The importance of fixed costs in animal health systems

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Summary

In this paper, the authors detail the structure and optimal management of health systems as influenced by the presence and level of fixed costs. Unlike variable costs, fixed costs cannot be altered, and are thus independent of the level of veterinary activity in the short run. Their importance is illustrated by using both single-period and multi-period models. It is shown that multi-stage veterinary decision-making can often be envisaged as a sequence of fixed-cost problems. In general, it becomes clear that, the higher the fixed costs, the greater the net benefit of veterinary activity must be, if such activity is to be economic. The authors also assess the extent to which it pays to reduce fixed costs and to try to compensate for this by increasing variable costs.

Fixed costs have major implications for the industrial structure of the animal health products industry and for the structure of the private veterinary services industry. In the former, they favour market concentration and specialisation in the supply of products. In the latter, they foster increased specialisation. While cooperation by individual farmers may help to reduce their individual fixed costs, the organisational difficulties and costs involved in achieving this cooperation can be formidable. In such cases, the only solution is government provision of veterinary services. Moreover, international cooperation may be called for. Fixed costs also influence the nature of the provision of veterinary education.

Keywords

Animal health systems – Economic decision-making – Fixed costs – Industrial structure – International cooperation – Overhead costs – Variable costs – Veterinary education.

Introduction

Fixed costs play an important role in shaping the structure of animal health systems and in determining the economics of procedures for maintaining and improving animal health. This article shows why and in what ways they are important. Fixed costs significantly influence all major components of animal health systems, including economic decisions about disease management at the following levels:

– prevention
– surveillance
– diagnosis
– treatment, control and monitoring of diseases.

They are also major economic considerations in:

– veterinary training (human capital formation)
– the supply and composition of veterinary-related research and development
– the manufacture of veterinary products
– the provision of veterinary services.

The institutional nature of animal health systems varies. However, they usually include both private and public components. Public components consist of national policies for the maintenance of animal health and international arrangements. Fixed costs affect the nature and structure of these systems.

Although fixed costs significantly influence the economics of the development and operation of animal health systems, the concept of fixed costs is by no means straightforward. Therefore, this article begins by considering the nature of this concept. Simple models are introduced to demonstrate the relevance of fixed costs to managerial decisions about animal health. The authors subsequently examine the influence of fixed costs on the development of the institutional structures of animal health systems, and on institutional strategies designed to cope with such costs.

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The nature of fixed costs

The concept of fixed costs was first introduced into the economic literature by Alfred Marshall (1), to help explain the economic behaviour of firms and the operation of market systems. He described fixed costs as costs that cannot be avoided if the firm wants to operate. Unlike variable costs, they do not vary with the level of the firm's production in the short run. However, his theory does allow for fixed costs to be varied in the long run. Marshall's concept of fixed and variable costs corresponds roughly to the concepts of overhead costs and operational costs used in the literature of accounting and business management.

Although Marshall's concept of fixed costs is useful for understanding the way in which market systems work, it has limitations in enabling animal health managers to make satisfactory or optimal economic decisions about animal health projects. This is because it does not explicitly allow for the passage of time (his modelling relies on comparative statics), and not enough attention is given to the varied components of fixed costs, the time at which these costs are incurred, and the extent to which these costs can be recovered when a project is discontinued, or when the items involved are transferred for use in another project.

Costs which have the attributes of fixed costs are pre-project costs, initial overhead costs and recurrent overhead costs. Pre-project costs include planning costs. Initial overhead costs consist of outlays on plant and equipment when a project commences and recurrent overhead costs are periodic outlays (such as the replacement of plant and equipment) necessary for the continuation of a project. Fixed costs can also include contractual costs for a period of time; for example, labour contracts and rental agreements. For some projects, there is room for some flexibility in the composition of fixed costs. For example, scope can exist for either buying or renting equipment, contracting out parts of a project, and so on. Moreover, as discussed later, there may also be the option of reducing fixed costs if extra variable costs are incurred.

Even though the concepts of fixed costs and overhead costs are not straightforward, simple models can illustrate their importance for animal health systems. Note that these two concepts of fixed and overhead costs are similar but not identical. Estimates of overhead costs are heavily influenced by accounting conventions. In the following examples, most attention is given to fixed costs as a part of single-period modelling, although multi-period modelling is also covered.

