ANIMAL HEALTH ECONOMY, TOOLS OF FINANCIAL EVALUATION AND ECONOMIC VIABILITY

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Summary. The animal health profile complies with matters of profitability, trade, and human nutrition not only through its state measured by bioproductive indicators but also through the way men interfere towards its modification. The singular nature of these phenomena and their relevance, enables to provide an identity to a specific discipline in the field of economic science: the animal health economy. The incidence of financing animal health services in relation to the public expense, the level of employment, the distribution of income and prices, as well as the impacts of several profiles on international trade, are reviewed from an an overall perspective.

In addition, the field of study includes livestock production systems and the links in the sequence production-transformation-distribution; the monitoring of public and private financing; unit costs by the type of service offered; the financial decentralization and the impact on every productive unit; models of losses by specific diseases and by productive profiles; the incidence of the changes of the animal health profile in human productivity through the modifications on the impact of the diseases caused by zoonoses, and by the conditions of hygiene and food quality; the utilization of financial tools to evaluate investment projects or program alternatives in animal health. The limits of the forecasting power of the instruments are also analysed.

Economic science essentially studies the production of goods and services, as well as their distribution and consumption. The topics to be approached, starting from animal health, require a particular treatment from an economic perspective because they enable the definition of a relevant object of study, establishing problems, hypotheses, concepts, models, tools, and languages proper to this field.

The conditions under which livestock units are organized and related, and those which provide supplies and demand products and subproducts related to livestock and other linked sectors, form the economic profile of animal health in a specific area. The mportance of this health profile in each country or region is measured according to general policies, to the source and amount of resources involved, and to its social and economic impact. Its adaptation to technological changes and to consumer preferences is normally associated with objectives of economic development because it purports a rise in productivity and livestock production, and/or the adaptation of the species to new guidelines linked to the quality of the product and the problems of the environment.

Firstly, this article deals with an approach to the object of study of animal health economy, with emphasis on the programs and on veterinary attention at the local level, and on the particularities it assumes in our region, basically in relation to cattle raising. Second, several examples are indicated on the way the programs and new projects implemented by the veterinary services may be analysed from the financial and economic viewpoint, taking into account the traditional mathematical models for the evaluation of projects, with emphasis on the non-deterministic character of the reality to be analysed.

In this way, some instruments are herein described, developed by financial mathematics and traditionally utilized to evaluate investment projects

or program alternatives. These include some habitual models of assessing operations that are useful for the decision-making process.

The limits of the forecasting power of these instruments are also analysed in relation to the animal health programs. These programs are frequently evaluated solely from the analysis made by disease and the modification in their epidemiological goals, from which profitability is measured. In fact, the cost-benefit relation should be directly referred to the treatment of economic health profiles, where the evolution of profitability is directly associated to the modification of the productive parameters that define such profile: birth rate, age at first birth, mortality, slaughter age of male for meat, and extraction of products (evaluated in quality and quantity).

In addition, the profitability of the animal health projects is measured by the overall effects on the producers and on the veterinary services, i.e., on the agents linked to the first phase of the livestock-production activity. Therefore, this approach usually loses sight of the fact that a profitability analysis thus conceived does not take into account the benefits of the losses incurred sectorially by the economic agents linked to this activity. In this sense, the economic impact of the projects and programs over the direct producers should be evaluated, as well as the suppliers of inputs and the consumers of products related to the primary production. On this basis, it is considered that the incorporation of these criteria is essential to determine the economic viability of animal health programs and projects on a more integral and realistic way.

OBJECT OF STUDY

Animal health is considered as part of a process that involves a state of productivity of the agricultural animals and the actions for its modification *(2)*. This process requires a macroeconomic perspective that enables the study of the incidence of financing animal health services at public expense and its impact over the level of employment, income distribution and prices. Thus, the international trade acquires a special importance, particularly concerning the presence of non-customs barriers linked to specific diseases. Nevertheless, the impact of animal health activities at the level of productive units and its influence in the formation of prices are two other matters of economic relevance.

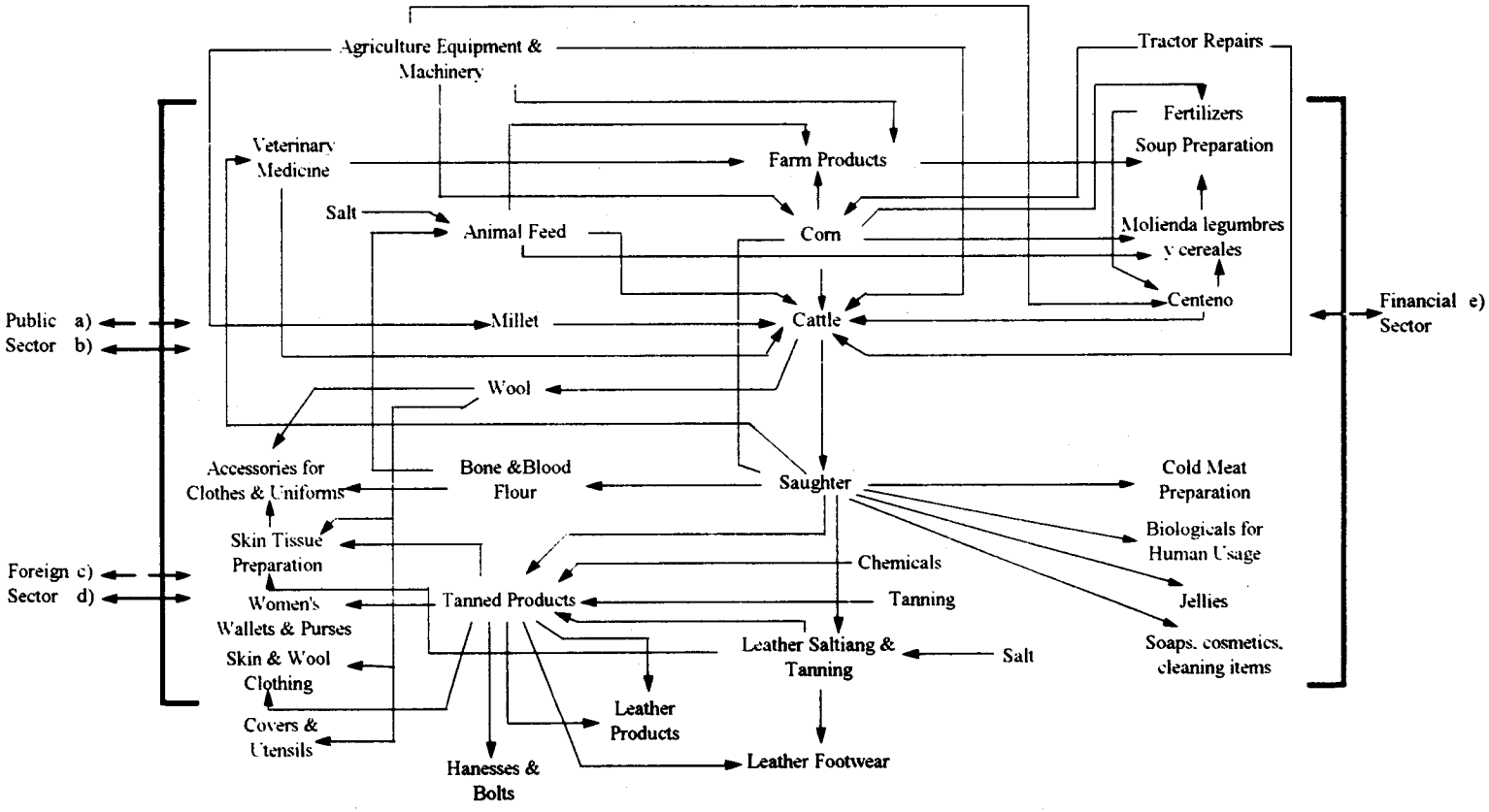
The economic profile of animal health is an axis around which develop activities, linked by flows of nature and intensity which vary according to the size, development, and complexity of the country or region (Figure 1). Hence, that includes the flows of animals, products, people, and financial resources, whose direction and intensity are indicators of the imperative productive process. This profile is also integrated by those companies that constitute the links in the sequence of production-transformation-distribution for internal consumption and exports. They are also productive units that generate and receive influences through the mechanisms of the market and of state intervention *(13)*.

