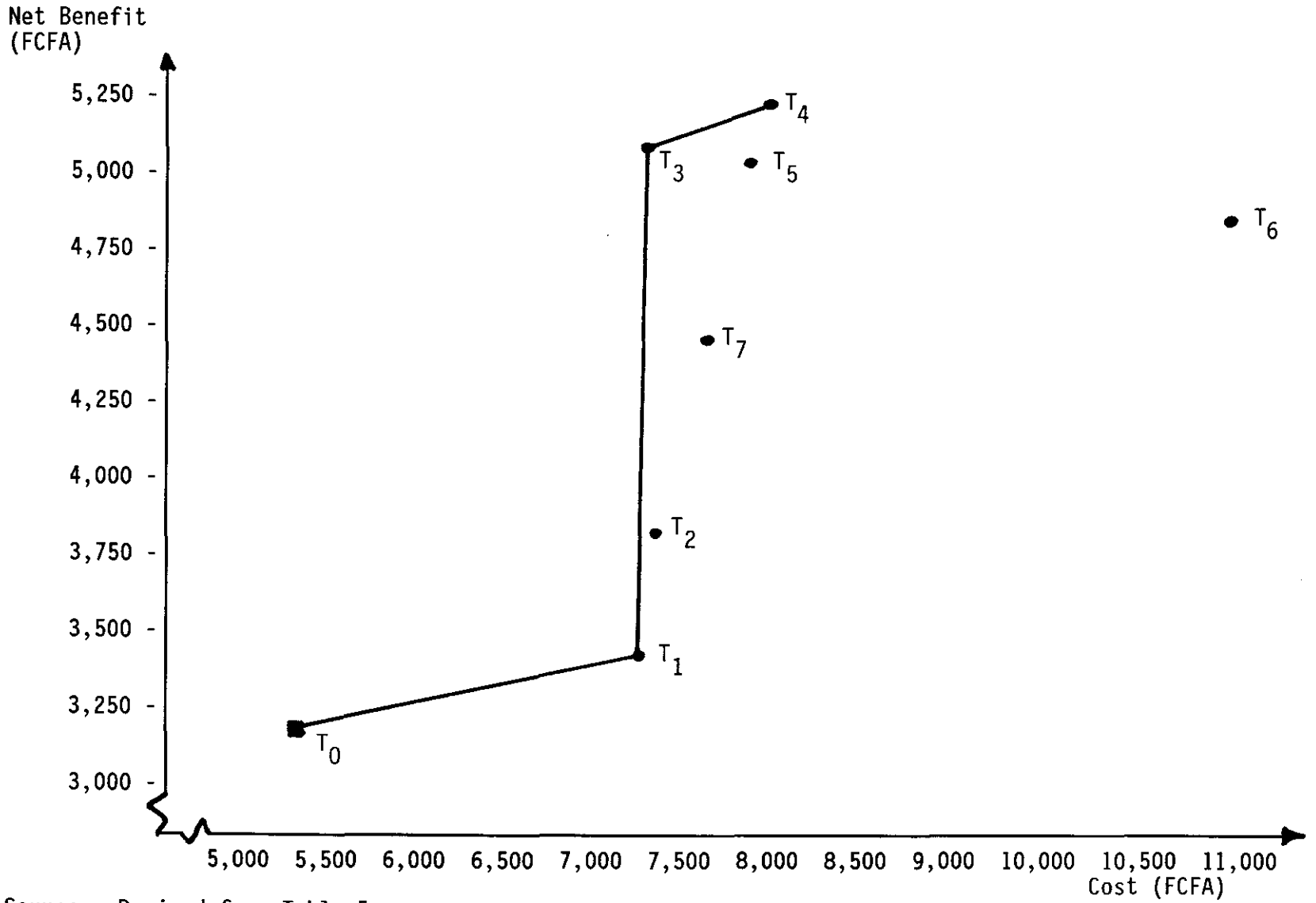
[b]Purchase price of live animal, plus feeding costs.

[c]A treatment is said to be "dominated" when there is at least one option which offers a higher net benefit at lower or equal cost.

[d]The additional net benefit for an undominated treatment is calculated in relation to the net benefit of the undominated treatment which immediately follows it in the list of treatments ranked in decreasing order of net benefit. Calculation of additional costs is performed in the same manner.