Single-period modelling

Single-period economic modelling is more informative than it may appear at first sight. This is because many multi-period problems can be reduced to single-period ones by estimating the present discounted value of alternative multi-period plans (2), or – as shown in game theory – by replacing the extensive form of a game with its reduced form (3). Furthermore, the length of time which constitutes a single period is flexible. Increased generality in the analysis can be achieved by analysing this problem as an economic cost–benefit problem. Depending on the particular case, costs and benefits of projects can be described in private or social terms.

The simple linear model shown in Figure 1 illustrates the basic concepts associated with fixed costs when making decisions about veterinary interventions. The line ABC represents fixed costs and the line ADE represents total cost in relation to the scale or intensity, x_1, of a particular veterinary activity. The difference between lines ADE and ABC measures total variable costs. The line ODF indicates the total economic benefit from this activity. If the activity is to provide a net economic benefit, the scale that it is engaged in must not be less than x_1. Other things being constant, the higher the fixed costs, the greater the required scale of veterinary activity before this activity becomes economic. In Figure 1, x_1 is the economic threshold constituting a watershed for decision-making: below x_1 the costs associated with veterinary intervention exceed the benefits, whereas above x_1, the opposite is the case.

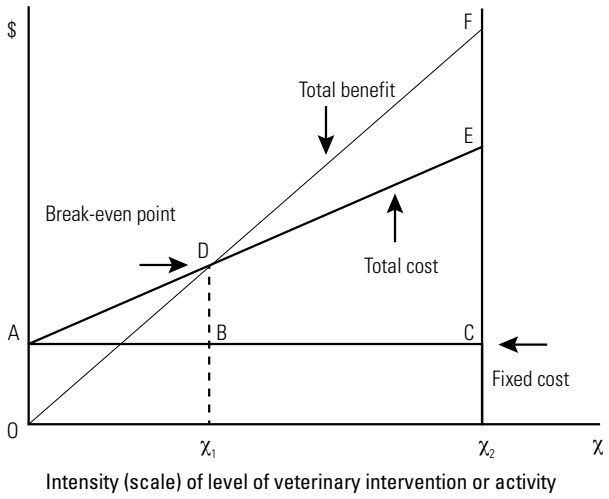

Fig. 1
A simple model to illustrate how the scale of veterinary intervention is important to achieve a net benefit from veterinary activity when fixed costs are significant

Figure 1 can be used to discuss the rationale for disease management, on either an individual or national scale, when fixed costs are taken into account. For example, it can be deduced that, if x represents the size of the herd requiring veterinary interventions, those with small herds (i.e. $<x_1$) would find preventative intervention uneconomic, whereas those with a larger herd (i.e. $\geq x_1$) would be economically justified in investing in preventative care. Or, given another interpretation, if only a small proportion of a herd is affected by a disease, it is likely to be uneconomic to treat those animals if the fixed costs of doing so are high and the disease is not contagious. Alternatively, if the decision-maker is able to reduce their fixed costs without increasing other costs significantly, it is likely to be more economic to maintain or improve animal health for a greater number of animals.

Neither the total cost curve nor the total benefit curve shown in Figure 1 needs to be represented by a linear function. In the case shown in Figure 1, preventative care is economic for the whole herd (x_2) if the herd exceeds x_1 in size. In non-linear cases, this will also hold true if the total net benefit rises with the size of the herd. However, in some non-linear cases, the net benefit function may reach a maximum before the whole herd obtains preventative care. If the economic value of the herd is very high, then the economic benefit curve may lie above the total cost curve. In this case, there is no minimum economic threshold for treatment and veterinary intervention would be justified even if only required for one animal. For further discussion and application of these types of models, see Tisdell (4).

The cost–benefit relationships shown in Figure 1 are continuous, even though, for many species, it would be more realistic to portray these as functions of integers. However, continuous representation does not affect the essentials of the analysis.

Multi-period modelling

In multi-period contexts, the Marshallian concept of fixed costs is not as analytically useful as it is in single-period contexts. In the multi-period management of animal health, it is often necessary to incur recurrent overhead costs, such as replacing equipment due to depreciation or obsolescence, and the skills of veterinary staff may need to be upgraded by investing in human capital. However, there is usually some discretion about the timing of these expenditures and whether or not to undertake them. Nevertheless, deciding to delay expenditure on 'recurrent' overheads can result in increased operational costs or reduced benefit from veterinary activity. For example, failing to replace veterinary equipment in a timely manner is likely to add to operational costs (for example, maintenance costs and down-time costs) and reduce benefits, for instance, as a result of reduced accuracy and increased time required for the diagnosis of a disease. Failure to maintain or upgrade veterinary qualifications can also contribute to economic inefficiency.

