Assessing animal health delivery for tick and tick-borne disease control in smallholder dairy systems of Kenya: an application of new institutional economics

by

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ABSTRACT

This thesis describes a two-component study undertaken in smallholder dairy systems of Central Kenya. One component characterized delivery systems for tick and tick-borne disease (TTBD) technologies including treatment packages, tick control products and vaccines, while the second component evaluated the important factors in their utilization by farmers. A combination of two economic analytical tools was used for the characterisation component. The first, the structure-conduct-performance (SCP) framework, was used to evaluate the performance of marketing systems and compare it to a perfectly competitive model, and the second, the new institutional economics (NIE) framework, was used to analyse the role of transaction costs in the delivery of products and services and their access by farmers. A probit model was applied to identify the specific factors that farmers consider in their choices of animal health services. Recommendations were made for the optimal pathways to deliver East Coast fever vaccines to smallholder farmers.

The study was conducted in three phases. The first phase involved a cross-sectional survey of 344 smallholder dairy farmers in the central highlands of Kenya, using a structured questionnaire. These farms were selected on a gradient of market access, with high, medium and low market access represented by Kiambu, Nakuru and Nyandarua districts, respectively. The second phase involved an exhaustive survey of all service providers delivering animal health services in the study areas. The third phase involved working backwards through the marketing chain to the distributors and suppliers of technologies, as well as interviewing key informants at policy and institutional levels.

Delivery of TTBD products and services was found to be highly competitive, mostly carried out by paravets (35% of the total) and stores (33%), particularly in rural areas.

Vets (18%) had a higher distribution in peri-urban areas, and their limited distribution in rural areas raised the transaction costs associated with rural farmers' search and screening for high quality services. There were no formal regulatory bodies supervising the quality of the products and services being supplied to farmers and no state restrictions existed on the type of service providers selling tick control products. Although pyrethrines (pour-ons) were only permitted for tsetse control, they were freely being sold to farmers for tick control. A live vaccine, the infection and treatment method (ITM) for ECF immunization, was available in the country but its sale was restricted to a single site, the Kenya Coast. Thus, this vaccine was not available in the study areas. The study identified three key problems that require specific policy intervention: i) poor access of services and products by farmers, with an undefined role of paravets who are presently under-utilized, ii) information asymmetries among farmers and the need to enforce service quality control of products and services, iii) lack of voice among smallholder farmers with no leverage for compensations in cases where they receive poor or inappropriate services.

Several transaction costs were identified as constraining the utilization of animal health services by farmers, and ranged from information, through negotiation to monitoring costs. Farmers considered the ethnicity and the service quality (as determined by past performance) of the nearest service provider as important in their choices, and the density of service providers over a given radius around each farm as well as travel time to a service provider were crucial determinants in farmer decision-making.

Using a combination of economic and epidemiological approaches, the study assessed supply and demand issues associated with delivery pathways for ECF vaccines among smallholder farmers. The supply-side component involved evaluating transaction costs associated with two ECF vaccines; ITM and a sub-unit vaccine under development, and identifying the appropriate role of public and private sector in delivery. The main constraints associated with ECF vaccine delivery and requiring appropriate policies included high information asymmetries faced by farmers, lack of appropriate quality control and limited accessibility to products and services by farmers. On the demand side, ECF risk was found to vary with cattle production systems and agro-ecology. Potential demand for vaccines was found to be high in both Nyandarua and Nakuru districts and relatively low in Kiambu, where zero-grazing reduces risk substantially. The study recommends utilization of paravets for ECF vaccine delivery as an effective means of reducing transaction costs by increasing service penetration especially in rural areas where the density of veterinarians tends to be low.

DEDICATION

To

Maria Wacera

My wonderful and caring daughter, whose gift of friendship I greatly treasure

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I am indebted to my supervisor Dr. Tom Randolph of the International Livestock Research Institute (ILRI), for giving my work direction and providing excellent academic guidance as well as moral support all along the way. Tom's door was always open for consultation and he never turned me away even when he had heavy demands on his time. My special and sincere gratitude goes to him for patiently believing in my ability to transform into an economist particularly during those moments when I had little faith in myself as I ventured into unknown territories.

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Above all, I thank God for giving me the strength to complete this study.

DECLARATION

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Candidate…………………………..

Leah Wanjiru Ndung'u

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ACRONYMS

AEZ	Agro-ecological Zones
AHA	Animal Health Assistant
CAHS	Community Animal Health Services
DVO	District Veterinary Officer
DVS	Director of Veterinary Services
ECF	East Coast fever
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
ITM	Infection and Treatment Method
KARI	Kenya Agricultural Research Institute
KVA	Kenya Veterinary Association
KVAPS	Kenya Veterinary Association Privatisation Scheme
KVB	Kenya Veterinary Board
LVI	Licensed Veterinary Inspector
ML	Maximum Likelihood
NIE	New Institutional Economics
P/A	Principal Agent
PCPB	Pest Control Products Board
PPB	Pharmacy and Poisons Board
SAP	Structural Adjustment Policies
SCP	Structure-Conduct-Performance
SDP	Smallholder Dairy Project
SP	Service Provider
SSA	Sub-Saharan Africa
TCE	Transaction Costs Economics
TTBD	Ticks and Tick-Borne Diseases

Chapter 1

General introduction

1.1. Introduction

The majority of developing country economies depend on agriculture. In most countries in eastern and southern Africa, agriculture contributes more than 30% of the Gross Domestic Product (GDP), is the most important earner of foreign exchange and contributes over 50% of the raw materials to industry (World Bank 1992). As a major component of agriculture, livestock plays an important role in provision of employment, foreign exchange and livestock products, including meat and milk (de Haan and Nissen 1985; Sansourcy et al. 1995). Sales of livestock and their products such as milk are used to generate cash income in most developing countries (Sansourcy et al. 1995). Livestock also contributes to sustainable agriculture by providing manure for fertilizer and/or fuel (Winrock International 1992), a means of transportation and a source of traction in agricultural production, and is also closely linked to the social and cultural lives of the majority of developing country populations (Sansourcy et al. 1995). Developing countries rear about two-thirds of the world's livestock, but output levels are lower than their potential as evidenced by higher livestock production levels achieved in developed countries (Ehui and Shapiro 1995). Consequently, developing countries only produce about a quarter to a third of the world's meat and about a fifth of its milk.

These patterns are likely to change with the global transformation of the livestock sector under the on-going "Livestock Revolution" process (Delgado et al. 1999). This revolution is demand-driven, as a result of a rapid increase in the consumption of livestock products worldwide, and particularly in developing countries. For example, in the period between 1971-1995, consumption of meat in developing countries increased by about three-fold and milk over two-fold, compared to the increase in consumption in the developed world, although the average per capita consumption levels are much lower in the former than in the latter countries. Increased demand for livestock products has been brought about by a combination of population growth, urbanization and rising incomes, and is expected to continue to increase even more in the next 20 years, leading to global transformation of the livestock sector by a rapid expansion of livestock food production (Delgado et al. 1999; Delgado et al. 2001). Demand increases for livestock products have also had to face the challenge of reduced grazing resources, resulting in intensification of production.

Some of the positive implications of the Livestock Revolution for developing country farmers, the majority of whom figure among the rural poor, include improved incomes. Evidence shows that the rural poor derive higher proportions of their income from livestock than do the relatively wealthier (Delgado et al. 1999; Heffernan and Misturelli 2000). The increasing demand for livestock products therefore offers these farmers an opportunity to improve their incomes from a rapidly growing market. Due to improved incomes, their consumption of livestock products is also increased, thus improving their nutritional and health status and consequently their food security. Some concerns associated with the Livestock Revolution are that firstly, increased intensification in livestock production may make smallholders uncompetitive compared to large producers. This could be addressed through elimination of the subsidies enjoyed by large producers or re-directing them to smallholder producers, as well as reduce the production costs, such as transaction costs faced by small producers in order to improve their competitiveness in producing their share of the increased demand for livestock products. Secondly, are the possible barriers to vertical integration of smallholder producers with processors, for example in the production and sale of milk. This can be overcome through participation by the smallholders in institutions of collective action such as dairy cooperatives (Staal et al. 1997; Delgado 1999). The challenge is to now identify policies and research investments that focus on rural organization in order to find the best market-oriented means to ensure that smallholder producers benefit from the Livestock Revolution.

1.2. Smallholder dairying in Kenya

Kenya has a relatively well-developed dairy industry compared to other sub-Saharan African (SSA) countries, which has been attributed in part to conducive government policies that promoted the expansion of smallholder dairy production after Independence. Dairy production is thus presently dominated by smallholder farmers, who currently produce over 80% of all milk marketed annually in Kenya (MALDM 1992; Staal et al. 1997). In addition, as of 1993, they owned about 80% of the estimated 2.5 million crosses and pure-bred dairy cattle population in the country in approximately 625,000 smallholdings (Peeler and Omore 1997; Staal et al. 1998). The smallholder systems may be intensive or semi-intensive types, with the former more common in Kiambu district near the capital city, Nairobi, where farmers typically keep 1-4 dairy animals on approximately 1 ha of land in highly labour-intensive mixed crop-livestock production systems. A high proportion of these farmers stall-feed their animals. In semi-intensive production systems found in more rural areas of Kenya, the land holdings and cattle numbers are slightly larger. Milk is produced both for subsistence and the market, providing a source of nutritional diet and regular cash income, as well as employment for many Kenyans. The role of smallholder dairying in Kenya's overall economy cannot therefore be overemphasized. Not only is it a catalyst for agricultural development, but it also has the potential for increasing income generation and employment in Kenya as well as in many other areas of Africa, with subsequent enhancement of food security and improvement of livelihoods (Winrock International 1992).