[e]MRR = (additional net benefit)/(additional costs), expressed as a percentage.

Figure 2. Graph of Net Benefit Against Cost. Sheep Fattening Trials, LNERV, 1973-76.



Source: Derived from Table 5.

does not take into account the capital invested, which results in an overestimate of the MRR.

2. Several treatments are dominated because their costs are higher than for treatment T_3, which shows the highest net benefit.

3. As can be seen in figure 2, all of the treatments, with the exception of T_0 and T_6, have similar costs. The peanut hay-based diets yield significantly lower net benefits than the peanut shells-based diets. The technical results show a relatively high consumption index and substantially lower weight gains for hay-based diets, compared with shells-based diets.

4. Treatment T_3 would be preferred on account of its high MRR and its net benefit which is only slightly lower than for treatment T_4. (We should note again that this net benefit is obtained over a ten-week period.)

5. In considering possible recommendations for producers, it is important to ask whether there are any other costs associated with fattening. The hypothesis is that certain costs (for example, medicines) would remain the same for all treatments. On the other hand, some costs (labor, structures, input acquisition, and perhaps processing and marketing) would probably be higher for intensive fattening than for the control group (which relies on natural pasture). Incorporating such costs would reduce the advantage of fattening compared to natural pasture to a degree which cannot be precisely measured with the available data.

Herd-Level Trials

In order to assess the effects of an intervention on an entire herd, its impact on animal productivity and reproduction must be monitored or estimated over a long period. A demographic model is often needed, except in the case where several years of monitoring have provided the necessary data concerning the impact of the intervention.

We will illustrate this problem with a trial related to bovine trypanosomiasis conducted in the Korhogo region of the Ivory Coast. The trial lasted close to two years and included individual monitoring of more than 3,000 cattle. Details of the trial are provided by Landais (1986b). Two treatments were used: 1) a curative product (treatment 1); and 2) a trypano-

preventive treatment (treatment 2). These treatments were compared to a control situation in which a placebo was administered.

The treatments were applied for one year. Follow-up continued for the next nine months in order to observe the effects of the treatments on mortality, animal weight, and female fertility. In order to determine the overall impact of these effects, a demographic projection was made for each treatment by including all of the parameters observed in the trial. In addition to a series of data extending over a 15-year period, the projection also provided, for each treatment, the herd characteristics at equilibrium (i.e., at the end of the period). This made it possible to achieve both objectives of the trial: 1) to compare the two strategies for controlling bovine trypanosomiasis; and 2) to evaluate losses due to trypanosomiasis.

Our purpose here is to present economic analyses which contribute to achieving these objectives. The two subsections which follow will discuss these objectives separately.

Comparison of the Two Strategies

Discounted benefit-cost analysis seemed most appropriate for comparing the two strategies. The basic question was to determine whether setting up a program of veterinary interventions to control bovine trypanosomiasis would be profitable from the point of view of the producer and the government.

Answering this question required a method which could incorporate the evolution over time of the costs and income attributable to the two strategies. Thus we chose the discounted benefit-cost analysis approach which, as it turns out, applies concepts and analytical techniques which are very similar to those presented earlier in this paper.

The economic analysis presented in table 6 is based on a costs and returns projection over 15 years. The procedure used for developing these figures is as follows:

1. **Gross benefit.** The demographic model determined the number of animals utilized year by year in each age and sex category. The utilization (offtake) rates correspond to those observed in each category; the same rates were used for all treatments. The number of animals utilized was then multiplied by the average weight observed for the animals utilized in each

TABLE 6

ECONOMIC ANALYSIS OF A BOVINE TRYPANOSOMIASIS TRIAL (KORHOGO REGION, IVORY COAST)