These companies interact with other productive units through the sale-purchase of supplies, products, and intermediate goods required for their activities; with the public sector, through the payment of fees, taxes, and contributions, receiving in turn several services including those that are offered by the national animal health services; and with the external sector, through the export and import of livestock products and supplies for production (8).

Within these productive units, animal health economy studies the systems of livestock production that arise as a strategy of food production, selfsupply, maximization of utilities, and other objectives related to the economic organization of each country. Likewise, the modifications in the presence and behavior of agricultural animal species due to human intervention are evaluated.

The animal health economy also uses, as a model of analysis, the livestock space which has been defined as a synthesis of the effects accumulated by the action of men over the environment at a given historic moment. As far as differences in the productive orientation are observed in the livestock space, different structures of animal production are observed at the level of investment and technification, in the enhancement and specialization of livestock exploitations. The same are defined as systems of livestock production. Following are some

FIGURE 1. Livestock production block.



Real Flows

Nominal Flows

a) Payment of taxes. fees. and contributions. Receipt of subsidies and income on sales.
b) Products and services delivered and received.
c) Payment of imports of goods and services. receipt of income on exports.
d) Imports and exports of goods and services.
e) Income through financing or capitalization. Payment of interests. redemption bonds, and dividends.

of these production systems *(1,17)*: extensive, of beef cattle; breeding, of beef cattle; fattening, of beef cattle; enterprising production of milk; and family systems.

Following are other fields of animal health economy:

- The evaluation of the impacts over the social and economic development of the small and medium producers which cause the actions intended to modify the economic profile of animal health.

- The forms of organization and monitoring of public and private financing , unit costs by the type of service offered, the financial decentralization and the impact on every productive unit. It is emphasized that the results of the analysis of unit cost per activity that are intended to obtain in this work will stablish a relationship between production and resources that enable the measurement of the relative efficiency in rendering of services, facilitating the budgetary control, at both the national and local levels.

- The measurement of the relationship between the costs incurred by the producers and the public sector regarding services should also include the development of models of losses by specific diseases and of changes in the productive profile, at the microeconomic and aggregate levels.

- The estimate, from variations on the animal health profile, of the consequences in the volume and quality of available proteins of animal origin and therefore, of potential modifications in nutrition. This topic is mainly important in Latin America and in the countries of the Caribbean. Besides, it is interesting to evaluate the incidence of the changes of the economic profile of animal health in human productivity, through the modifications on the impact of zoonotic diseases, and the conditions of hygiene and food quality *(6, 12)*.

- The determination of the influence of the changes in productivity and production over the environment, the social-economic level of the population, and the public health.

ECONOMY OF ANIMAL HEALTH IN SOUTH AMERICA, CENTRAL AMERICA AND THE CARIBBEAN

The global characterization of the current Latin American problems is subject to the bias related to the different junctures of the countries. The characteristics that have been dominant in the past years are presented in Figure 2. These factors are relevant in the definition of the animal health profile.

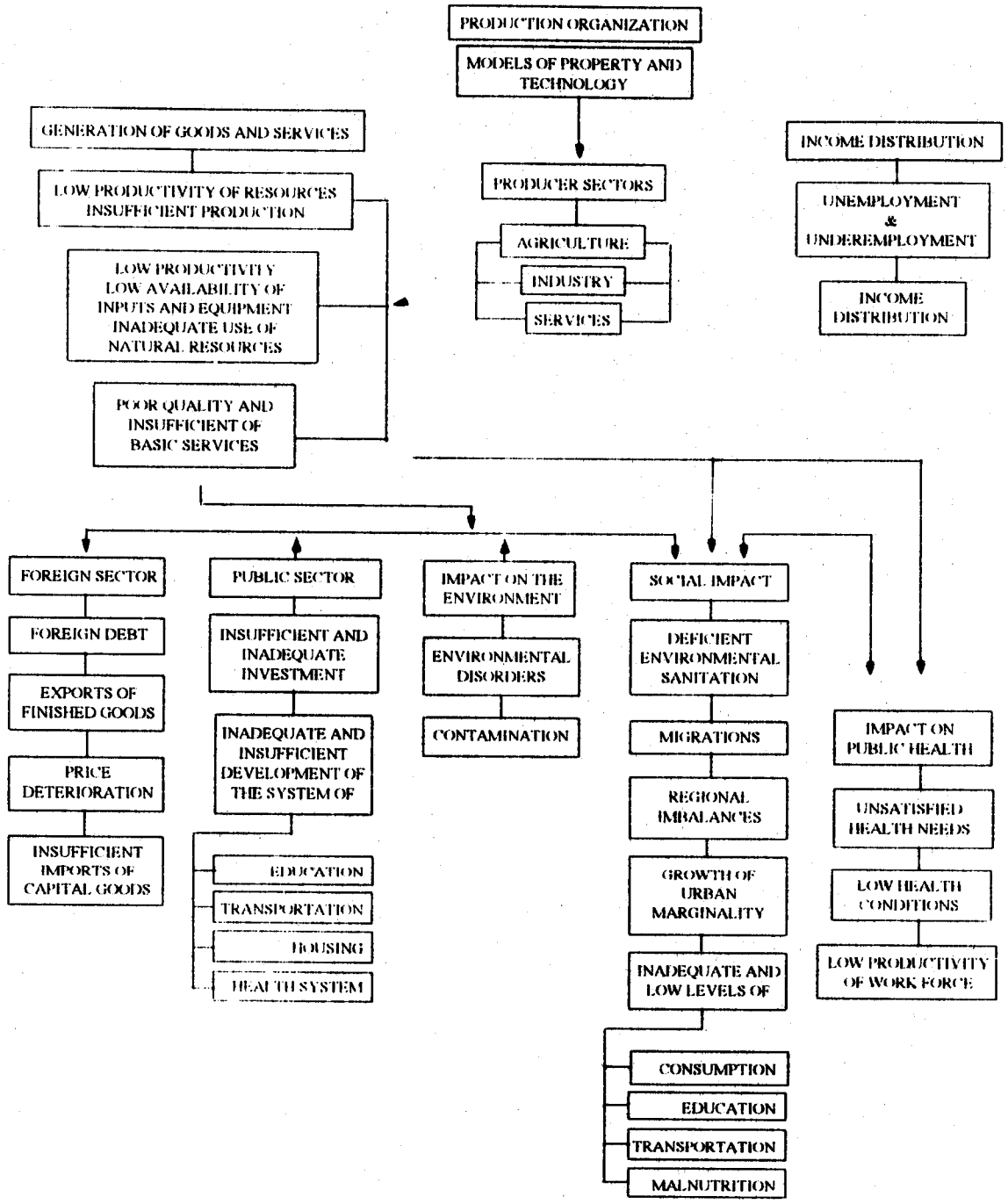
In most countries of the area, the distortions in the productive apparatus are expressed mainly in terms of low productivity levels of several factors, the inadequate use of the natural resources, and the poor quality of the products and the deficiencies of basic services. The offer of products for basic consumption is often insufficient as, for instance, the great global deficit of Latin America and the Caribbean concerning production of milk and its by-products.