1.3. Constraints to smallholder dairying

Despite the central role of smallholder dairying in Kenya, production levels are lower than their potential (Walshe et al. 1991; Omore et al. 1994) and continue to decline, currently approximating to only 5 kg of milk per cow per day and calving intervals of about two years (Omore et al. 1997). Among the constraints hampering increased production in these systems are under-nutrition and seasonal fluctuation in the quantity and quality of feeds, disease challenge and unreliable access to inputs (Omore et al. 1999). And as in other SSA countries, poor genotype, inadequate farming skills among farmers, inappropriate policies and inadequate infrastructure are also contributory factors (Winrock International 1992).

Disease is particularly singled out as sharply reducing livestock productivity across production systems in SSA. Studies have estimated annual value of losses to be about US$ 2.0 billion, equivalent to 30% of the total value of livestock population (FAO 1994; Sidahmed 1997). These losses are important contributions to the large gap between supply and demand for meat and milk, particularly since most dairy cattle are exotic or improved crosses which are considered to be more susceptible to disease than indigenous stock (Brumbly and Gryseels 1985; Brumbly and Sholtens 1986). The most significant losses are experienced due to tsetse-transmitted trypanosomiasis and tick-transmitted diseases (de Haan and Nissen 1985). In high potential dairy production areas in particular, ticks and tick-borne diseases (TTBD), caused by a variety of protozoan and rickettsial parasites, present the greatest challenge (Brumbly and Sholtens 1986; Young 1988; de Castro 1997) with East Coast fever (ECF) accounting for the highest losses. In addition to reducing the productivity of the existing livestock population, these diseases restrict the increase of livestock numbers due to disease-related mortality and morbidity.

While losses associated with disease can be avoided through the use of available disease control technologies and services, their uptake among farmers is low. This low uptake has often been attributed to poor and ineffective delivery (Mlangwa and Kisauzi 1994; Holden et al. 1996). However, from the demand perspective, poor access to drugs, services and information have also been identified as important constraints to service utilization (Heffernan and Misturelli 2000).

1.4. Trends in animal health delivery in Kenya

Provision of animal health services is critical if the livestock sector is to attain its full productive potential. In Kenya, as in other SSA countries, the public sector has traditionally delivered these services to producers. These were initially established mainly to control epizootic diseases through national vaccination and diagnostic services, with a bias to serving European large-scale commercial farmers. By Independence in 1963, most European farmers had left and the land was sub-divided into small units to settle the landless indigenous people who were encouraged to keep exotic crosses for dairy production. The demand for veterinary services therefore grew, and the government responded by expanding its range of services through clinical "runs" to bring them within walking distances of the producer. These services, which included tick and tsetse control, preventive services (vaccinations, disease control and pest eradication) and veterinary laboratories, were provided free or at highly subsidized rates (Umali et al. 1992). At the same time, the state also employed all the veterinary graduates completing training from the University of Nairobi and other recognized agricultural colleges.

The Kenya government experienced a fiscal crisis in the late 1980s that resulted in a large budget deficit, a huge external debt and a negative trade balance, which was also compounded by a decline in donor support (Agref 1992). All this led to large reductions in funding for publicly-funded activities including research, extension and veterinary services. This resulted in poor performance of state-delivered services due to lack of operational and maintenance funds, adequate transport and supply of drugs, coupled with under-pricing of services. At the same time, Kenya began to implement structural adjustment policies (SAP) aimed at resuscitating the economy. The main SAPs related to the reform of the delivery of veterinary services, like elsewhere in SSA, included public sector reforms and liberalization of veterinary drug supply, cost recovery for services and privatisation of those activities that could be handled by the private sector (de Haan and Bekure 1991). The World Bank and other donors made the reform of the veterinary services a regular component of SAPs with the aim of increasing the participation of the private sector in the delivery of animal health inputs. The government responded by encouraging the development of the private sector with the hope of enhancing competition and consequently improving the efficiency and effectiveness of animal health delivery services. In order to encourage government vets to go into private practice, the Ministry of Agriculture made proposals in 1983 for the privatisation of clinical services and artificial insemination (AI) (Kenya Government 1986). A special credit program, the Kenya Veterinary Association Privatisation Scheme (KVAPS), was introduced in 1994 using European Union (EU) funds to facilitate veterinarians entering into the private sector (Wamukoya et al. 1995; Tambi et al. 1997).

These trends have continued and the current picture presents rapidly evolving delivery pathways in which the government is continuously reducing its role. The emerging private sector, however, has not performed as expected to fill the gap. This means that farmers under utilize the available disease control technologies and services, with the result that disease-induced losses continue to be a constraint to increased productivity in the livestock sector.

1.5. TTBD control and delivery of ECF vaccines

As mentioned earlier, the highest losses experienced from TTBD effects are attributable to ECF. Current ECF control strategies are mainly directed towards controlling the tick vector either through acaricide application or through feeding management strategies such as the zero-grazing systems widely practised in peri-urban dairy production areas. In addition, treatment of sick animals with anti-theilerial drugs is also commonly practised to prevent the high morbidity and mortality losses associated with ECF. While these methods are not only relatively expensive and may not always be affordable for the smallholder farmer, acaricide application is also associated with high toxicity, environmental contamination and the possibility of tick resistance to acaricides, and widespread use of treatment packages may bring about the development of carriers which then act as a source of infection for healthy in-contact animals. These shortcomings can be overcome by use of vaccines for ECF control. A sporozoite-based live vaccine, the infection and treatment method (ITM) of ECF immunization was developed in the 1970s, but its widespread adoption over the years has been limited by technical constraints and policy restrictions. Research efforts at the International Livestock Research Institute (ILRI) have been directed towards the development of an improved sub-unit vaccine to address some of the technical problems associated with ITM.

In order to achieve maximum disease control impact at farm-level, an important question that needs to be addressed is whether these technological options can be effectively delivered and at the same time, successfully adopted by farmers. Lessons can be drawn from ITM to not only improve its delivery and adoption, but also to pave the way for the successful implementation of the new vaccine through identifying the most appropriate pathways for its delivery, while at the same time adapting the new technology to the needs of the end users. To this end, a multi-component project has been undertaken by ILRI with the overall goal of evaluating the potential impact in smallholder dairy production systems, of the new ECF vaccine currently under development[1]. The current study is one of the components of this broader project, with the goal of addressing delivery and adoption of the ECF vaccines.

1.6. Problem statement

Livestock productivity in developing countries continues to be low as a result of poor disease control associated with under-utilization of disease control technologies by farmers. Research efforts have addressed this poor uptake by focussing on measures that identify opportunities for improving animal health delivery through privatisation (Holden et al. 1996; Leonard 1993), while others have argued for a balance between public and private delivery (Schillhorn van Veen and de Haan 1995; Umali et al. 1992). Although these studies have highlighted the role of poor delivery in ineffective utilization of disease control technologies, they have not addressed the efficiency of the delivery systems themselves, which determines how appropriately these systems are adapted to the needs of the end users.

The issue of efficiency as it affects utilization of technologies is best addressed by examining both the supply and the demand sides. On the supply side, an efficient system is determined not only by the inherent technical and economic characteristics of the technology, but also by the types of actors involved in the system, as well as the transaction costs associated with the delivery chain. On the demand side, an understanding from the farmer perspective of the factors that influence their decision

[1] IFAD Technical Assistance Grant Number 376. Enhancing the impact of immunisation against East Coast fever with an improved sub-unit vaccine on smallholder dairy sector in East Africa.

making in accessing disease control technologies can also help to explain their poor uptake of available options. This study hypothesizes that constraints to farmers' utilization of disease control technologies can be explained in terms of transaction costs, which can help to explain their poor uptake.

1.7. Research objectives

The following are the specific objectives of the study:

1. Identify and characterise current delivery pathways for tick-borne disease control technologies to smallholder dairy farmers in Kenya.

2. Identify constraints affecting the effective demand of smallholder dairy farmers for tick-borne disease control technologies.

3. Identify 'best bet' pathways for the delivery of anticipated TTBD vaccines to smallholder dairy farmers given existing constraints.

1.8. Conceptual framework

In order to address these objectives, a framework that combines two economic analytical tools is applied in this study. The first tool, the structure-conduct-performance (SCP) examines the efficiency of marketing systems and compares them to a perfectly competitive market. SCP is therefore used to study the institutional structures in place including current policies, types of actors involved in TTBD control delivery and their patterns of behaviour (conduct), as well as the competition levels of the marketing systems. The second tool is the new institutional economics (NIE) framework, which is used to identify the implications of the characteristics of the different technologies and to study the role of transaction costs as a constraint to both delivery and farmer uptake of control technologies.