Item	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Treatment 0	(Values in thousands of CFA francs)														
Gross product = net profit (costs = 0)	3,438	3,593	3,755	3,924	4,100	4,285	4,478	4,679	4,890	5,110	5,340	5,580	5,831	6,093	27,751
Treatment 1															
Gross product	3,581	3,984	4,460	4,937	5,348	5,780	6,222	6,721	7,262	7,822	8,443	9,137	9,910	10,667	72,490
Producer costs I	222	248	277	305	335	365	395	428	465	502	543	587	634	684	735
Government costs II	1,110	1,240	1,385	1,525	1,675	1,825	1,975	2,140	2,325	2,510	2,715	2,935	3,170	3,420	3,675
Net profit I	3,359	3,736	4,183	4,632	5,013	5,415	5,827	6,293	6,797	7,320	7,900	8,550	9,276	9,983	71,755
Additional net profit I	-79	143	428	708	913	1,130	1,349	1,614	1,907	2,210	2,560	2,970	3,445	3,890	44,044
Net profit II	2,471	2,744	3,075	3,412	3,673	3,955	4,247	4,581	4,937	5,312	5,728	6,202	6,740	7,247	68,815
Additional net profit II	-967	-849	-680	-512	-427	-330	-231	-98	47	202	388	622	909	1,154	41,064
Treatment 2															
Gross product	3,709	4,277	5,160	6,100	6,750	7,459	8,258	9,158	10,182	11,341	12,735	14,181	15,940	17,832	146,551
Producer costs I	281	333	388	441	493	553	622	700	791	890	1,003	1,129	1,265	1,414	1,579
Government costs II	1,265	1,499	1,746	1,985	2,219	2,489	2,799	3,150	3,560	4,005	4,514	5,081	5,693	6,363	7,106
Net profit I	3,428	3,944	4,772	5,659	6,257	6,906	7,636	8,458	9,391	10,451	11,732	13,052	14,675	16,418	144,972
Additional net profit I	-10	351	1,017	1,735	2,157	2,621	3,158	3,779	4,501	5,341	6,392	7,472	8,844	10,325	117,221
Net profit II	2,445	2,779	3,414	4,116	4,532	4,971	5,459	6,008	6,623	7,336	8,222	9,101	10,248	11,469	139,445
Additional net profit II	-994	-815	-341	192	432	686	981	1,329	1,733	2,226	2,882	3,521	4,417	5,376	111,694

Source: Based on data from Landais (1986b).

[a]The value in year 15 includes the additional value of the herd: 44,245 - 22,862 = 21,383 (Treatment 0), 83,511 - 22,862 = 60,649 (Treatment 1), and 149,568 - 22,862 = 126,706 (Treatment 2).

[b]Treatment 0 = no treatment; Treatment 1 = curative treatment (BERENIL ND); Treatment 2 = preventive treatment (TRYPAMIDIUM ND).

[c]The economic values are defined as follows: Gross product = value of animals utilized, according to weight and price by age and sex category. Producer costs I = financial cost of the product used for the treatment. Government costs II = producer costs I multiplied by 5 (for Treatment 1) or by 4.5 (for Treatment 2). Net profit I = gross product - producer costs I. Additional net profit I = net profit of Treatment 1 or 2 - net profit of Treatment 0. Net profit II = gross product - government cost II. Additional net profit II = net profit II of Treatment 1 or 2 - net profit of Treatment 0.

category. Then, to obtain the gross benefit, this value was multiplied by observed prices per kg, as follows: males: 150 FCFA/kg; females 1-4 years old: 175 FCFA/kg; 5-7 years old: 150 FCFA/kg; 8 years old: 135 FCFA/kg; and 9 years or older: 120 FCFA/kg. This assumes that the entire product is sold, whereas in reality half of it is consumed by the producer. To make the calculation even more precise, the portion of the product destined for home consumption could have been valued at a price equivalent to the purchase price rather than the sale price.

The value of the milk produced was not included. It was assumed that the milk value was equal to the cost of herding, the two thus cancelling each other. The value of manure, which is not marketed, was not included either. The animals in the herd did not perform any work, so there was no estimated value in this category.

We should point out that the gross benefit for year 15 incorporates the additional value of the herd in relation to its value in year 1. This represents the incremental salvage value of the herd, also referred to by Landais (1986b) as "the gross fixed capital formation."

2. **Producer costs I.** Only the financial cost of the treatment product was included, namely:

a. Treatment 1 = BERENIL ND, 3 injections/year at a rate of 3.5 mg/kg each, for a cost of 143 FCFA/year/100 kg live weight.

b. Treatment 2 = TRYPAMIDIUM ND, 3 injections/year at a rate of 0.5 mg/kg each, for a cost of 180 FCFA/year/100 kg live weight.