Regarding the level of employment, high rates of underemployment and unemployment are recorded. The distribution of income is highly concentrated in the sectors of higher income. On the other hand, the external sector indicates a high level of debts (during this period, most debts are in the process of re-financing), deterioration of prices of agrolivestock products, and an insufficient level of imports of capital goods *(6, 12)*.

As one of the mechanisms to revert the crisis, the public sector is transferring its participation in the generation of goods and services. Nevertheless, problems persist such as: the inadequate and insufficient development of education and health systems; the inadequate investment and obsolescence in areas where the state has a significant presence; and the scarce attention to other topics of the social sector (eg. housing, culture, environment).

This situation causes socio-environmental and contamination disorders and leads to regional unsteadiness with the consequent internal and outward migrations, the growth of the cities with a scarce forecasting level, sequels of urban margination, as well as a very limited access to employment, education, transportation, and to consuming other goods and services. In addition, malnutrition and the lack of drainage cause undesirable profiles

FIGURE 2. Current problems in Latin America.



of animal health, and enhance the low productivity of the workforce.

Yet, in this context, even in the entrepreneurial areas of greater tradition and financial capacity, livestock productivity is far from corresponding to the parameters of developed countries. This situation may yet result more evident if the major natural advantages of certain regions of the continent are considered.

ANIMAL HEALTH, ECONOMIC DEVELOPMENT AND MANAGEMENT AT THE LOCAL LEVEL

In consonance with these general conditions, the profile of animal health in South America is characterized by maintaining a traditional picture of the problems that affect the health of the animal populations. Infectious, parasitic, and deficiency diseases have a great incidence. On the other hand, diseases of production, which are non-communicable and which are related to metabolic and functional problems, are becoming increasingly important. However, the low productivity results basically from problems of feeding, management, and genetics. The modification of this profile of animal health has a very outstanding role in the efforts that are made to revert several basic problems which include:

Available proteins of animal origin

There is an insufficient generation of milk and its by-products in Latin America and the Caribbean, where high indices of malnutrition are recorded. This tendency is far from being corrected. The same situation is observed with the availability of meat, although this lack of meat is less critical to attack malnutrition precociously. Nevertheless, the problem is not only about the volumes of these foods. There are also problems associated with their hygiene and quality that affect public health, and which are focused in all countries as a responsibility of the veterinary public health area *(9)*.

Foreign sector

Diseases of animals have consequences that surpass their influence on the productivity or public health of a determined area or country. The international trade of meat and its byproducts and other connected markets, is marked by health barriers that limit or avoid the flow of these products and therefore, affect the volume and prices that the countries of the region are potentially in a condition to negotiate *(18, 19)*.

Income distribution

The positive modification of the animal health profile in Central America, the Andean region from south to north, and extensive regions of Brazil, implies the incorporation of a technological change that modifies productivity, the ways of commercialization, and the level of income of livestock exploitations of the familiar type.

Communicable diseases

Zoonoses are of great importance in all countries of the continent and have a transcendent impact over the health profile of these areas, in several communities. Therefore, the modification of the animal health profile has an immediate and direct impact over public health.

Health and development

The social objective of economic development is to attain a given health status as defined by PAHO/WHO. This desired welfare condition has siginificant restrictions, even in those countries which have been constituted as social models to the rest of the nations *(10)*. Nevertheless, in South America, Central America, and the Caribbean countries, it is observed a group of basic questions remain unresolved. Thus, it is in vain to hold discussions on which should be the best way towards this welfare, without its solution. As already seen in previous points, modification of the animal health profile may contribute to reach this objective, in some of these problems.

Amongst the immediate advantages, the generation of a volume of offer that enables the direct consuming by the local population may be mentioned, or else the exports that in general, offer a very favorable balance of foreign exchange credits; the increase of the productivity of the small and medium producers and its impact over the income

and the consuming of these economies; and the reduction of disease transmission by animals and its influence on the productivity and income of the workforce. Nevertheless, these effects contribute to the solution of the most complex problems. First, it enables attenuation of the migration produced by regional disorders and therefore, to reduce the pressure over the large urban centers. Second, it increases the power of negotiation of countries with export capacity by eliminating the non-customs barriers. Through the fight againt zoonoses, Veterinary Public Health is articulated with Primary Health Care. Likewise, the increase of productivity and income in family economies improve nutrition conditions that constitute one of the basic causes of human disease.

These objectives of veterinary attention were pursued for a long time through programs and activities in which a central and scarcely participative conception prevailed. The accumulation of experiences, together with the reformulation of the actions of the state on the economy caused significant changes. Nowadays, social participation constitutes the main element for success in the campaigns of control and eradication. The implementation of the plans at the local level, generates new needs that arise from management of resources coming from the private sector and the public treasury.

On the one hand, the need to distinguish service rationalization and to link its costs with a precise production of services is stressed. In this way, the distribution of funds should be tried in terms of quantity and quality of the services derived from their use. This logic forces exploration of the components of unit cost by the type of services, which enables evaluating efficiency in the evolution of each local unit. Secondly, the private administration of the actions of schemes of epidemiological control, which include vaccination for sets of properties, generates a series of alternatives to face distinct aspects, such as the hiring of vaccinators, the purchase of vaccines, the organization of the cold chain, transportation, and the inspection of animal transit. This approach forces a permanent exercise of management control that permits revision of financial options.