Results from the demand and supply aspects addressed by the combined framework are used to make recommendations on the appropriate pathways to deliver the envisaged improved ECF vaccine as well as to identify measures for improving the delivery of existing vaccine-based technologies such as ITM.

1.9. Organization of the thesis

The remainder of the thesis is organized into five chapters as follows. The second chapter presents the general approach, sampling strategies and methodology used in the study. The next three chapters are presented as individual articles in the same format as has been submitted to peer-reviewed journals. The article in chapter three focuses on the supply side and assesses delivery systems for the control of tick and tick-borne diseases using both the SCP and NIE paradigms. Chapter four shifts the focus to the demand side and uses a NIE approach to evaluate the constraints facing smallholder dairy farmers in the utilization of animal health services, with a specific focus on the role of transaction costs. Chapter five reviews the supply and demand issues specific to ECF vaccines to make recommendations on the best-bet delivery pathway to deliver an improved sub-unit East Coast fever (ECF) vaccine. Chapter six presents a summary of the general findings, an evaluation of the methodology used in the study, policy recommendations and suggestions for future research.

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Chapter 2

Study design

2.1. Introduction

To evaluate the existing delivery systems for TTBD control, data collection was conducted in the main smallholder dairy zones of Kenya. The study was planned to collect information from smallholder dairy zones in the central highlands of Kenya using three phases. The first phase was a household survey of 340 dairy farmers, followed by an exhaustive survey of all service providers delivering animal health services in those same areas. The final phase was at policy and institutional levels, where interviews were conducted with key informants and policy makers in the government and the pharmaceutical industry.

2.2. Questionnaire development

A structured questionnaire was developed with sections containing questions covering household demographics, farm characteristics and activities, livestock inventories, feeding systems for dairy animals, milk production levels, farmer perceptions of ticks and their association with disease, use and availability of animal health services (see Appendix 2).

2.3. Study site selection

Several criteria were used for the selection of sites for this study, including production systems, market access, and TTBD risk represented by agro-ecological zones. The first criterion was the type of production system, which dictated the specific areas to be selected. Of the different types of cattle production systems found in Kenya, smallholder (small scale) systems comprise about 60% of the total cattle herd and produce most of the milk in the country compared to large-scale production systems (Table 2.1). The majority of smallholder dairy cattle are found in the intensive and

Table 2.1. Dairy and indigenous cattle production systems in Kenya

Production system	Breed type	Major products	Production purpose	Management system	Cattle population '000	Cattle population %	Milk prod ('000 MT)	Major production regions
Large scale:								
1. a) Intensive dairy	Exotic	Dairy	Entirely market oriented	Intensive	500	4	782	Central Rift Valley
b) Semi-intensive dairy	Exotic/ crosses	Dairy	Entirely market oriented	Semi-intensive				
2. Extensive dairy-meat	Zebu	Dairy-meat	Mostly pastoralism	Extensive	4,500	35	246	N. & S. Rift Valley, Eastern & Coast
Small scale:								
1. a) Intensive dairy-manure	Exotic/ crosses	Dairy-manure	Mostly market oriented	Mostly intensive	2,500	20	1719	Central Province, Central Rift Valley, Coast
b) Semi-intensive dairy-manure	Exotic/ crosses	Dairy-manure	Mostly market oriented	Semi-intensive				
2. Extensive dairy-meat-draught-manure	Zebu/ few crosses	Dairy-meat draught-manure	Mostly subsistence	Semi-intensive	5,300	41	326	Nyanza, Western, Coast, Eastern, Rift Valley

Source: Omore et al, 1999

semi-intensive systems in the Central and Rift Valley Provinces of Kenya (see also Appendix 1.1), where the predominant breeds are exotics and their crosses. Here, production is mostly market-oriented, as opposed to the extensive systems in Nyanza and Western Provinces where production is mostly for subsistence (Omore et al., 1999).

Unreliable access to inputs has been cited as one of the primary constraints to increased dairy production (Omore et al., 1999). Given that animal health services and products are a major input to dairy production, access to markets was used as a main selection criterion in order to address the problem of access to inputs. Study sites were therefore selected on a gradient of market access. Kiambu District of Central Province was selected as a high market-access zone as it is peri-urban, bordering Nairobi metropolitan area, which provides a major output and input market for dairy production (Staal et al., 2001). Nyandarua district (also in Central Province) represented low market access while Nakuru district (Rift Valley Province) represented medium access.

As noted earlier, several studies have identified TTBD as an important constraint to smallholder dairy production, particularly in the high potential areas of Central and Rift Valley Provinces. TTBD control technologies and services were therefore used as a model to study delivery systems, necessitating the selection of areas that had a high risk of tick-borne diseases.

In addition to being major determinants of the types of farming systems, agro-climatic factors have also been previously identified as key determinants of TTBD risk (Gitau et al., 1999; Maloo et al., 2001; O'Callaghan, 1998). Such factors include altitude, duration and amount of rainfall, types of vegetation and soil patterns, which have been used as a basis to classify geographic regions according to agro-ecological zones (AEZ) (Jaetzold and Schmidt, 1983). The land use potential for crops and livestock for each region will depend on AEZ distribution, with belts ranging from high-altitude, cool tropical alpines to low altitude, warm coastal lowlands (Table 2.2).

Table 2.2. Agro-ecological zonation of Kenya

AEZ belt	Temperature belts (annual mean temperature in ^{0}Celcius)
Tropical Alpines (TA)	2-10^0 - mountain swamps
Upper Highlands (UH)	10-5^0 - seasonal night frosts
Lower Highlands (LH)	15-18^0 - minimum: 8-11^0, normal, no frost
Upper Midlands (UM)	18-21^0 - minimum: 11-14^0
Lower Midlands (LM)	21-24^0 - minimum: >11^0
Inner Lowlands (IL)	> 24^0 - maximum: > 31^0
Coastal Lowlands (CL)	> 24^0 - maximum: < 31^0

Source: Jaetzold and Schmidt, 1983

Table 2.3. Moisture availability and temperature range

Zone	Range	Evaporative potential (%)
1	Humid	<15
2	Sub-humid	15-25
3	Semi-humid	25-40
4	Semi-humid to semi-arid	40-50
5	Semi-arid	50-65
6	Arid	65-80
7	Very arid	>80

Source: Jaetzold and Schmidt, 1983

In addition, each AEZ belt has differing moisture availability with an index ranging between 1-7 and varying evaporative potential (Table 2.3), which will determine the suitability of the belts for livestock production and survival of the tick vector, and consequently, disease. Generally, belts 1-4 are suitable for dairying, but belts 5-7 are considered dry and are more suitable for pastoral types of livestock production.

Due to their importance in determining the dairy productive potential of each area and the suitability of the tick vector (consequently, level of disease risk), AEZ were used as a criterion for farm selection. However, information on the relative importance of each belt in determining disease risk in the study areas was not available. Care was therefore taken to represent the major AEZ proportionately using their distribution patterns and weight in each administrative district, division, location and sub-location. A map showing the study districts with the distribution of AEZ is presented in Appendix 1.2.

2.4. Farm selection

A cross-sectional survey carried out by ILRI's Smallholder Dairy Project (SDP) to characterise dairy activities in Kenya (Staal et al., 2001) provided a list frame from which dairy farms were selected for this study. The Staal study had surveyed the same districts, selecting two administrative divisions 'that would be most indicative of dairy productive potential within each district' and reflecting contrasting agro-ecology. A stratified sampling procedure had been used at sub-location level, selecting every fifth household on the right and then on the left of each of the transects that were developed using GIS[2]. All the dairy farms surveyed in the characterisation study in each sub-location served as a sampling frame for a random selection procedure using a computer programme developed in SAS. A random sample of the required number of households was then selected from each sub-location.

2.5. Enumerator recruitment and training

The large number of households to be interviewed necessitated the use of enumerators for data collection. Enumerator candidates were expected to have a secondary level education. Higher training levels were not preferable as such individuals would probably be more difficult to train and less likely to follow

[2] Households were selected for the Staal study regardless of whether they were agricultural or whether they kept dairy animals or not.

instructions, with the possibility of introducing bias during data collection. Applicants were expected to be conversant with *Kikuyu*, the local language in Central Kenya as their first language, and went through an interview consisting of an oral and a simple written examination. Selected candidates went through a ten-day training which entailed the following:

- Familiarity with the research topic, objectives and expected outputs.
- The critical role of an enumerator in the research process.
- Methods of data collection.
- Role-playing, where the enumerator candidates simulated the household interview. Each enumerator was given a chance to play the role of a farmer and that of an enumerator, going through the questionnaire. In the process, the enumerators developed an interview guide with the best way to ask each question in order to get the required information.
- Developing a coding system for the analysis alongside the verbal response to each question, making the analysis process easier.
- Familiarisation with Geographic Positioning Systems (GPS), coding, recording and storing of GPS readings.