The cost of herding was assumed to be equal to the value of the milk produced. The cost of constructing and maintaining enclosures was not included. Since the animals fed exclusively on natural pasture, feeding costs were assumed to be zero. Veterinary expenses were also assumed to be zero, since the vaccinations were provided free of charge by the Livestock Service.

3. **Government costs II.** In order to include the cost of operating the infrastructure required to conduct a program for controlling bovine trypanosomiasis, the producer costs were multiplied by 5, based on a subjective estimate. For treatment 2, the multiplication factor was 4.5, which gives approximately the same proportion of costs as for treatment 1 (we

assume that the infrastructure expenses remain constant even when the product itself is more expensive).

4. **Net benefit I and II.** The net benefit I for each treatment is the difference between the gross benefit and the producer costs I. The net benefit II is based on the government costs II.

5. **Additional net benefit I and II.** This is the net benefit I and II for treatments 1 and 2, less the net benefit for treatment 0 (which, in this case, is equal to the gross benefit, since the costs are zero). This gives the additional net value of each treatment compared to the control. Figure 3 shows the evolution of additional net benefit over time for each treatment.

6. **Net present value I and II.** This is the sum of the annual values of the additional net benefit, each multiplied by the annual discount factor C_t:

$C_t = 1/(1+r)^t$

where: r = discount rate

t = year ($t = 1, 2, \ldots, 15$)

This represents the total economic value of the treatment, taking into account the evolution over time of benefits and costs. In theory, the discount rate used should represent the opportunity cost of capital, in other words the average rate of return for the best alternative investment.

7. **Internal rate of return.** This rate is defined as the discount rate at which the net present value equals zero. It is calculated iteratively. The internal rate of return represents the average annual rate of return on the investment, taking into account the evolution over time of benefits and costs.

The net present values and the internal rates of return for this trial are presented in table 7. An illustrative example of the method used for calculating these values is provided in appendix 1.

The internal rates of return for variant I (producer costs) are very high, because the negative additional net benefits (which constitute the "investment") are negligible and are only recorded in year 1. Given these results, the producer would not be expected to encounter cash flow problems.

The rates for variant II (government costs) are satisfactory according to the standards applied in analyzing projects. From all points of view, it can be concluded that a systematic intervention to control bovine trypanosomiasis would be profitable, especially in the case of the preventive treatment. It

Figure 3. Time Path of Additional Net Benefit over Fifteen Years. Bovine Trypanosomiasis Trial, Korhogo, Ivory Coast.