COMMON MATHEMATICAL MODELS FOR THE FINANCIAL EVALUATION OF ANIMAL HEALTH PROGRAMS[a]

Generally included in the field of social sciences, economics systematically makes use of the so-called formal sciences: mathematics, logic, and semantics. Erected on a set of axioms that form economic theory, and on the observation of facts, models are constructed through logical or mathematical transformations. According to the goals defined, the models then make it possible to design the economic policies that, in combination with the administrative structure, form the basis for the formulation of plans *(7)*.

As opposed to the first stage of economic thought wherein the models were purely theoretical frameworks lacking empirical validity, in contemporary times such empirical validity is a requisite linked to the formulation of policies and plans. Consequently, this requirement has accompanied the more generalized use of mathematical instruments that correspond more to an essentially probabilistic - when not quasi-structural - behavior, than to the rational deterministic mechanisms presented in the first models.

Although other financial criteria are customarily utilized to measure the effectiveness of the programs or projects, there is a generalized use of the tools developed by mathematical economists, who incorporate the concepts of accumulation and discount in their consideration of the value of money over a period of time. The starting point of the financial calculation rests on the principle of the remuneration earned by the owners of the monetary units when those units are applied over time, thus relinquishing their immediate consumption or other profitable business usage. In other words, the use of those monetary units as savings therefore represents an opportunity cost, that is rewarded with a rate of interest.

[a] Taken from the paper presented by Vicente Astudillo during Cost/Benefit Analysis for Programs in Developing Countries, FAO, Rome, 10-14 September, 1990.

Three elements are pondered in financial mathematics: money, with which the payments related to a transaction are made or received; time, which refers to the interval between the closing of the operation and the due dates or times set for the payments or collection to occur; and the interests, which connote the remuneration owed for the use of the money during the timespan of the operation *(4) (3, 4, 11)*.

That is:

P = Initial quantity or present value
i = interest rate
I = quantity of interest per monetary unit
V = final quantity or future value, i.e. P+I

The final value for the year will be determined as follows:

$V = P+I$
$= P + Pi$
$= P(1+i)$

The final value for the 2nd year will be:

$V2 = P2\,(1+i) = P1\,(1+i)\,(1+i) = P1\,(1+i)2$

Similarly, for the 3rd year it will be:

$V3 = P3\,(1+i) = P1\,(1+i)3$

In general $Vn = P\,(1+i)n$ (1*)
Where: 1, 2, 3, ... n = years

Net present value (NPV)

From equation (1*) it follows that the current or present value is:

$$P = \frac{V}{(1+i)n} = V\frac{1}{(1+i)n}$$

This equation is insufficient when the objective is to establish the current or present value of an irregular series of inflows and outflows, which is the usual way in which the inflows and costs of animal health programs occur. In such case:

$$P = R\frac{1}{(1+i)} + R\frac{1}{(1+i)2} + R\frac{1}{(1+i)3} + \ldots\ldots + R\frac{1}{(1+i)n}$$

Where: R = yearly factors

The NPV results from the application of a rate of interest that is normally considered the opportunity cost of a project's or program's annual inflows and outflows (cash flows). If the result is positive, it expresses *prima facie* that the respective program or project is favorable, in financial terms in terms of the rate utilized.

$$NPV = \sum_{t=1}^{n} \frac{\text{Benefits}}{(1+i)n} = \sum_{t=1}^{n} \frac{\text{total benefits/total costs}}{(1+i)n}$$

Cost-benefit relationship

It indicates an index of profitability resulting from dividing the Present Value of the Annual benefits by the Present Value of the annual costs, as shown in the following formula:

$$C/BR = \frac{\sum_{t=1}^{n} \frac{\text{Total benefits}}{(1+i)n}}{\sum_{t=1}^{n} \frac{\text{Total costs}}{(1+i)n}}$$

Internal Rate of Return

The Internal Rate of Return (IRR) of a project is the interest rate that makes the present values of the projects's or program's inflow equal to its outflows. In other words, two cash flows are equivalent to a given rate when the current values of those rates are equal. If those equalized cash flows on the one hand represent the inflows of a project A and, on the other hand, the project's forecast outflows, that rate is the IRR. The IRR should be compared to the minimum required profitability rate that will be considered as the opportunity cost; if the IRR were lower than the proposed rate, then the project program in question should be rejected. If the ITT were equal to or greater than the proposed rate, then from financial standpoint alone, there would be an important element in favor of its approval.

The IRR may be expressed in equation terms as follows:

$$IRR = In + \sum_{t=1}^{n} \frac{\text{Total outflows}}{(1+i)n} = \sum_{t=1}^{n} \frac{\text{Total inflows}}{(1+i)n}$$

Where: In = Initial investments

RISK AND UNCERTAINTY IN FINANCIAL EVALUATION

The factors that influence the variation of plans and projects, when these are put into practice include, as inherent components, the characteristic elements of risk and uncertainty. To prove this statement, all the elements influencing a plan's viability in terms of the situational planning could be enumerated, with special respect to the behavior of the social actors involved in the plan. Nevertheless, even in the traditional or normative conception, the programs or projects must face the problems of variations in relative prices, the changes in the national and foreign macroeconomic policies, the technological changes, the greater or lesser achievement of the goals envisioned, among others.

This situation of uncertainty constitutes a risk situation, when it is possible to estimate the probability of the occurrence of certain events. In other words, the risk involved in an alternative decision is defined according to the variability of the possible future results. The more variable a decision's expected results, the greater the risk implicit in that decision. This degree of uncertainty may be defined and measured according to the probability distribution of the predictor, and with probability estimates associated with each one of the possible results. As shown in Figure 3, the closer the distribution of the probability of the possible results, the lower the risk in a given decision *(3, 4, 11)*.

There are many decision techniques based on an awareness of the nature of risks. However, this study will only consider three alternatives, as an example.

Sensitivity Analysis

The analysis of the sensitivity refers basically to the variations that may occur in the structures of relative prices during the life of the program assessed. Generally, sensitivity calculation does not take into account the probability associated with each event, but serves as a starting point to verify the possible results. That analysis establishes the percentage variation of the investment profit, and of the variation of the net present value. That calculation may also be used to forecast the program's financial behavior in the case of an anticipated achievement or delay in achieving the epidemiological goals that are translated into some of the production indicators already mentioned.

Figure 4 indicates a sensitivity analysis considering flows that may arise from a comparison of two projects. The point of intersection of the three curves reflects the project's IRR. Three major categories are considered: the initial investments, the project's inflows, and its outflows. The percentage variations in the flows, taken separately as expressed on axis X, generate modifications in the IRR, as observed on axis Y.