2.6. Pre-testing

After the enumerator training, the questionnaire was pre-tested in eight farms in nearby Kikuyu division of Kiambu district, which was going to be one of the survey sites. During this pre-testing, two objectives were achieved:

- Testing of the questionnaire to make sure that the questions were working, and adjusting those questions that were not getting the desired information.
- Evaluation of the enumerator candidates and selecting the best five of eight trainees. The advantage of having trained enumerators in reserve was that

they could always be hired at some later time without further training should any of the hired enumerators fall sick or need replacement.

2.7. Actual data collection

Planning of farm-level fieldwork was carried out in collaboration with extension officers from the Ministry of Agriculture and Rural Development (MoARD). The Ministry officials in each administrative division were provided with the lists of selected farms in their division, which they used to contact the farmers and arrange the household interviews. Thereafter, they accompanied the team during farm-visits, introducing us to the farmers and helping us to establish rapport, as they, unlike us, were well known to the farmers and the latter felt more at ease with us in their presence.

GPS readings were recorded on each farm, and were later used to identify the geographic position of each farm (Appendix 1.3). It had been established that on average, a questionnaire took about 1.2 hours to administer. Allowing for time to travel between farms, each enumerator was expected to visit an average of three households in a day. The researcher also carried out 1-2 interviews in addition to enumerator supervision either accompanying them during the interview or paying random checks. Additionally, the researcher went through filled-out questionnaires to verify collected information, pointing out any that needed repeat farm visits.

2.8. Lessons from data collection

The intensive training of the enumerators prepared them well for the fieldwork, and helped to establish a good working relationship amongst them and with the researcher, creating an atmosphere of teamwork and raising the level of individual motivation. In addition, the enumerators were well familiar with the questionnaire, which helped them to be confident and relaxed during the interviews, building a good rapport with the farmers. This had a positive effect on the quality of information obtained.

A few minor problems were encountered during the fieldwork. Four farms needed repeat visits to verify answers to a few questions that had been incorrectly entered. This happened in the first few weeks of the fieldwork but was soon overcome with further interviews and increased enumerator experience. Four farms had to be replaced: one farm had experienced bereavement of a member, a second farm had a very old household head (> 90 years) who mistrusted the team and complained that they reminded him of the colonial pre-independent period, particularly because of the presence of an American student on attachment. Two other farms were inaccessible due to bad weather and poor roads. Interviews were also carried out with four farms that had not been selected for the study. The farmers insisted on being included (when they saw their neighbours being visited) as they argued that they wanted to contribute their views and needed to benefit from the discussions with the team.

2.9. Service provider survey

A structured questionnaire was developed for use in a survey of all service providers delivering animal health services in the same sites where the farm-level survey had been conducted. Questions included personal details (including qualifications), production systems covered, perceptions on important diseases and those commonly treated, types of services offered, TTBD products handled, and list of suppliers and government policies regulating practice (see Appendix 3).

Two field assistants were hired to facilitate field enumeration, and trained for two days in order to familiarise them with the questionnaire and the required information. University graduates in fields related to the veterinary discipline were preferred for two reasons: i) they would be more familiar with the more technical aspects of our questionnaire and ii) due to their professionalism, they would easily win the confidence of our respondents, who consisted of field veterinarians, animal health assistants, farmers co-operatives and others carrying out animal health clinical work. A list frame was developed from the farm-level survey, in which farmers had provided a list of all service providers in their area. This was made more exhaustive during the actual service provider survey, which included a question on service competition for every respondent. A total of 177 service providers were interviewed over a period of four weeks.

Among the problems encountered in this phase was the issue of making an appointment with a service provider, particularly the private veterinarians, who often had very tight schedules. They often had to be visited twice, the first time to identify the most appropriate time, and the second time to obtain the information. Interviews were sometimes scheduled early in the morning or late in the evening after working hours. Additionally, information on sales volumes was difficult to obtain as this was treated as confidential.

2.10. Institutional survey

The last phase of data collection involved interviews with key informants and policy makers influencing animal health delivery at government offices and the pharmaceutical industry, including the distributors and suppliers of products and services. An interview guide was developed to guide the discussions, which covered the various elements of market structure and the conduct of the actors, as well as the national level policies influencing animal health delivery. The researcher carried out these interviews over a period of four weeks. Problems encountered at this level included the failure to secure much of the marketing information, particularly the sales volumes handled by the different companies, as respondents feared the possibility of leakage of this information to their rivals or the government departments. Appendix 4 presents the interview guide used.

2.11. Data entry and cleaning

A data clerk was hired for computer entry of the information into a database. Microsoft Access was preferred as a data management system for its ability to retain data integrity, ease of entry while minimising entry errors and ease of data retrieval. Data cleaning and later, preparation and analysis, were carried out by the researcher using Microsoft Excel and Stata for Windows (StataCorp, 2001).

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Chapter 3

An economic assessment of current delivery pathways for the control of tick-borne diseases in Kenya

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Abstract

One of the principal constraints to increased dairy output from the smallholder dairy sector in East Africa is ticks and tick-borne diseases (TTBD), with the largest losses due to East Coast fever. These losses continue to be experienced despite the existence of several technology packages for their control, including chemotherapeutic agents, tick control by acaricides, and live vaccines, which farmers have not been utilizing optimally. The poor uptake of existing control technologies has been attributed primarily to weak or inappropriate delivery systems.

An economic analysis is applied to evaluate current delivery systems and identify opportunities for their improvement. A combination of two approaches is used to evaluate the performance of current systems and assess their effectiveness for delivering TTBD control technologies and services to smallholder dairy production systems in Kenya. The first, the structure-conduct-performance framework, evaluates the performance of a marketing system by comparing it to a perfectly competitive model. The second approach, the new institutional economics, offers a framework for analysing transaction costs and using economic characteristics to determine the suitability of delivery pathways for the various TTBD control technologies.

Analysis of TTBD market structure provides evidence of competition in the delivery of both chemotherapy and tick control products at all levels of the delivery chain, while a single company has the monopoly of supply of the only ECF vaccine, the infection and treatment method. At the service provider level, service provision appears to be competitive, mainly carried out by paravets, while stores play a major role in the supply of tick control products, particularly in rural areas. At the farm level,

transaction costs are an important constraint to farmer access of TTBD technologies. Policy implications are discussed.

3.1. Introduction

The delivery of livestock health services has received a lot of attention in the last decade, particularly in the wake of liberalization of developing markets in sub-Saharan African (SSA) countries. Most studies to-date have emphasized privatisation as a solution to poor delivery (Umali et al. 1992; Leonard 1993; Schillhorn van Veen and de Haan 1995; Holden 1999; Leonard et al. 1999). However, the emerging private sector has not expanded as hoped and animal health service delivery remains poor, particularly in rural and remote areas, with a resultant downward trend in the performance of the livestock sector (Holden et al. 1996). The current trend towards a reduced role of the public sector and increased participation by the private sector presents an opportunity for utilizing economic theory to guide the transition process towards more appropriate delivery pathways. However, a clear applied analytical framework for assessing appropriate systems is lacking.

This study evaluates current delivery pathways for TTBD control services and products to smallholder dairy farmers in central Kenya using a conceptual framework that combines two complementary approaches. The first uses industrial organization theory to compare current systems with a perfectly competitive model while the second evaluates the role of transaction costs using the new institutional economics approach.

3.2. Theoretical framework

In order to identify opportunities for improving delivery systems for veterinary services, it is necessary to evaluate their performance. This can be done using the structure-conduct-performance (SCP) framework, founded on industrial organization theory. SCP is an analytical tool used to study the performance of a marketing system and evaluate its deviation from a perfectly competitive model. Theory suggests that market structure strongly influences market conduct, which in turn determines market performance (Scarborough and Kydd 1992; Scott 1995). An assessment of market structure is therefore a good starting point to evaluate the presence or absence of other conditions of competition and develop hypotheses about the conduct of the players involved. A set of efficiency criteria can then be used to assess the performance of the marketing system.