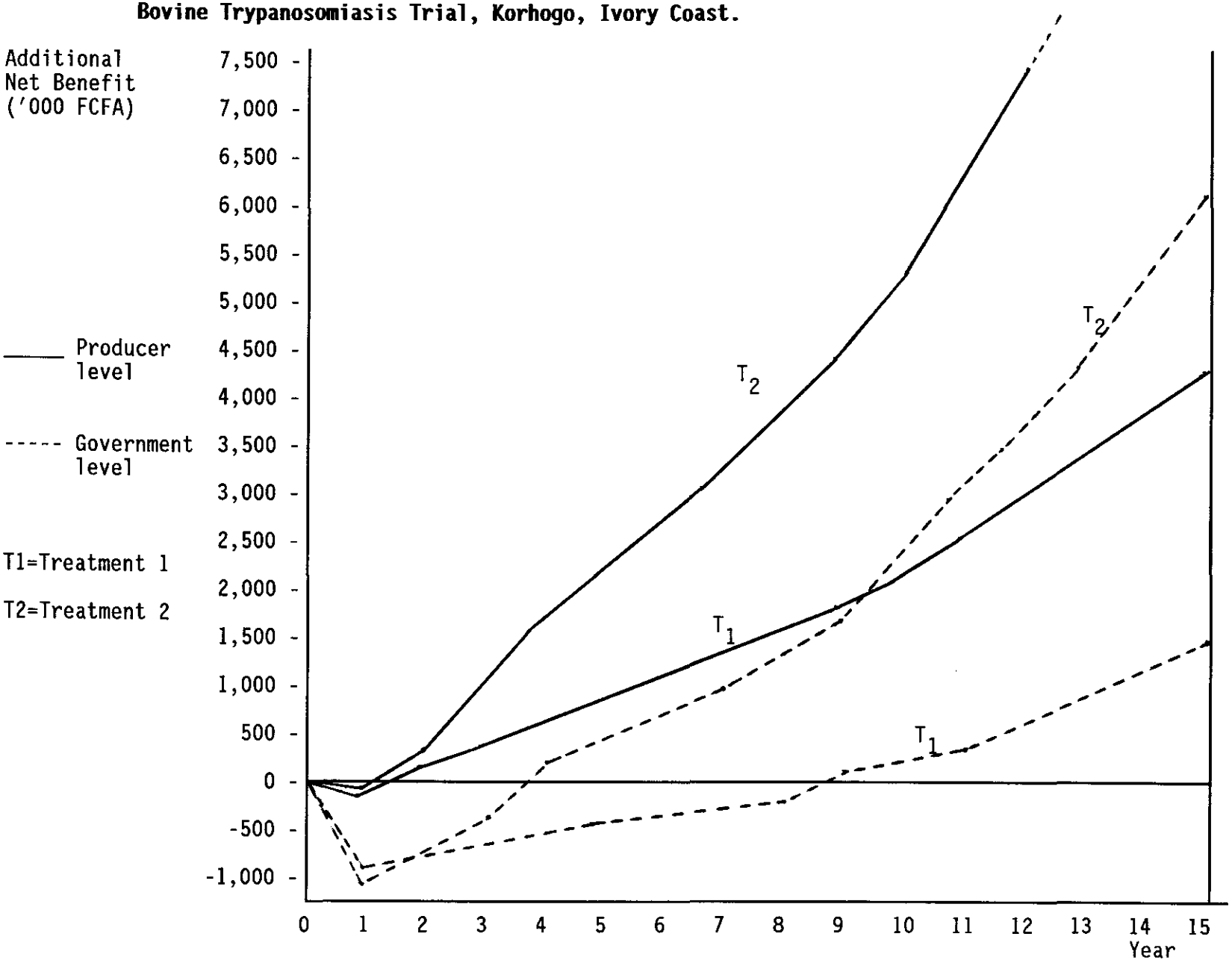


TABLE 7

NET PRESENT VALUES AND INTERNAL RATES OF RETURN FOR THE BOVINE TRYPANOSOMIASIS TRIAL

Item	Net Present Value in 1000s of CFA francs, at a rate of 20%	25%	30%	45%	Internal Rate of Return (%)
Treatment 1					
Add'l net benefit I	7,008	4,514	3,043	1,175	above 300
Add'l net benefit II	599	-517	-1,038	-1,344	22
Treatment 2					
Add'l net benefit I	17,838	11,443	7,694	2,988	above 500
Add'l net benefit II	9,046	4,708	2,344	-166	43

Source: Derived from table 6.

appears that the problem of cash flow deficits is not an issue either. During the first years, treatments 1 and 2 yield net benefits which are lower than for the control group, but which are nonetheless positive in themselves. However, in a situation where the infrastructure did not already exist, major investments would be necessary during the first years of the project, and loans would probably be needed to cover initial deficits.

Evaluation of Losses Caused by Trypanosomiasis

It is assumed that the preventive treatment (TRYPAMIDIUM ND) provides complete protection from the disease, and that the values associated with treatment 2 thus represent the trypanosomiasis-free situation. The values associated with treatment 0 represent the situation with trypanosomiasis. Thus the evaluation of losses amounts to a comparison between treatment 0 and treatment 2. It is considered appropriate to perform the evaluation based on figures for the equilibrium achieved 15 years after initiating the preventive treatment. Thus we are comparing two stable situations.

The technical and economic results of this evaluation are presented in table 8. Several observations should be made concerning the principal variables:

1. The evaluation is based on a standard herd of 1,000 head of cattle in each case.

2. The value of the initial capital is higher in the "no trypanosomiasis" case than in the opposite case, based on the hypothesis that a herd which has been untouched by trypanosomiasis will be characterized by a higher average weight, given the superior health status of the animals and the different herd structure (the value per head is a function of the average weight of the animals).

3. The value of the final capital is obtained by multiplying the final size of the herd by the unit animal price, according to age and sex category.

4. The utilization factors (or "offtake rates") are identical in both cases.

5. The total value of production is obtained by multiplying the number of animals utilized by the unit price, according to age and sex category.