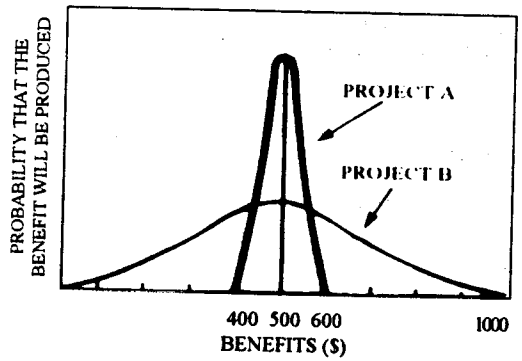
Figure 5 illustrates ten alternatives of possible project returns, by cross checking information referring to the three major factors. Axis X starts with situation S-1 in which, for instance, a 50% decrease in inflows is combined with a similar increase in investments and costs, and so forth, successively. The originally calculated IRR is found between alternatives S-5 and S-6. The maximum IRR, corresponding to the most optimistic calculation, would be S-10.

Finally, Figure 6 indicates what would be the magnitude of the project's NPV expressed in monetary units, according to the discount rate by which the project's net annual flows are evaluated. It can be observed that the NPV will evolve along a direction inverse to the applied discount rate.

Decision trees

Decisions are not made at a point in time but in stages. Each stage is likewise the product of previous results, forming a sequence of events that can be represented in a model called a "decision tree". In the example shown in Figure 7, the numbered squares represent points of decision. At square 1, there are three possible decisions: a) undertake a new program with more ambitious epidemiological goals; b) maintain the current control program with slight modifications; and c) reduce the control tasks to a minimum and orient efforts toward a study that provides more complete information about the possibilities of attaining the pre-established epidemiological goals. Let us presume that the cost of implementing a) is 30,000 monetary units, b) is 13,000 monetary units, and c) is 1000 units. If the first plan

FIGURE 3. Probability distribution of the expected indices of benefits, by program.



Adapted from Brigham, E., Pappas, J., Economía y administración; Ed. Interamericana, México, D.F.; 1978; p. 68.

FIGURE 4. Sensitivity analysis.

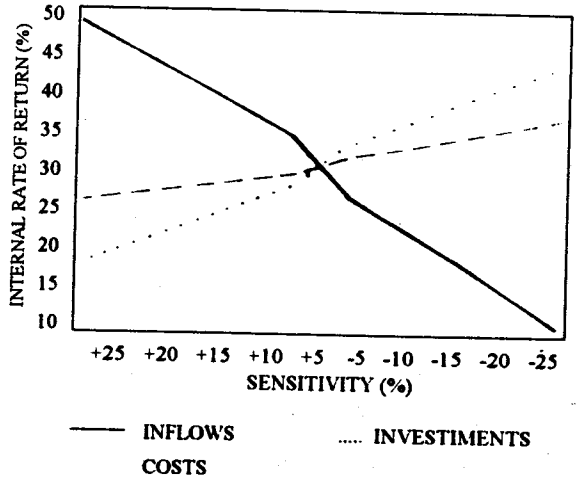


FIGURE 5. Cross sensititivy.

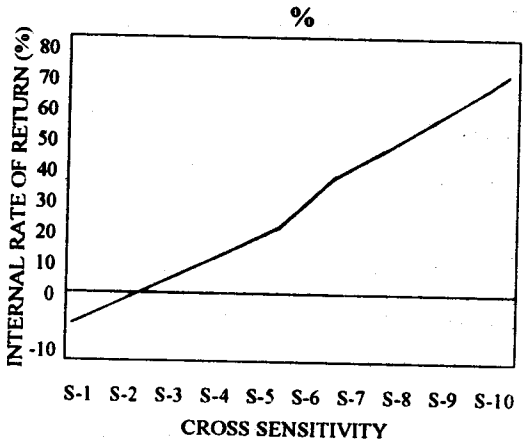


FIGURE 6. Net present value.

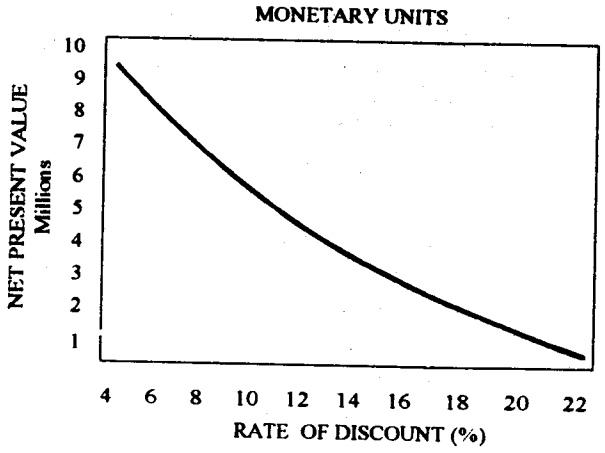
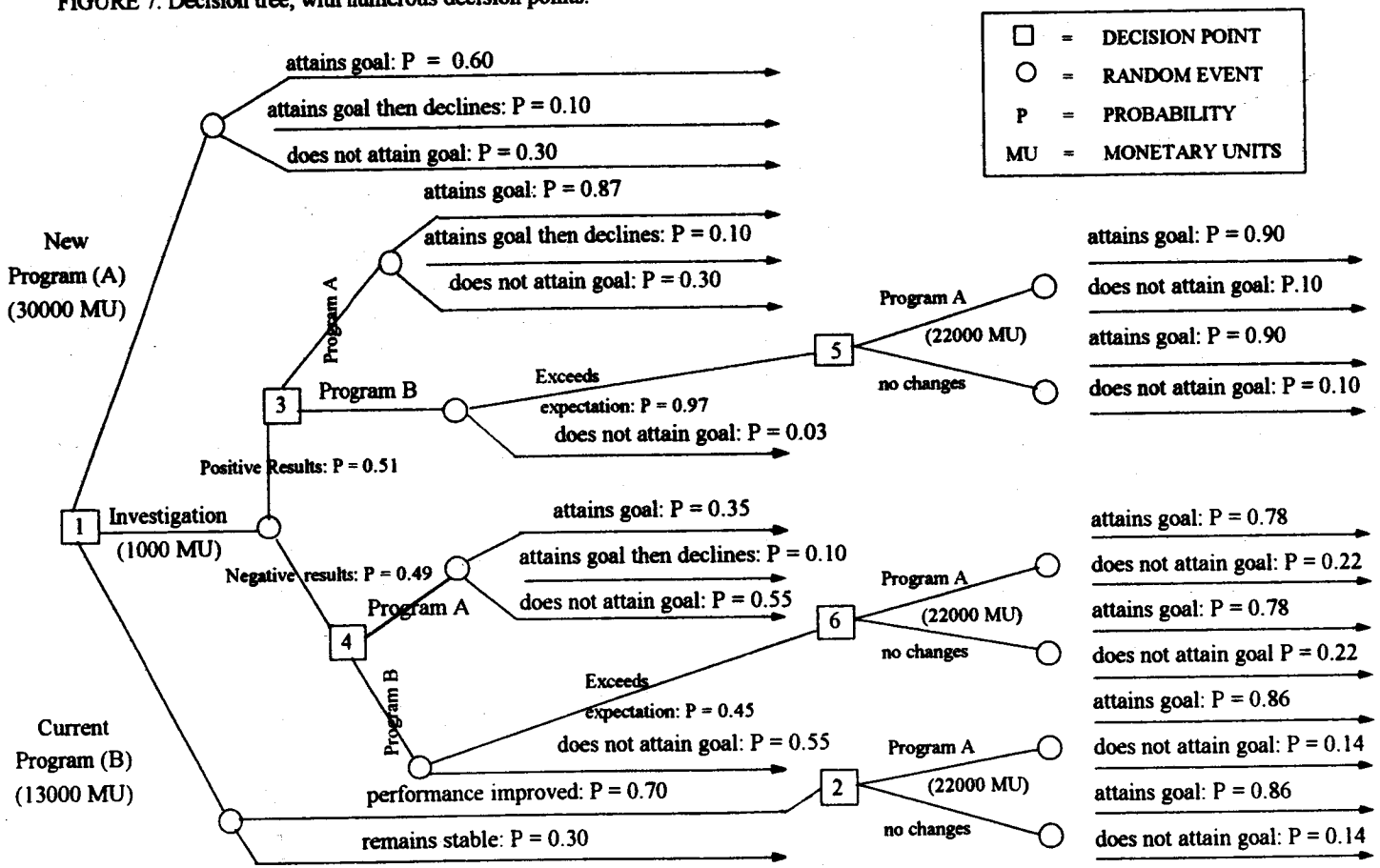