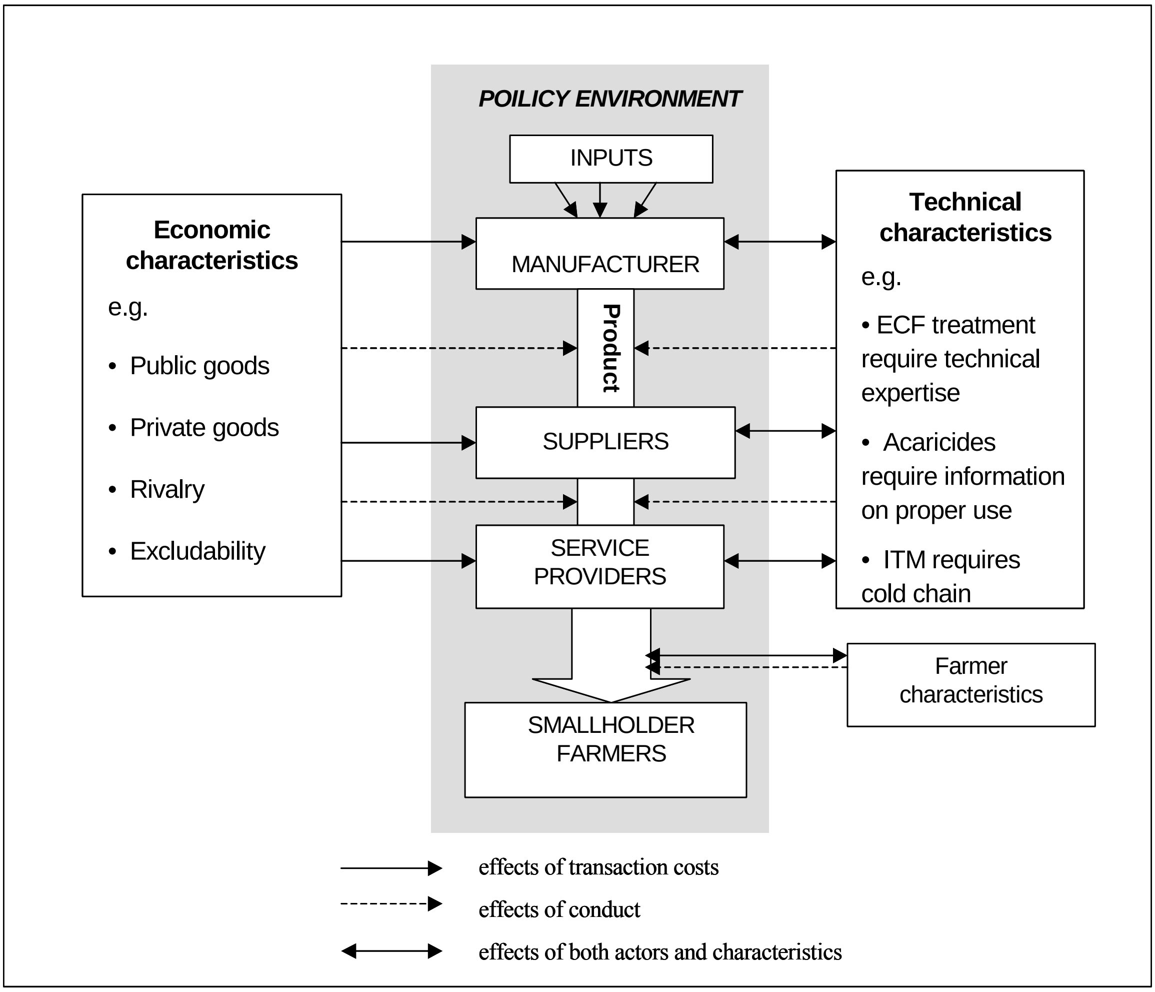
The SCP framework has been applied to study fish marketing in developing countries (Pomeroy and Trinidad 1995), the food manufacturing industry (Prakash et al. 1998; Vlachvei and Oustapassidis 1998; Bhuyan and Lopez 2000) and has been proposed to study policy delivery systems (Sandiford and Rossmiller 1996). For example, Vlachvei and Oustapassidis (1998) showed that profitability is determined by advertising, which is in turn determined by concentration. Although SCP has not been used in veterinary delivery systems studies before, it can be applied to assess their performance in order to identify any lack of competition including the existence of barriers to entry and poor market information. However, SCP overlooks the effects of transaction costs even though much of the conduct of the players in developing country markets is often directed towards minimizing these costs. Also, SCP has typically been applied to products that are essentially private goods passing through a perfectly competitive market e.g. grain marketing (Maritim 1982; Randolph and Gueye 1989), which often is not the case for livestock health technologies.

The new institutional economics (NIE) provides a good complement in addressing these shortcomings and suggesting the appropriate veterinary delivery systems. NIE focuses on the effects of transaction costs, asymmetries of information and the institutional arrangements that emerge to reduce these. Transaction costs are costs, often non-monetary, associated with arranging a market exchange (Toye 1995; Hubbard 1997) and can be classified into information, negotiation and enforcement costs (Hobbs 1997). Information costs arise *ex ante* and include price discovery and searching for and screening potential trade partners, while negotiation costs are incurred during the actual transaction, including the physical transfer of the product or service. Costs associated with monitoring and coordinating the terms of exchange generally occur *ex post* and are termed as enforcement costs.

Few empirical studies have measured transaction costs to-date, apparently due to the difficulties associated with their identification and measurement. Transaction costs may be so high relative to the benefits of the transaction that the exchange does not occur (Staal et al. 1997). The available studies on developing country markets have tended to focus on distance to market as a single indicator of transaction costs (Oruko 1999; Staal et al. in press). One of the first studies to carry out empirical measurement of transaction costs was the innovative approach by Hobbs (1997) that considered the transaction costs faced by farmers who had to choose between two marketing pathways for their beef cattle sales in the United Kingdom. Since there is no standardized methodology for collecting such information, her survey included questions covering a wide range of indicators of potential sources of transaction costs which would be expected to influence the choice of cattle marketing channels. Results found three negotiation costs and one monitoring cost to be significant while information costs were insignificant. This can be attributed to the easy access to information in a developed country market. In a developing country context, however, one of the major transaction costs associated with delivery of services is precisely the general lack of market information. Gabre-Madhin (1999a) studied the role of brokers in grain marketing in Ethiopia and identified the main functions of the brokerage institution as being directed towards minimizing transaction costs associated with lack of information and limited contract enforcement. In a complementary paper, Gabre-Madhin (1999b) modelled the trader's choice of using a broker to reduce the transaction costs associated with price discovery, searching and screening for trade partners. From the NIE perspective, this brokerage is an institutional arrangement that evolved to overcome problems of transaction costs in grain marketing in a developing country.

How can SCP and NIE be applied to the delivery of TTBD control? Most SCP studies use a set of well-defined quantitative techniques, which are possible because they involve the marketing of a single, easily identified commodity with a well-developed market. In veterinary delivery systems, several different products are passing through a variety of actors in the marketing system and delivery to the end user is associated with specific services. This complexity is often further compounded in developing countries by a thin market comprised of dispersed, mostly resource-poor smallholder farmers. SCP can be used to characterize existing systems of TTBD control delivery, including types of actors, their conduct, institutional structures in place and levels of competition (Figure 3.1), but needs to be complemented by other approaches to address the shortcomings pointed out earlier. An important issue that is not addressed by SCP and that merits attention is the costs of transacting, which are considered as key to economic performance (North 2000; Kherallah and Kirsten 2001). The NIE framework is used to analyse the effect of transaction costs and to classify products by their technical and economic characteristics in order to identify the appropriate pathways for their delivery (Figure 3.1). The resulting framework is therefore primarily diagnostic, pointing out inefficiencies in the performance of current systems rather than necessarily providing prescriptive answers. It does offer, however, indications of how to improve the appropriateness of delivery pathways for control technologies or interventions.

Figure 3.1. Conceptual framework for delivery of TTBD products and services



3.3. Data collection methods

The analysis examines delivery systems for TTBD control technologies in a range of situations characterizing smallholder dairy production in Central Kenya. Data were collected using surveys at three levels, starting at the farm level with 344 farmers across three smallholder dairy production zones. These sites were selected on the basis of access to market, and include Kiambu (close to the main urban market in Nairobi), Nyandarua (rural and far from market) and Nakuru (rural-urban transition zone). Information on availability and use of veterinary services as well as indicators of transaction costs influencing farmers' choices was collected using a structured questionnaire. This was followed by an exhaustive survey of all service providers delivering veterinary services and products in the same areas. Data collected from service providers included types of products handled, sources of these products and transaction costs associated with their procurement and delivery to farmers. The surveys then worked backwards to the third level: the distributors and suppliers of products and services. Information was also collected from key informants on national level policies and institutions influencing the delivery systems identified, including various elements of market structure and their conduct, often involving strategies adopted to reduce specific types of transaction costs.

3.4. Overview of TTBD technologies and their delivery

TTBD products may be grouped into two broad categories: curatives and preventives. Under curative products are the various chemotherapeutic drugs used on an already infected animal, while preventive products are used for protection against disease. Prevention may be effected using i) vector (tick) control measures by acaricide application, ii) immunization using vaccines, and iii) use of grazing management, in which animals are kept under strict stall-feeding conditions and have limited exposure to the tick vector compared to those grazing in open paddocks. The available types of TTBD technologies can therefore be summed into chemotherapy, vector control and immunization (Table 3.1). Only one vaccine, the infection and treatment method (ITM) of immunization, is currently available for the control of East Coast fever (ECF).