An important economic consideration in multi-period management of animal health is the magnitude of overhead costs and the time-pattern in which they must be incurred. If high upfront costs are involved and large 'lumpy' expenditures are required at some stages of the health programme, some providers may be unable to finance these outlays, even if the health programme would be economic from their perspective.

Multi-stage veterinary decision-making as a sequence of fixed-cost problems

Veterinary diagnosis (and sometimes treatment) frequently occurs in several discrete steps or stages, and the cost to the customer of proceeding to each stage is often a fixed, specified amount. Therefore, each stage involves a fixed cost to the customer. Usually, the continuation of this multi-stage process depends on the results obtained in earlier stages. How far a customer decides to proceed with this process (for instance, in attending to the health of a particular animal) will be influenced by the extra benefits in comparison to the extra costs envisaged by the customer. However, especially in the beginning, the costs and benefits of this process are likely to be uncertain, but they normally become clearer as the stages advance.

Optimality would require stopping the multi-stage process once it becomes apparent that the extra benefit from engaging in further stages can be expected to be less than the additional cost. However, it is not easy for the customer to determine when to stop because his/her knowledge is much less than that of the veterinarian, even if the latter may also have imperfect knowledge. Consequently, asymmetry of knowledge occurs (5). This asymmetry can result in over-servicing by the veterinarian if he/she takes advantage of the customer's relative ignorance.

On the other hand, the main motive for 'over-servicing' by the veterinarian may not be to increase his/her profit from dealing with the customer, but to safeguard his/her reputation – that is, to reduce the likelihood of incorrect diagnosis or treatment. This may also accord with the customer's objective, if the customer is very risk averse.

The cost to the customer of over-servicing depends on the attributes of the net benefit obtained as a function of the

discrete stages involved in diagnosis and treatment. If this function is very peaked, then considerable benefits will be lost by the customer as a result of over-servicing. If it is relatively flat for those stages after this function reaches a maximum, this loss will be quite small (see 6).

The role of multi-stage fixed costs extends well beyond the rationale for the provision of veterinary services. For example, some research projects are funded in multiple stages, with the donor contributing a fixed sum at each stage. Each stage involves a fixed cost from the donor's point of view, even though the amount of funds to be provided at each stage may vary. This concept extends into dealing with fixed-price contracts or multi-stage contracts as, at each stage, the principal incurs a fixed cost. In all the cases mentioned above, the fixed costs associated with each stage are a significant influence on the net benefits of taking part in the decision-making process and continuing funding the activity. Relevant models can be formalised but there is not room to do that here.

Trade-off between fixed costs and variable costs in animal health systems

Alternative methods combining different mixtures of fixed and variable costs are often available for maintaining or improving animal health. There is frequently an inverse relationship between the level of fixed costs and the level of variable costs incurred when operating an animal health system. Consequently, the average total costs (per unit of activity) of veterinary systems with high fixed costs are usually higher than those with lower fixed costs for low levels of veterinary activity. This relationship is normally reversed at high levels of activity. This is illustrated in Figure 2. The curve ABC represents average costs when a technique with high fixed costs (Technique I) is adopted and curve DBE shows this when a technique with lower fixed costs (Technique II) is chosen. Technique II minimises the total cost if $x < x_1$ but Technique I minimises the total cost if $x > x_1$.