FIGURE 7. Decision tree, with numerous decision points.



Adapted from Eugene F. Brigham, James C. Pappas; *Economía y Administración*; Ed. Interamericana, México, D.F.; pp. 79-82, 1978.

is decided, then once the investments are made, the only step left is to achieve the goals envisioned as it is expressed in the uppermost "branch" of the tree. If the decision is to continue with b), the current control program (the lowermost branch), and the program is fulfilled according to normal expectations, no new actions will need to be undertaken (in this particular example). On the other hand, if epidemiological conditions are seen to improve, steps could be taken to move toward program a), which would require 22,000 monetary units (5000 more than having decided to begin with a). Finally, the possibility of developing an epidemiological study that modifies the understanding of the reality is reviewed. Better or worse, foreseeable perspectives could emerge from that information and would, moreover, require new decisions as indicated in squares *3, 4, 5, 6*.

So far, we have discussed only the way in which the decision tree is built. Obviously, the example lacks basic data for a real decision. It is seen that no allusions are made to the topic that concerns us, i.e., the financial results that could arise from each alternative.

Simulation techniques

Supposing that probability distributions can be developed for each of the determinants of the program's or project's inflows and costs, a computer program can be devised to simulate what may beprobably produced. To this end, the computer randomly selects a value for each of the distributions, combines it with other selected values, and produces the profitability analysis in successive combinations. It expresses the frequency with which certain levels of benefits appear, as a distribution of frequencies (Figure 9)).

FORMALIZATION OF THE ALTERNATIVE ANIMAL HEALTH PROFILES

Animal health should correspond to a state of the animal population, in a concrete space and moment, in which certain economically important bioproductive processes tend to approach their maximum relative potential as a response to the furtherance of environmental and management conditions favorable to their development, provided that the attainment of those conditions is socially viable and ecosustainable. The bioproductive processes are represented by a set of indicators that includes the following *(2)*:

N = Natality
M = Mortality
AFB = age at first birth
SA = slaughter ages of males for meat

That is: PPP = f (N, M, AFB, SA) (i*)
where: PPP = profile of production and productivity

Therefore, the health of animals should not be regarded simply as the opposite of disease since in its universe, animal health considers the result not only of the actions intended to protect the population against diseases but also includes the effects of the activities intended to improve the health of the animal population.

The concept assumes new forms and should not refer today to a strict conception of productivity, as it has been generally characterized, even in this study. The appearance of new preferences of consumers towards products elaborated with technologies that exclude agrochemicals may, on the one hand, cause a reduction of productivity in certain areas. On the other hand, it may generate products of a better quality and under less aggressive conditions for the environment.

The problem of many of the countries in this continent is associated with an increment in the magnitude of the offer of animal proteins, particularly milk. However, this is not incompatible with a self-sustaining livestock industry and with a production which, like in other areas which generate goods and services, establishes the purpose of implementing Total Quality Control Programs. These are defined in terms of the verification of the productive process in each stage, so as to ensure the generation of products free from diseases classified by OIE in Lists, A, B, and C, free from agrochemicals, hormones, and other drug residues.

The close relationship that exists between animal health profiles and the socioeconomic organization of livestock production, as well as with the economic and social structure of the community, breeds a situation in which the problems that arise

in the animal health field are measured by their unfavorable effects on various aspects of the livestock sector, such as were expressed in equation (i*), as well as on other sectors of the society. The following are some of the areas that feel the impact of the animal health problems:

LPP = livestock production and productivity
AT = animal trade
IL = investments in the livestock activity
PH = public health
OS = other sectors of the livestock block
RB/C = Relation of benefit cost

Where: PPP is synthesized in equation (i*). In other words, in a broader sense:

HP = f (LPP, AT, IL, PH, OS, RB/C) (ii*)

The damages to livestock production and productivity are of the physical type, with economic consequences, and constitutes a manifestation of infectious and contagious diseases as well of noncommunicable disturbances. Among these damages that affect both the livestock product itself, and the livestock capital, are the following: decrease in production volume, product loss, loss of productivity, elimination of products and poor quality of the products

The damages in animal health may have an immediate or delayed effect. The immediate damages have to do with the decrease in production, the increase in mortality, and with the loss of production through sanitary restrictions. On the other hand, damages occurring over a mid-term period, are related to the loss of productive capacity, to deficiencies of bioeconomic development, and to the decrease in the reproductive capacity. The investments applied in relation to the livestock production activity have other unfavorable impacts derived from animal health problems. Those effects may act on the investments made by the livestock producers as well as on those made by the state.

On the other hand, in the countries whose livestock production activity is one of the economy's important sectors, the damages caused by animal health problems include those that affect the international trade in products of animal origin. Those problems likewise disturb domestic trade both in animals and in livestock products within each country. Moreover, other fruit and agricultural products, and cereals, are exposed to international discrimination according to the type of prevailing animal sanitary problem. Among the socially unfavorable effects produced by animal health problems, those which have an effect on public health merit special consideration.