Table 3.1. Conduct issues at different levels of market chain

Control type	TTBD package	Institutional / policy-level	Service provider (SP)-level	Farmer-level
Curative	Chemo-therapy	• Government veterinary offices continue to carry out clinical work in most areas • Limiting sale and prescription of drugs to vets is a way of addressing quality issues • KVB & KVA oversees registration & ethics of private vets (but not other SP* types) • There were no supervisory bodies to oversee service quality at farm-level • Issue of follow-up of treated cases is not addressed	• 82% SP were in private business, 17% in public and 1% in co-ops. • 70% SP were selling products in addition to clinical service provision • 54% SP offered clinical services, [57% paravets, 29% vets & other cadres (14%)]	• 62% of the sampled farms had experienced disease problems in the preceding year and 85% of these had sought vet curative services • 50% of those who sought curative services went to private practitioners, 34% to government office and 13% to experienced farmers • Of those who had bought curative packages 83% bought from vets / paravets, 10% from agrovet shops and 7% from chemists
Preventive	Vector control	• Government officers are available to offer technical recommendations through extension • Restricted use of acaricide classes is used to address issue of resistance (e.g. pour ons should not be used for tick control) • There are no barriers to entry for sale of vector control products as a response to liberalization • Quality control issues only addressed at the institutional level by registration rules	• High competition in sale of products with highest sales going through stores • Majority of qualified SP offer free technical advice on use of products during transactions in order to reduce their search costs for trade partners • Product uncertainty reduced by buying directly from distributors • Product quality is not addressed	• 91% of the sampled farmers across the three sites carried out tick control by acaricide use - 92% by spraying & 8% by dipping • Products were bought from agrovet shops (71% of respondents), chemists (14%), vets / paravets (5%), co-ops, general shops and government supplies through communities • Farmers required technical advice on product types and their use
	ITM immunization	• Delivery of technology is not yet established - initially delivery limited to private vets but when these became hesitant policy was relaxed to include government vets • Monopoly of distributorship to company having large share of treatment and vector control sales presents potential conflict of interests in TTBD product sales • Until 2002 ITM use limited to Kenya Coast where clinical trials were carried out • Liability problems have not been addressed	• 57% of SP had never heard of ITM and of the 43% who knew about it only 2% had ever used it • Liability problem has not been addressed and SP are hesitant to use ITM due to reactor rate that may damage their reputation • Monitoring visits are perceived to be tedious and to increase effective cost of ITM	• ITM has not been well publicized and farmers are not aware of technology • Monitoring visits make vaccine appear experimental and increase the effective price - farmers are hesitant to use it • ITM is not in use in the study sites although trials were conducted in parts of the study area

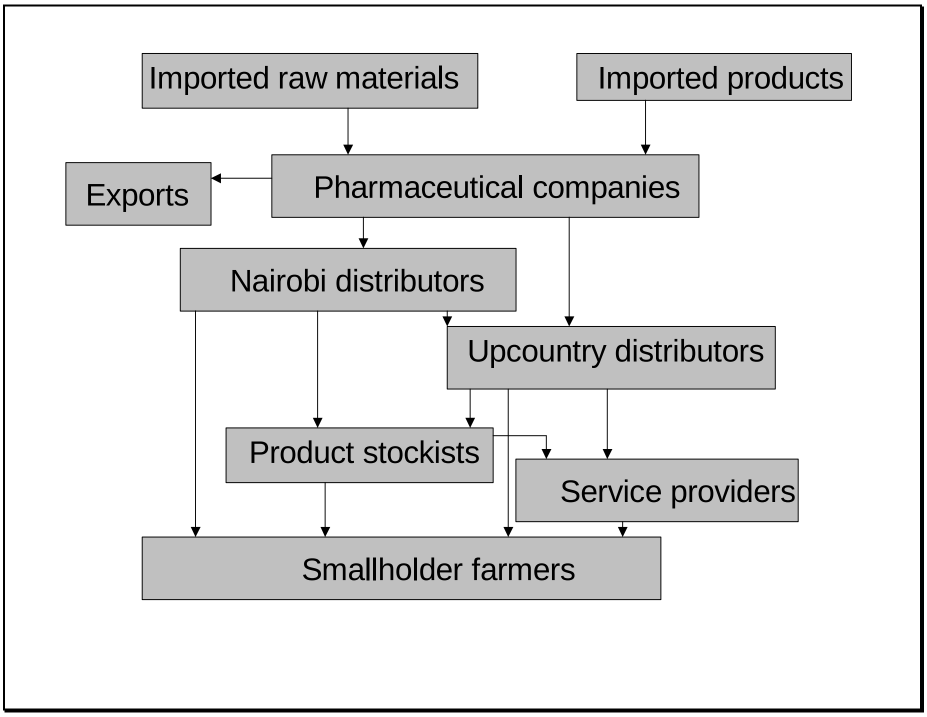
SP* Service provider

The supply of these TTBD products and their associated services to farmers involves specific delivery systems (channels), which are defined as the passage of a given technology through a series of actors at different levels of the delivery chain. These actors include a central manufacturer who supplies the products through distributing channels to the various types of service providers who then sell the products to the end user (Figure 3.1). Each product is sold to the farmer in combination with specific services (represented as the thick arrow at the bottom of the chain). Services associated with ECF treatment include diagnosis of disease, acquisition of treatment products, and product administration to the sick animal and follow-up to monitor its recovery. Those associated with tick control include product sale, advice on product usage and actual administration, while ITM immunization is also associated with the additional need for monitoring of vaccinated animals in order to treat any reactors.

The current market structure for the distribution of TTBD control products in Kenya is depicted in Figure 3.2. At the top of the delivery chain (pharmaceutical industry level), the manufacturer imports raw materials or products, which are re-packed for sale. Nearly all the companies are specialized in selling either human health products or agro-chemicals, with only 7-10% of their business coming from veterinary sales, with the exception of two companies that handle only veterinary products. A large percentage of the industry's veterinary sales are TTBD products with acaricides constituting a substantial component of these sales. All companies cited the smallholder dairy production systems to be the most important target clientele for their TTBD control products, and for which proportional company business ranges from 50-100%. Other production systems, including large-scale commercial farmers, ranches and pastoralist systems, provide approximately 2-40% of the total TTBD sales to the different companies.

From a company, products pass through the main suppliers in Nairobi or the larger rural towns. Each company has 2-8 distributors within the country, and some suppliers may distribute for several companies. Products then pass to the stockists located in the main rural markets and supplying to the different types of service providers and sometimes directly to farmers (Figure 3.2).

Figure 3.2. Distribution of tick-borne disease products and services



Actors involved in the delivery of TTBD control technologies are all subject to public policies that govern their conduct and influence market performance (Figure 3.1). For example, pharmaceutical companies are expected to register with either the Pest Control Products Board (PCPB) or with the Pharmacy and Poisons Board (PPB), both of which are responsible for product registration and quality control. The District Veterinary Officer (DVO) is in charge of all veterinary activities in a given administrative district, specifically through government-employed service providers although private ones are also answerable to this office. Government veterinarians are responsible for disease control activities such as quarantines, livestock movements and vaccinations as well as veterinary public health services such as meat inspection, and are not allowed to operate private clinics. Only private veterinarians, registered with the Kenya Veterinary Board (KVB) and members of the professional body, the Kenya Veterinary Association (KVA), are allowed to carry out private veterinary work. KVA is responsible for the welfare of its members and offers regulatory guidelines based on their code of ethics, while KVB regulates service provision by providing private practitioners with annual licenses at a fee from the Director of Veterinary Services (DVS). Para veterinarians (paravets) are expected to operate under the supervision of a vet and are answerable to the DVO. They are excluded from the KVA, are not expected to register with KVB, and are therefore not eligible for operating a private practice. They are also officially not allowed to sell products requiring prescriptions such as ECF treatment drugs, hormones and steroids, though they often do.

3.5. SCP and the delivery of TTBD technologies

This section reviews the existing delivery systems in Kenya using SCP and evaluates their appropriateness to deliver each of the available TTBD control technologies based on the survey of delivery channels servicing the three study areas.

3.5.1. General overview of market structure

Prior to market liberalization in the early 1990s, there were only three pharmaceutical companies supplying tick control products, but these have since increased to ten while those supplying TTBD treatment products now total fifteen (Table 3.2). These numbers indicate sufficient competition in the marketing of TTBD control products with the exception of ECF treatment drugs, which are manufactured by a single pharmaceutical company. In addition, ITM is produced by a state research institution and marketed by a single company, which has sole monopoly of distributorship. The supply of ECF treatment and immunization products is therefore indicative of a highly concentrated market, representing the other extreme of perfect competition. This monopoly of supply may bring about uncompetitive conduct including pricing. Otherwise, the number of distributors of treatment and tick control packages in the study areas was indicative of competitive markets.