TABLE 8

VALUATION OF LOSSES CAUSED BY BOVINE TRYPANOSOMIASIS

Item	With Trypano. Treatment 0	No Trypano. Treatment 2
1. Initial herd size	1,000	1,000
2. Final herd size	1,046	1,112
3. Value of initial capital ('000s FCFA)[a]	22,860	30,200
4. Value of final capital ('000s FCFA)[b]	23,912	33,582
5. Value of additional capital (4 - 3)	1,052	3,382
6. Number of animals utilized[c]	139	137
7. Value per head (FCFA)[d]	24,740	32,640
8. Total value of production ('000s FCFA)[e]	3,439	4,472
9. Gross benefit (5 + 8)	4,491	7,854
10. Additional gross benefit for T_2 ('000s FCFA)[f]	--	3,363
11. Index: $T_0 = 100$	100	175

Source: Based on data from Landais (1986b).

[a]The value is higher for T_2 due to the higher average weight associated with the superior health status of the animals.

[b]Final herd size multiplied by the unit price of the animals, according to age and sex category.

[c]The utilization (offtake) rates are identical in both cases.

[d]The unit prices are directly related to the average weight of the animals.

[e]Number of animals utilized multiplied by the unit price, according to age and sex category.

[f]The additional gross benefit represents the estimated value of losses resulting from the disease.

6. The gross benefit is the sum of the total value of production plus the value of additional capital (final - initial).

The results indicate substantial economic losses caused by trypanosomiasis: 3,363,000 FCFA over a one-year period, or 3,363 FCFA per head for the standard herd. The value of production is 1.75 times greater in the trypanosomiasis-free herd.

NOTE ON STATISTICAL SIGNIFICANCE

As a general rule, economic analyses are done for trials where the difference in impact of various treatments is considered to be statistically significant. However, it can happen that no treatment produces a significant effect, or that only one factor produces a significant impact. In this situation, the approach to be followed is not totally obvious, but a few comments are worth mentioning:

1. First of all, the power of statistical tests is low (particularly for livestock trials). In the case of a trial where the different treatments are not considered significant, the researcher should nonetheless examine the results carefully. If he observes results which seem interesting, it would be worth repeating the trial. The results could conceivably be of sufficient interest to producers that they would test the treatment themselves, under their own conditions, so long as the risks involved are not too high. (See Perrin, et al.; Smail, et al.)

2. In the event that no statistically significant difference has been demonstrated among the treatments, the preferred treatment in an economic sense is the treatment with the lowest cost. For example, a new cropping technique could reduce production costs without affecting yield. If all other factors are equal, this technique should be of interest to producers.

3. If, in a trial involving multiple factors, only one factor is statistically significant, the economic values could be calculated on the basis of the average values for this factor by grouping the results obtained for all the other factors. For example, in the case of a trial where the design includes three levels of concentrate in animal feed and three different sheep breeds, if it is found that the weight gain does not vary significantly according to breed, the average weight gain could be calculated for each

concentrate level by grouping together data for all breeds. (This procedure is clearly less applicable to livestock trials than to agronomic trials, insofar as livestock trials typically involve single-factor designs.)

4. Finally, as stated earlier, if the results of the trial are not conclusive, the proper approach is to carry out additional trials in order to confirm the impact of the treatments, before formulating definitive recommendations.

DATA PROCESSING OPTIONS

The analyses discussed in this paper can of course be performed manually. However, using a computer can facilitate the work if there are many trials to be processed or many sensitivity analyses to be conducted. For data processing by computer, two options are currently available to I.S.R.A.:

1. The MSTAT software package includes the ECON subroutine which can be used to perform all of the analyses presented in this paper. ECON can accept the data file created by using the MSTAT software for other statistical analyses. MSTAT can be used on the IBM PC or the Apple II (in CP/M) and is available to all I.S.R.A. researchers. The manual for using MSTAT includes a section which explains how to use ECON and shows the tables that can be produced.