Most of these analyses require other evaluation techniques. In the case of projects of social type, the analysis of cost-effectiveness enables to compare the costs and the benefits when these are not expressed in the same measuring unit. A classic example in the projects of animal health arises when, on the one hand, costs translated into monetary units are considered, while benefits are " lives saved ". The analysis of cost effectiveness enables placing the decision options in a hierarchy, by comparing all the effects in terms of a non-monetary product unit and by comparing the impact of the alternatives *(5)*.

This method is mainly important in the specific evaluation of certain zoonoses, and in the projects in which aspects considered refer to local veterinary attention as related to small and medium owners, and to primary health care.

APPLICATION OF MATHEMATICAL MODELS TO ANIMAL HEALTH PROGRAMS

Animal health programs may influence the makeup of the health profile in various ways, depending on the objectives and resources applied. Evaluation of these programs from a strictly financial and economic standpoint is related to the inflows and outflows that derive from that program, vis-a-vis an alternative or cost opportunity that, eventually, may be another project or the interest rate foreseeable over the medium and long term.

Based on the assumption of the existence of a health profile able to be projected in time, HP1 = f (LPP, AT1, IL1, PH1, OS1) (iii*), the achievement of the goals implicit in the profile presume a financial effort as the product of investments, costs, and expenses originating from the public and private sectors. When this program concerns a specific disease, its development will necessarily include all

variables that may explain the changes obtained in the health profile and the sacrifices imposed on the various sectors involved. The next step will consist of projecting this program if its technical and political viability has been previously considered possible, and it will be compared to an opportunity cost that may eventually be an alternative program, which likewise proposes a new animal health profile.

In the case of foot-and-mouth disease, the Pan American Foot-and Mouth Disease Center (PANAFTOSA) has undertaken to determine the variables and associated parameters that express the changes in health profiles derived from a program to combat the disease. As previously mentioned, this profile is defined by a set of other factors wherein the sanitary aspect, in the usual strict sense, is only a part.

Therefore, the model presented here is useful to the extent that it is incorporated into a broader analysis of the animal health problem.

ECONOMIC LOSSES ATTRIBUTABLE TO FOOT-AND-MOUTH DISEASE

The economic losses attributable to FMD can be grouped into three main classes: restrictions on foreign trade, reduced production and productivity of herds, and higher animal health costs. This article places special emphasis on the last two points. However several criteria, valid for the exporting contries, are incorporated in the methodological development used for the calculation of losses attributable to FMD.

Foreign Trade Restrictions

Losses due to restrictions placed on foreign trade are of utmost importance in those countries whose significant exportable surpluses of red meat posses suitable quality for competition in the markets of the FMD-free circuit. In Latin America, Argentina, Brazil, Colombia, Paraguay, and Uruguay find themselves precisely in such a situation.

Although no model is presented in this case for calculating foreign trade losses, it is suggested that the factors to be taken into account for a total estimate of losses should be: the decline in the volume of meat production, due to sanitary restrictions in the international marketplace; the annual volume of chilled or fresh meat which, although exportable, was not exported; the difference between the price of a ton of fresh (or chilled) meat paid to countries not affected by FMD, and the price paid for the same ton to countries with FMD; and the value of the quantity of fresh meat that is cooked and canned and sold as canned products. To this should be added the economic disturbances that provoke limitations on temporary or permanent exportation of other byproducts of the livestock industry and agriculture in general.

Reduced Herd Production and Productivity

Foot-and-mouth disease may cause indirect and direct physical losses. The former are caused by the decline in the production of milk and meat, which occasions short-term decreases in the economy of the affected establishments. The indirect physical losses caused by FMD reduce the establishment's productivity over the middle and long term, owing to the decline in the affected animals' reproductive capacity and to the higher number of deaths, culling and abortions. Other indirect losses result from increased cases of mastitis, which frequently accompanies an outbreak of FMD and may also lead to permanent losses in affected cows.

Higher Animal Health Costs

The mere presence of FMD obliges the countries having an economically important livestock sector to vaccinate the herd systematically three times a year. This practice means higher costs for both the public and private sectors in the acquisition of vaccines, the roundup of animals, and the actual vaccination.

Other significant losses of an economic and social order, on general and specific levels, cannot be quantitatively evaluated.

METHODOLOGY FOR CALCULATING THE MEASURABLE ECONOMIC LOSSES

Based on the characteristics indicated above, the model below calculates the losses that can be used to assess the historical development, and carry out the forecasts that enable the future

behavior of an existing program to be compared with that of an alternative one. The methodology is based on that developed in the Ministry of Agriculture, Brazil/Inter-American Development Bank/ Pan American Health Organization (MA/IDB/ PAHO) project conducted by the Brazilian Ministry of Agriculture with technical cooperation from the Pan American Foot-and-Mouth Disease Center and financial assistance from the Inter-American Development Bank.

For the calculation of losses in herd production and productivity the following components are considered:

- Losses in milk production (MP), including temporary losses in MP (T) and permanent losses in MP (P).
- Losses in meat production (PM). This group also considers the permanent losses (when the affected animals, especially the young ones, are unable to recover their weight loss) and the temporary losses, which after a certain period, are recuperated. This includes those cases in which the fattening period has to be extended to achieve weight recovery.
- Losses due to mortality (LM), including the death of capital animals and product animals.
- Losses in replacing breeder animals (LRB). Such losses comprise the expense of replacing breeder animals, subtracting the residual value of the replaced animals in the marketplace.
- Losses due to the reduced reproductive capacity of female animals (LRC). These losses include the value equivalent to the delay in the commencement of the heifer's reproductive life, as well as the cows' shorter useful reproductive life.

The total of physical losses caused by FMD is shown as follows:

$$P \sum_{t=1}^{n} = (MP + PM + LM + LRB + LRC)$$

After establishing the model of loss to be used, the population structure, and the costs and behavior of the health profile projected according to the various alternative epidemiological goals, it is possible to apply the financial categories described, to develop those alternatives.

ECONOMIC VIABILITY

The group of tools that has been reviewed enables a more complete and structured approach to a very critical topic for the livestock activity as is animal health, such as it is conceived in this study. In addition, these tools enable a partial orientation on how to act to improve health profiles. This can be considered as a basic need, whereas the livestock production is carried out in a good portion of Latin America under conditions inadequate for contributing to improve of the situation of vast social sectors.

Experiences starting from the principles of normative planning, that uses the above mentioned tools, have been at least insufficient, when not inappropriate to improve those profiles *(14, 15, 16)*. For this reason, it becomes even more necessary to incorporate elements of strategic-situational analysis. The starting point is to conceive planning as a social event. This implies not only to start from the fact, obvious and accepted by all schools of thought in planning, that it is men who generate and conduct the process of change in a society. The differences between the situational planning and other schools revolve around how to conceive the relation among men dedicated to planning, and the object to be modified through the plan to be used.