Table 3.2. Number of actors by level of market chain

Actors	Treatment products	Tick control	ITM	Total*
Manufacturers	15	10	1	15
Distributors	12	14	1	14
Service providers	114	147	0	177
Farmers using product/ service	148/181+	314	0	344

* Total here indicates number of actors interviewed at the different levels. Most actors were selling more than one product type
+Number buying products / number using services

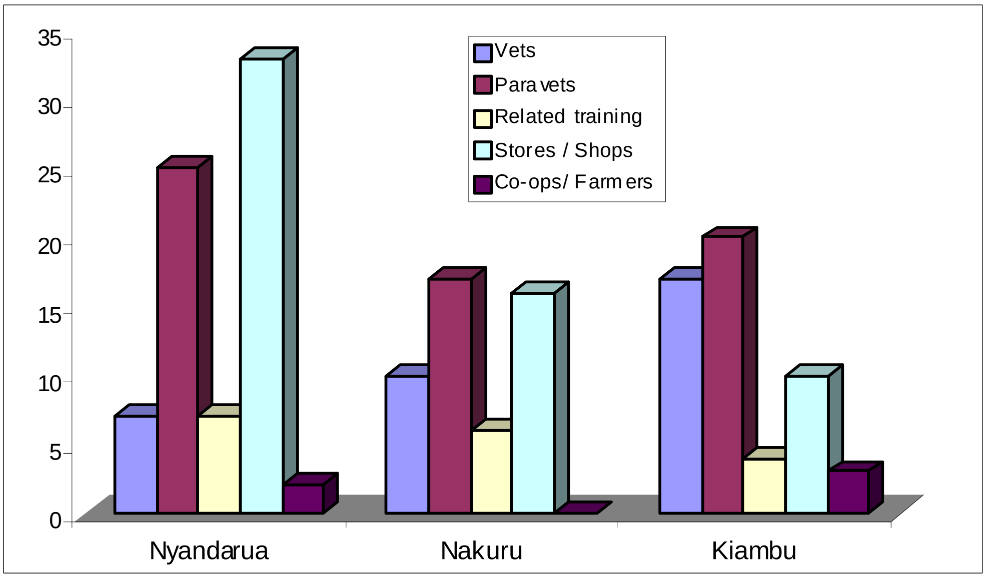
At the next level down the marketing chain are the service providers. A total of 177 service providers were interviewed, comprising farmer co-operatives, different types of stores, professionals trained in fields related to livestock production and husbandry, and individuals with no formal veterinary training, in addition to field veterinarians and animal health assistants (AHAs or paravets) (Figure 3.3). The most important category is paravets, constituting 35% of the total number of agents interviewed, while stores and shops (33%) played a significant role in the sale of tick control products, particularly in rural areas. Veterinarians constituted 19%, with half of these located in peri-urban Kiambu, compared to 3/10 in Nakuru and only 2/10 in rural Nyandarua. Other professionals included animal productionists, agricultural extensionists, pharmacists, inseminators and meat inspectors, all constituting 10%, while farmer co-operatives and experienced farmers constituted 3% of the total number of service providers interviewed. With all these service providers delivering services to the same clients, the end result is efficiency in pricing and quality due to competition. Diversification of services including selling a wide variety of products and offering free technical advice is often used as a way of advertising.

3.5.2. Market conduct

Using SCP, we examine the general conduct of the marketing system to point out any deviations from a perfectly competitive model.

Pricing behavior: Prices are set primarily at the pharmaceutical company level using a combination of both cost-based pricing, which takes into account production, distribution and technical support costs, and competition-based pricing, which involves monitoring the competitiveness of similar products owned by rival companies in the market and adjusting product prices accordingly.

Figure 3.3. Service provider distribution by type



Buying and selling practices: A common service used at the pharmaceutical company level was credit provision as a strategy to attract more distributors and consequently raise sales. However, all companies interviewed provided credit through their company lawyers as an insurance against defaulting and often limited these services to 1-2 months. Companies also provided commissions and discounts to their valued distributors on the cash purchase of large volumes, often in the form of 5-15% off the cost of purchased products. Lower down the chain, distributors would give a lower percentage (2-10%) depending on what they had received from the suppliers, and by the time the product got to the farmer-level, there were hardly any discounts given.

Conduct issues at different market levels: Other conduct issues are specific to the type of technology, and have been evaluated at the institutional, service provider and farmer levels as summarized in Table 3.1. For example, quality control for chemotherapy is addressed at the policy level by limiting to veterinarians certain responsibilities such as the supply of ECF drugs through prescriptions, and by the veterinary professional bodies KVA and KVB ensuring that veterinarians observe professional ethics and are kept up to date with the latest treatment procedures. For vector control, the government restricts use of acaricide classes[3] in order to address the issue of tick resistance to acaricides. However, there are no barriers to entry for selling vector control products and any individual can obtain a license. ITM is manufactured by a state research parastatal and sold to farmers through a single supplier, and its supply has been limited to a single geographic area, the Kenya Coast, thereby excluding farmers located elsewhere such as the central highlands where ECF is a major disease risk. No policies specifically target the problems of asymmetries of information and quality control associated with the cold chain requirement or liability issues.

At the next level, TTBD control delivery in the study areas is carried out by a variety of service providers, with 82% in private practice, 17% in state employ and 1% in farmer co-operatives. In addition to provision of clinical services, the majority of

[3] Synthetic pyrethrines are not allowed for tick control use but are reserved for tsetse control.

service providers also sell veterinary products as a major component of their business. There was high competition in vector control product sales with a wide range of stores providing a major outlet for these products, and service providers offered free technical advice to attract more clients. Further, 91% of surveyed households carried out tick control by use of acaricides, with majority of these (71%) buying their products from various types of stores, a few from veterinarians and paravets (14%) and a small proportion (5%) from co-operatives and government supplies through community dips (Table 3.3). Since ITM was not available in the study sites, there was little awareness of its existence among service providers. At farm level, 85% of those who experienced disease sought veterinary curative services while the rest chose to buy products and treat the cases themselves. Purchases of curative products were made mainly from veterinarians and paravets as well as from a variety of stores.

Table 3.3. Use of tick control measures by 344 farms

District	**Sources of tick control products**					
	Stores	Chemists & Drug companies	Vets & Paravets	Government	Co-ops / community	Total
Kiambu	44	14	3	2	9	72
Nakuru	86	14	3	1	1	105
Nyandarua	71	13	7	11	4	106
All three districts	201	41	13	14	14	283

3.5.3. Summary

Due to limited quantitative information on TTBD product sale volumes, no concentration indices have been used in this study to measure the size distribution of buyers and sellers. However, the analysis shows that TTBD control delivery is generally competitive, with the exception of ECF treatment and immunization (Table 3.2). Other than for ITM delivery, there are no other detectable barriers to enter or exit the TTBD market at the company and distributor levels. There is no evidence of excessive marketing margins detected at any level, and the overall pricing conduct is suggestive of efficient allocation of resources. Buying and selling practices are also suggestive of presence of competition, involving services that offer incentives to clients as a way of raising business sales and use of legal measures to solve conflicts that may result from defaulting.

At the next level down the marketing chain, supply of TTBD control technologies is highly competitive among a wide range of service provider types. Although the number of service providers may appear competitive, their spatial distribution translates to varied service quality available to farmers across the market gradient. Veterinarians have a more peri-urban distribution, stores are more important in rural areas, and paravets are the most important type across the three survey sites. However, despite their higher density relative to the other types of service providers, paravets are not allowed to own private clinics. While this barrier to entry is associated with protecting professionalism created through state policies concerned with quality control, the end result is limited access to services by farmers, particularly in the rural areas with low densities of veterinarians. At the farm level, there appears to be sufficient demand for TTBD control technologies among smallholder dairy farmers as evidenced by the large proportion of farmers buying TTBD control products and seeking service providers for their sick animals.

3.6. A NIE analysis of TTBD technologies

Based on the hypothesis that the appropriateness of the delivery systems for a given technology is in part a function of the technology's inherent characteristics, this section analyses TTBD control technologies first by their technical characteristics, which determine the types and levels of their associated transaction costs, and then by their economic characteristics, which determine appropriate actors and sectors for their delivery.

3.6.1. Technical characteristics and transaction costs

Table 3.4 summarizes the technical characteristics of each TTBD technology type, listing, though not exhaustively, transaction costs associated with these characteristics.

<u>Chemotherapy</u>*:* When a farmer is faced with a sick cow, the first decision he/she makes is whether or not to engage a service provider. This decision will be a function of the type of disease encountered (and therefore the technology package required), and will determine the type and level of transaction costs that he/she will face, besides the monitoring costs for the products and services received. For example, if the animal is suspected to be suffering from ECF (the principal TTBD), it is necessary to make a diagnosis and administer appropriate treatment drugs quickly, as delays may result in the death of the animal. If the farmer decides to use professional services, he/she needs to engage a service provider who can respond quickly, diagnose the ailment correctly and be trusted to administer the right dosage of the appropriate drugs. However, the farmer possesses imperfect information (incomplete/ uncertain knowledge) on the characteristics of service providers, such as promptness and availability when required, quality and price of products and services that they provide, and whether they can be trusted to follow-up the animal to recovery. The farmer will therefore incur a variety of information-gathering costs in estimating these characteristics in order to locate and negotiate a transaction with the appropriate service provider. Some of the costs are direct, such as travel time and transportation costs incurred while seeking for a service provider, while others such as the opportunity costs are indirect. Opportunity costs relate to the time taken to

search that would otherwise have been used for other activities. However, all these transaction costs are a function of information on potential agents that a farmer will select from, and on the types of services and products they deliver. Searching and screening increases the probability of the farmer identifying a service provider with the appropriate attributes required for the contract, but also increases the efforts, or transaction costs in doing so. The less information the farmer is able to secure, the higher the risk of making a contract under uncertainty (Challen 2000).

Other important transaction costs that a farmer may face are negotiation costs associated with the density of service providers in a given area. Where there are limited numbers of veterinarians, for example, negotiation of a contract becomes more costly for a farmer because the few available veterinarians operate under local monopolies and are therefore unlikely to offer competitive services and prices, reducing the bargaining power of the farmer who becomes a price-taker. Such a veterinarian may not always be available when needed, bringing about other information costs of seeking alternative services and engaging an unqualified service provider under imperfect information. These costs further increase the risk of losing the animal to ECF.