2. The LOTUS 1-2-3 program, which represents an "electronic worksheet" with the capability of manipulating data bases and producing graphics, allows the user to create his own framework or "template" for economic analysis. In theory, it is possible to develop a general template applicable to any type of trial, but in practice, it is better to create a specific template for each type of trial. This last option represents both an advantage and a disadvantage in comparison to MSTAT/ECON, which is capable of processing several types of trial. Plans have been made for installing LOTUS 1-2-3 in the various I.S.R.A. centers that are to be equipped with IBM PC-XT. An illustrative example of how LOTUS 1-2-3 can be used for the economic analysis of agronomic trials is available from the author (Production Systems Department, I.S.R.A., Dakar).

CONCLUSIONS

In this paper we have presented some simple methods of economic analysis which can be applied to trials set up to formulate recommendations for a target group of producers. We would like to emphasize two important aspects: the role of economic analysis in the process leading up the formulation of recommendations, and the critical importance of identifying and valuing costs and benefits.

For the various types of trial examined in this paper, economic analysis comes into play as soon as the statistical analysis of the experimental results has been completed. The objective is then to identify the best treatment from the producer's point of view. But economic analysis can also contribute to formulating or reorienting the design of trials, based on the results of surveys on the performance and the constraints of production systems, or else as a follow up to the interpretation of earlier experimental data. The objective then is to reorient the design so as to achieve a better understanding of the costs and the risks as perceived by the producer.

We have presented certain principles and methods for valuing costs and benefits. However, it is clear that the trials presented in this paper scarcely illustrate the application of these techniques. The reader has no doubt noticed, for example, the small number of cost categories included in the analysis. This is quite simply because these different elements are not included in the documents which present the results, or because the way in which the trial was designed or monitored did not allow for recording this information. While recognizing the constraints on livestock research, it is nonetheless appropriate to emphasize the importance of carefully determining the various relevant costs for the decision-maker, whoever he might be.

APPENDIX TABLE 1. EXAMPLE OF CALCULATION OF NET PRESENT VALUE AND INTERNAL RATE OF RETURN.

TREATMENT 1:	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	NET PRESENT VALUE
ADD'L NET BENEFIT (ANB) II	-967	-849	-680	-512	-427	-330	-231	-98	47	202	388	622	909	1154	41064	
DISCOUNT FACTOR AT 20%	0.833333	0.694444	0.578703	0.482253	0.401877	0.334897	0.279081	0.232568	0.193806	0.161505	0.134587	0.112156	0.093463	0.077886	0.064905	
NET PRESENT VALUE AT 20%	-805.8	-589.6	-393.5	-246.9	-171.6	-110.5	-64.5	-22.8	9.1	32.6	52.2	69.8	85.0	89.9	2665.3	598.6
DISCOUNT FACTOR AT 25%	0.8	0.64	0.512	0.4096	0.32768	0.262144	0.209715	0.167772	0.134217	0.107374	0.085899	0.068719	0.054975	0.043980	0.035184	
NET PRESENT VALUE AT 25%	-773.6	-543.4	-348.2	-209.7	-139.9	-86.5	-48.4	-16.4	6.3	21.7	33.3	42.7	50.0	50.8	1444.8	-516.5
DISCOUNT FACTOR AT 23%	0.813008	0.660982	0.537383	0.436897	0.355201	0.288781	0.234781	0.190879	0.155186	0.126167	0.102575	0.083394	0.067800	0.055122	0.044814	
NET PRESENT VALUE AT 23%	-786.2	-561.2	-365.4	-223.7	-151.7	-95.3	-54.2	-18.7	7.3	25.5	39.8	51.9	61.6	63.6	1840.3	-166.4

CALCULATION OF INTERNAL RATE OF RETURN:

IRR = LOWER DISCOUNT RATE + DIFFERENCE BETWEEN THE TWO RATES X (NET PRESENT VALUE AT THE LOWER RATE) / (SUM OF TWO NPV'S IGNORING SIGNS)

$$IRR\ (ANB\text{-}II) = .20 + .05 \times \frac{(\ 598.6\ )}{(\ 598.6 + 516.5\ )}$$

$$= .20 + .05 \times .5368$$

$$= .2268 = 23\%$$

NOTE THE EFFECT OF CLOSER INTERPOLATION:

$$IRR\ (ANB\text{-}II) = .20 + .03 \times \frac{(\ 598.6\ )}{(\ 598.6 + 166.4\ )}$$

$$= .20 + .03 \times .7825$$

$$= .2235 = 22\%$$

SOURCE: DERIVED FROM TABLE 6.

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