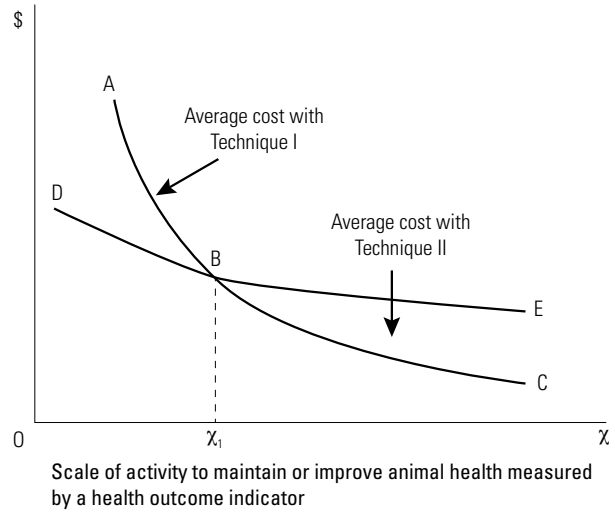

Fig. 2
An illustration of cost minimisation, achieved by switching from a method involving low overhead costs to one with higher overhead costs as the scale of veterinary activity increases
Each cost curve should be based on a cost-efficient expansion path

To avoid cluttering, the average fixed-cost curves and variable-cost curves are not shown separately in Figure 2. However, the average fixed-cost curves form rectangular hyperbolas. In Figure 2, the fixed-cost curve is assumed to be lower for Technique II than Technique I. The average variable-cost curve can take a variety of mathematical forms. It can, for example, be constant, decreasing, rising, or – after falling at first – could begin to rise. Its nature depends on the particular case. In some cases, the average total-cost curve can be U-shaped. Each cost curve ought to be based on a cost-efficient expansion path for sustaining or improving animal health. A detailed application of this type of approach to human health can be found in Tisdell (7). Rushton (8) applies this type of analysis to the economics of livestock production.

According to standard microeconomic analysis, maximising net economic benefit requires the total cost corresponding to any level of gross economic benefit to be minimised, i.e. the 'golden rule' of cost minimisation (9). However, this rule is based on a series of assumptions that are not always satisfied; for example, perfect capital markets and perfect knowledge. Capital markets, especially in developing countries, are far from perfect. Farmers may fail to get funding to cover significant fixed costs, even when the associated technique is the least expensive one. Moreover, demand uncertainties may make animal healthcare providers or managers reluctant to invest in techniques that involve high overhead costs.

In addition, the benefits obtained from a method of health control may vary with the composition of the costs. For example, the adoption of more expensive capital equipment or consulting with highly qualified veterinarians increases fixed costs but the diagnosis and treatment of the disease may be more reliable. Consequently, in relation to maintaining or improving animal health, the cost-minimisation rule should not be applied blindly.

In applying the simple economic modelling of cost minimisation to the wider economics of animal health, it can be difficult to obtain a single, precise health-production indicator. Moreover, health consequences can be more

multi-product in nature than single-product. This requires more sophisticated analysis than usual.

Effects of high fixed costs on industrial structure and methods for efficiently coping with these

Structural aspects

High overhead costs often preclude businesses from entering a market and consequently the supply of a product may be dominated by only a few enterprises. Pharmaceutical veterinary businesses face high overhead costs to pay for the research and development of new products, as well as high costs for producing these goods, for registering and marketing new products and for protecting their investments in intellectual property. Persistent market dominance by a few enterprises compounds this exclusion of new entrants (10).

This dominance in the global supply of animal health products is evident in Table I, where the top ten producers of animal health products are presented by their worldwide sales revenue in 2013. These firms differ considerably in size. For example, the sales revenue of Zoetis was more than tenfold that of Vétoquinol S.A. in 2013. Most of these companies are associated with, or have been spun off from, even larger companies involved in the production of human health products. Each company has tended to develop its own area of specialisation in different product areas (relying partly on patents). Consequently, market competition is limited and some form of monopoly power is evident in their respective market niches. One observable vector of specialisation is the various health requirements of different species, e.g. cattle, pigs, poultry, dogs and cats (see reports on the top animal health companies in 11).

Opinions are divided about the economic benefits and drawbacks of market concentration (12, 13, 14). The economic performance of particular industries needs to be assessed individually, not just on their structural attributes.

The size of the market influences the economics of the private sector developing and supplying pharmaceutical veterinary products. When overhead costs are high, the size of the market must be large enough, or the willingness to pay for the product must be high enough, to enable these costs to be recouped. Consequently, private enterprises are likely to favour the development and supply of products which are needed in higher-income countries in preference to those wanted in lower-income countries with a lesser ability to pay.