The normative planning conceives the object of transformation as treated exogenously by a subject that is the one who plans. Normally, this subject is the State and the object is the social economic reality, or part of it, according to the characteristics of the plan.

"The actor who plans is out and above the planned reality and does not coexist in this reality with actors who also plan. (...) The subject and the planned object are independent, and the former may "control" the latter. The planned object is highly manageable if the subject who plans gets to know it. (...) The thesis expressed herein states on the contrary, that the reasons for the lean results of the traditional planning in Latin America should be looked for in the mentioned basic assumption of normative planning that, on the one hand, leads to a restricted concept of planning and planner, and on the other, leads to an economicist and technocratic practice that becomes isolated from the politi-

cal planning and the process of government as a system for calculations that precedes and determines the action." *(16)*.

Although the defenders of the normative planning would not be ready to accept explicitly this conception of the subject-object relationship, this assumption is implicit, and the building of the normative model rests upon it.

An initial consequence that defines the rest of the theoric reasoning on the topic is that the situational approach starts from the consideration that the social planning presumes the existence of social powers that face each other, for objectives often incompatible, besides the conflict each individual bears, during the process of differentiation or identification, with some of the collective projects in conflict.

Traditional planning could find its own space in the corrective action of some specific phenomenon of nature, in which there would be a social consensus about what to do and how to go about to correct this change. Therefore, more than a general theory, the normative conception is a partial theory of planning, that only uses up the plans to be elaborated under practically ideal conditions of consensus.

In other words, a general theory of planning should contain the understanding that in the economic and social system what is good for some, may also be neutral, and even bad for others. The promotion of a change hardly does not generate social actors that harm themselves and that act in consequence with these affected interests. Following is a simple example. During many years, due to the international requisites linked to the trade of meat, byproducts, and other articles, in countries with a significant livestock activity, mandatory anti-foot-and-mouth disease vaccination of cattle (and at times sheep and swine) was established. During that period, sites of production of vaccines were installed, an important distribution network was generated in each country, quality control techniques were improved by the National Services, prices were established by agreements among productive companies and the State and finally, new production techniques were implemented.

As any productive activity in a market economy, the objective of private companies in charge of vaccine production was to maximize its profit rate at long term. On the other hand, as long as the disease persists and independently of the good results obtained today in terms of the reduction of the physical losses caused by foot-and-mouth disease, agrolivestock producers spend great sums of money annually for purchasing vaccine and its application. Obviously, what is considered a product by means of which profits are materialized for a sector (laboratories), for others (the livestock producers) it is a supply and a cost that, if it could be avoided without reducing the levels of production and the commercialization conditions, would enable the profitability of breeders to increase. The elaboration of a plan with a directional arch aimed at the eradication of foot-and-mouth disease should take into account the existence of these conflicts of interests, among others.

The existence of conflict dilutes the idea that the subject who plans is an unique actor. Each social sector or individual affected by a present or foreseeable action will operate in several ways according to the damage or benefit, its relative and absolute magnitude, etc. Just as the subject who plans from the State is an internal part of the process, in which he will intend to modify the course of events in terms of its own interests and wishes, other sectors related to this field also plan.

The social actors plan by means of the application of distinct methods and from very diverse situations. The fact that an alternative formal plan does not explicitly appear from each actor, does not assume that each one of them does not act in terms of its objectives. The degree of formality and systematicity will depend fundamentally on the situation in which the actor is found. The strategic calculation, as in fact occurs in most situations, may be accompanied by actions that have nothing to do with a formalized planning, such as the one that usually characterizes the public organisms and the state in general. Moreover, it is common that the directional arch, defined as the way between the present situation and the goal-situation, is not expressed by the actors.The desirable goal-situation for an actor may not only be undesirable for some

others, but also totally incompatible in relation to a certain social consensus.

The planner that from the state or from a more specific service, does not incorporate the strategic calculation that obviously includes the possible answers to the remaining actors, will continue with the schemes that have guided planning in our countries. The planner in the strategic conception is an actor that therefore, plans politically and not from a exclusively technical perspective which, under determined situations, may modify the reality about the assumption of foreseeable conducts of the social agents, that passively accomodate themselves to the new situation. This presumes the existence of uncertainty, of a dynamic process of changes and conflicts. Thus, it is necessary to reach for a theory of a broader social production, in which each production event requires power resources, economic resources, natural resources, and applicable values, as well as knowledge.

Therefore, economic viability does not only allude to the results that arise from the cost-benefit relation and from the remaining tools mentioned herein, but it should incorporate the conflicts of interests among several actors, and the possible stages that will arise from its strategies.

CONCLUSIONS

The proper challenge of the field of animal health economy is the qualification and quantification of resources, and the expected results in each one of the aspects detailed so far.

Together with the activity of the producers and of other private sectors linked to the generation of several veterinary products used for the control of diseases, there are state actions basically through the national services of animal health that entail a public budget.

The program of these activities requires an analysis of the productive characteristics of the livestock exploitations. That is, the technological, social, and economic conditions in which production is developed should be evaluated since, it is a basic fact of the animal health profile within each country.

In the specific case of South America, a central topic consists of reconciling the actions of control and eradication with the introduction of policies of structural adjustments and the organization of economic blocks through the conformation of macromarkets.

The following topics are also considered relevant in the field of animal health economy:

- the establishment of congruence among general economic policies and sectorial policies and strategies;
- the promotion of the change in the animal health profile, in terms of its contribution to a larger economic development and welfare of the population;
- the evaluation of the advantages of different actions of animal health, in terms of international trade and the processes of economic integration;
- the application of the policies and strategies defined by the public sector of each country, in the integration of the private sector for the financing, control, and evaluation of the animal health activities;
- the establishment of links among the activities of animal health services with others of the public sector which are equally oriented to economic development, with emphasis on the strategy of decentralization of veterinary attention and;
- the introduction of systems of monitoring, control, and management evaluation of public and private actions in this area.

The characterization of animal health problems should address homogenous animal populations in relation to the forms of socioeconomic organization of the animal production system, which tend to be expressed in specific disease-health profiles. The modification of an animal health situation, as projected and visualized in the future, entails portraying a situation in a temporal horizon that includes the viewpoints of all actors. The prospective scenarios refer to the desired goal-situation and to the paths that connect it to the initial situation, as a resource for diminishing the uncertainty of the results to be reached. Facing this fact, various plans must be devised to account for the diverse foreseeable contingencies. Yet, this does not preclude the possibility of forecasting errors. Therefore the prospective scenarios must be con-

stantly reviewed in order to adjust them to the evolution of the situational changes in animal health. In view of the possibility of such ever-changing needs, the techniques described herein do not exhaust the instruments required for an assessment of the programs and for the selection of the most suitable alternatives for the future. Nevertheless, the instruments are of paramount importance as guideposts, especially in relation to one of the scarcest elements at the moment an animal health program is implemented: the financial resources.

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