Table I
Top ten animal health companies worldwide in 2013, based on their revenue in US$ billions and their shares in their aggregate revenue
Source: based on FiercePharma (11)

Company		Revenue US$ billion	Percentage	Cumulative percentage
1.	Zoetis	4.56	22.87	22.87
2.	Merck Animal Health	3.36	16.85	39.72
3.	Merial	2.73	13.69	53.41
4.	Elanco	2.15	10.78	64.19
5.	Bayer Animal Health	1.80	9.30	73.22
6.	Boehringer Ingelheim Vetmedica	1.80	9.30	82.85
7.	Novartis Animal Health	1.17	5.87	88.11
8.	Virbac S.A.	1.00	5.02	93.13
9.	Ceva Sante Animale	0.96	4.81	97.94
10.	Vétoquinol S.A.	0.41	2.06	100.00
Total		**19.94**	**100.00** [a]	

a) Does not add up to 100, due to rounding
US$: United States dollars

Coping strategies

There are several ways to cope with high overhead or fixed costs when managing animal health. Let us, initially, consider the supply of veterinary services by the private sector.

Most private veterinary practices supply general services, so the market concentration is low in this segment of the veterinary industry (15), whereas only a few practices provide specialised services. Usually, veterinary clinics supplying specialised services have higher overhead costs than general suppliers, and may rely on referrals by general practitioners for much of their custom. The higher overhead costs of specialists often consist of outlays on more expensive equipment and higher levels of investment in human capital than in the case of general practitioners. Nevertheless, overhead costs are important for all suppliers of veterinary services and, on average in Australia, account for at least 18% of costs (2).

This type of specialisation within an industry increases economic efficiency. Its specific economics depend upon the size of the market (more generally, on the level of market demand), as first observed by Alfred Marshall (1).

The larger the size of the market, the greater the scope for beneficial economic specialisation.

However, they also depend on market-transaction costs. The lower these costs are, the more economic it is to focus on providing specialist veterinary services. In modern times, reductions in the real cost of transport and the increased use of advanced information technology have accelerated the trend towards specialisation. Furthermore, increases in the amount of veterinary knowledge and associated technologies have contributed to this process. In addition to this, lower market-transaction costs increase the size of the market.

Livestock farmers (especially smallholders) may cooperate to reduce their individual overhead costs of gaining access to veterinary services. However, organising such cooperation does not come free and the main burden of organising usually falls on those initiating the process. This creates a barrier to creating cooperative arrangements for maintaining or improving animal health, even when such arrangements would collectively increase economic efficiency and the benefits from investing in area-wide animal health management. These transaction costs also facilitate market failure.

Consequently, the best possible solution to preventing neglected diseases from becoming communal problems and dealing with transaction costs may be for government action to fill such gaps in the market failure of the animal health system. This can involve different layers of government, as well as international cooperation by governments in setting up and maintaining relevant international bodies, for example, the World Organisation for Animal Health (OIE). As a result of government intervention, it may be possible to cover the necessary fixed costs associated with the economic operation of national and international health systems, thereby ensuring that economic animal health initiatives are undertaken which would not be met by the private commercial sector or by individual cooperative arrangements between animal owners.

Veterinary education is another component of animal health systems which can involve high overhead costs, particularly advanced education, which is often associated with research tilted in favour of basic research. Such research may be of considerable collective economic value but is unlikely to be undertaken by the private sector because intellectual property rights cannot be safeguarded and the outcomes can be very uncertain (16). Making the results of this type of research freely and widely available is usually beneficial from a collective economic point of view.

In national terms, because of the high level of overhead costs, it is only economic to have a limited number of higher education and research bodies engaged in training veterinarians and in veterinary research. Furthermore, some less-developed countries do not find it economic to provide these services and must rely on institutions in more developed countries to supply them. However, the extent to which the requirements of the former are met by the latter can vary. For example, some veterinary educational institutions in higher-income countries may primarily focus on animal health issues in those countries (e.g. companion animals) and give correspondingly less attention to the animal health priorities of less-developed countries, such as their endemic livestock diseases.

Conclusion

While all costs incurred in maintaining and improving animal health are important, fixed or overhead costs are particularly important for several reasons. First, they have a major influence on the thresholds at which animal health interventions become economic. Secondly, they have significant implications for the evolution of the structures of animal health systems, which may or may not be optimal from a collective economic point of view. Thirdly, they motivate health managers to search for economic ways to cope with their presence. This article has provided insights into each of these aspects.

Furthermore, this article has clearly shown that the concept of fixed costs is more complex than it seems to be at first sight, especially when the dynamics and consequences of managerial decision-making about animal health are considered. In addition, several economic aspects of trade-offs between fixed and variable costs have been discussed. This issue usually involves economic decisions about how much expenditure should be committed to obtain capital items, as compared to non-capital ones.

L'importance des coûts fixes dans les systèmes de santé animale

C.A. Tisdell & D. Adamson

Résumé

Les auteurs de cet article décrivent en détail la structure et la gestion optimale des systèmes de santé, telles que les influencent l'existence et le volume des coûts fixes. Contrairement aux coûts variables, les coûts fixes ne sont pas modulables et sont donc indépendants du volume d'activité du secteur vétérinaire à court terme. Leur importance est illustrée par l'utilisation simultanée de modèles couvrant une période unique et de modèles multi-périodiques. Il est démontré qu'en santé animale, le processus décisionnel par étapes peut souvent être envisagé comme une séquence de problèmes liés aux coûts fixes. En général, il apparaît clairement que plus les coûts fixes sont élevés, plus grand doit être le bénéfice net dégagé par les prestations vétérinaires, si l'on veut que celles-ci soient rentables. Les auteurs évaluent également l'intérêt éventuel de réduire les coûts fixes en essayant de compenser cette baisse par une augmentation des coûts variables.

Les coûts fixes ont des répercussions structurelles majeures sur l'activité du secteur des produits de santé animale ainsi que sur les prestations vétérinaires du secteur privé. Dans le secteur des produits de santé animale, les coûts fixes favorisent la concentration des marchés et la spécialisation de l'offre. Dans le secteur de l'exercice vétérinaire privé, ils incitent à une spécialisation accrue. Si la coopération individuelle des éleveurs peut contribuer à réduire leurs charges fixes à l'échelle individuelle, les contraintes organisationnelles et les coûts induits par une telle coopération peuvent s'avérer redoutables. Dans de telles configurations, la seule solution consiste à confier la prestation des services vétérinaires au secteur public. Il peut aussi être fait appel à la coopération internationale. Les coûts fixes influencent également la nature de l'offre de formation en médecine vétérinaire.

Mots-clés

Coopération internationale – Coûts fixes – Coûts variables – Enseignement de la médecine vétérinaire – Frais généraux – Processus décisionnel en économie – Structure sectorielle – Systèmes de santé animale.

Importancia de los costos fijos en los sistemas de sanidad animal

C.A. Tisdell & D. Adamson

Resumen

Los autores exponen en detalle la estructura y la gestión óptima de los sistemas sanitarios en aquellos aspectos que se ven influidos por la presencia de costos fijos y por su cuantía. A diferencia de los costos variables, los fijos no pueden ser modificados y por lo tanto son, a corto plazo, independientes del nivel de actividad veterinaria. El uso de modelos relativos a un periodo único y a periodos múltiples pone de manifiesto la importancia que revisten los costos fijos. Los autores explican que el proceso de adopción de decisiones veterinarias, que discurre en varias etapas, puede ser entendido a menudo como una secuencia de problemas ligados a los costos fijos. En general queda claro que, cuanto más elevados sean los costos fijos de la actividad veterinaria, mayor beneficio neto debe deparar esta para ser rentable. Los autores también valoran en qué medida

resulta rentable disminuir los costos fijos y tratar de compensar esta reducción con un aumento de los costos variables.
Los costos fijos influyen sobremanera en la estructura de actividad económica del sector de los productos de sanidad animal y en la estructura de la prestación privada de servicios veterinarios. En el primer caso, favorecen la concentración del mercado y la especialización en el suministro de determinados productos. En el segundo, potencian un mayor grado de especialización. Aunque la cooperación entre los ganaderos puede ayudar a reducir sus costos fijos individuales, este tipo de cooperación entraña enormes dificultades y costos organizativos. En tales casos, la única solución reside en la prestación de servicios veterinarios desde instancias oficiales. Por otro lado, también cabe recurrir a la cooperación internacional. Los costos fijos influyen asimismo en el tipo de enseñanza de la veterinaria que se imparte.

Palabras clave
Adopción de decisiones económicas – Cooperación internacional – Costos fijos – Costos generales – Costos variables – Enseñanza de la veterinaria – Estructura industrial – Sistemas de sanidad animal.

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