Farmers who opt to treat the animals themselves face a higher risk of misdiagnosing the problem and using the wrong treatment packages. Costs of acquisition of the appropriate drugs depend on access to information, which itself is a function of, among other things, infrastructure, travel distance and farmer characteristics such as experience with health problems, level of education, gender, membership to a farmer organization, and ethnicity. For example, uneducated farmers will face a higher level of imperfect information due to their inability to access written information about available alternative drugs and their sources. Other important transaction costs are summarized in Table 3.4.

Table 3.4. Characteristics of TTBD control technologies and associated transaction costs

TTBD Package	Technical Characteristics	Transaction costs		
		Information	Negotiation	Enforcement
Chemo-therapy	• Treatment package includes a combination of anti-theilerial drugs and antibiotics • Early diagnosis & treatment necessary for effectiveness • Treatment package is quite expensive	• Imperfect information on SP* and products being used • Search and screening costs for SP and price discovery costs • Time and transport costs while seeking for SP • Promptness since delays will result in deaths • Uncertainty costs and information asymmetries as a function of farmer characteristics	• Limited distribution of SP - lack of bargaining power for farmer • Probability of a transaction with an unqualified SP • Availability of SP / products when required	• Product / service quality: correct diagnosis and use of appropriate drugs • Follow-up services after treatment • Liability - compensation in case of complaints
Vector control	• Lethal effect on ticks depends on correct mixing • Several acaricide classes are available in market • Repeated use of low strength may lead to resistance • Dipping has fixed location (other products are "mobile")	• Imperfect information on SP who will offer technical advice on product use • Uncertainty costs and imperfect information on appropriate product • Travel and transport costs to buy products	• Availability of products when needed	• Liability - compensation in case of complaints • Probability of repeated change of acaricides increases risk of tick resistance
ITM Immuni-zation	• Technology is relatively new in market and in the stage of introduction to farmers • Delivery limited to vets • Involves live organisms, hence requires cold chain • Vaccinated animals need monitoring for 28 days and treatment for ECF if they fall sick	• Information asymmetries on ITM and its availability • Lack of experience with ITM at various levels - search for willing trade partners • Product uncertainty and price discovery costs • Search and screening costs for willing and able SP	• Limited availability of vets increases risk of not finding a service provider • Additional travel time to look for alternative SP causes additional costs and possible	• Cold chain requirement - quality control and liability problems • Monitoring of post- immunized animals makes vaccine appear experimental • Risk of reactors requires ECF treatment and increases vaccine's effective price

SP* Service provider

Of the farmers whose cattle experienced disease in this study, 85% sought veterinary curative services while the rest chose to buy products and treat the cases themselves. Preference for professional services would reduce negotiation costs associated with quality since veterinarians would be more likely to administer the correct dosage of the appropriate drugs. Moreover, the use of private veterinarians would be expected to reduce the probability for farmers, of incurring costs associated with liability in cases of dissatisfaction and, because of the higher quality of their services, reducing the probability of incurring costs associated with losses. Of the proportion of farmers engaging a service provider, 50% went to private practitioners (both veterinarians and paravets), 34% to government offices and 13% to experienced neighbors and farmer co-operatives. Private practitioners were more preferred probably because they tended to be more common than those from the public sector. Their better accessibility lowers the transaction costs associated with travel time for farmers as well as the need for prompt services. However, in more rural areas where veterinarians had a much lower density than other types of service providers, farmers had limited choices of qualified veterinarians. This resulted in not only higher information costs in terms of uncertainty for service providers to deliver the expected level of service quality, but also higher risks of missing them when they were required and engaging the service of unqualified individuals.

Vector control by acaricides: Current acaricide application methods include dipping and spraying by use of mechanical equipment, a simple hand pump, or even hand washing. Other methods such as synthetic pyrethroids presented as pour-on, spot-on and intraruminal boluses have also been used (de Castro 1997) to address environmental concerns and lack of infrastructure, including water supply in some areas. The technical characteristics of tick control include the need for proper mixing of the formulation with water, as high acaricide concentrations may be toxic (for both the animal and attendant), and under-dilution may result in ineffective tick control

(Table 3.4). Correct mixing is influenced by the level of imperfect information on product use, and farmers therefore incur information costs to identify a service provider who offers this technical advice on how to use products correctly.

Each product therefore has its specific technical attributes, and farmers face a wide range of products available in the market, which introduces product information costs when farmers chose among them, as well as travel and time opportunity costs for purchase. The level of these costs is a function of the service provider chosen and farmer characteristics as discussed earlier. Personal attributes of the service provider, particularly their level of veterinary training, determine their ability to supply technical advice on the appropriate products to use, recommendations on the one to adopt should resistance develop and directions for their use. Farmers will therefore incur search and screening costs to identify an appropriate service provider from which they buy their products. An important negotiation cost for farmers is the availability of products when needed, which means that they need to identify service providers who are likely to have products at hand. Most of the transaction costs associated with vector control are therefore information costs on products and service providers delivering them.

In this study, stores provided a major outlet for tick control product sales and were generally managed by individuals with no formal veterinary training, who were unlikely to pass any technical information on recommended use of products. Several counterfeit tick control products were also found in circulation, increasing uncertainty costs for farmers in identifying genuine products, and raising the probability of repeated change from one acaricide to another, hence increasing the risk of tick resistance to acaricides. Quality control is an issue as there is no supervisory body to monitor products being sold to farmers.

Immunization: The only available ECF vaccine, ITM, is produced by a state research parastatal, Kenya Agricultural Research Institute (KARI), and distributed by a private pharmaceutical company, with its use presently limited to the Kenya Coast. Its technical characteristics include strain specificity and the need for a cold chain, which requires using liquid nitrogen during vaccine transport and delivery. After immunization, animals need monitoring for at least 28 days to detect clinical reactors, which are treated with antitheilerial drugs. The estimated cost of US$ 16-20 for this product is relatively high compared to other ECF control measures. In addition to this high cost, farmers face information asymmetries not only regarding its availability, but also on the costs and benefits of the procedure, particularly its efficacy to protect against ECF, as well as price discovery for both the product and associated services. The service provider for this product is always a vet, whose distribution is often low compared to other types of providers. Farmers therefore incur high uncertainty costs in obtaining a vet, particularly in rural areas, and additional search and screening costs for one who is willing and able to deliver ITM. Additionally, there are the negotiation costs of the risk of missing a vet and having to look for alternatives. The requirement of a cold chain brings about the enforcement costs associated with product quality, which cannot be determined at the time of immunization. Thus should the cold chain break anywhere along the distribution chain, this can only be detectable afterwards when immunized animals fall sick with ECF and require treatment. In such a situation, problems of liability also arise as to who should compensate the farmer for any losses incurred (Table 3.4).

3.6.2. Economic characteristics and delivery

In addition to the technical characteristics of TTBD control technologies, their economic characteristics also determine the appropriateness of their channels of delivery to farmers by identifying the roles of the different actors in delivery.

Economic theory can be used to classify the technologies by their economic characteristics on the basis of their public or private-good nature, which is in turn determined by their levels of rivalry and excludability (Picciotto 1995). Private goods are those for which consumers capture full benefits because the goods exhibit a high degree of rivalry and excludability. With high rivalry, consumption by one individual diminishes product availability to other consumers, while high excludability means that individual consumers, usually non-payers, can be prevented from benefiting (Umali et al. 1992; Picciotto 1995; Holden 1999). Treatment drugs have high excludability and high rivalry since they are only available to those who pay for them, and only one farmer benefits at any one time from the service provider who carries out their administration to sick animals, making them private goods (Table 3.5). Services associated with ECF treatment, including diagnosis, purchase of treatment drugs and drug administration are also private goods, which are best delivered to farmers by the private sector (Umali et al. 1992; Holden 1999). Both product registration and quality control have public good characteristics, which, together with disease reporting for epidemiological surveillance, may merit collective action or state intervention.

Table 3.5. Economic characteristics of TTBD products and services

Excludability	**Rivalry:** *Low*	**Rivalry:** *High*
Low	Public goods • Animal health management and advice • Quality control of ITM • Quality control of TTBD drugs • Quality control of TTBD services	Common Pool goods • ITM immunization to establish endemic stability in an area
High	Toll goods • Tick control by dipping • Production of ITM	Private goods • Disease diagnosis and administration of treatment drugs • Purchasing of treatment package • Purchasing of acaricides • Tick control by hand spraying • Tick control by pour ons (synthetic pyrethroids) • ITM immunization

Adapted from Picciotto, 1995, pp7.

Tick control measures (dipping, spraying and pour ons) have different economic characteristics that cover the spectrum from toll goods to fully private goods. Dipping is a toll good whereby several animals can be attended to at the same time but farmers who fail to pay for their animals can be excluded. The high excludability makes it possible for delivery by the private sector. However, poor management may result in negative externalities such as environmental contamination and tick resistance to specific acaricides, whose costs may not be fully met by the individual farmers causing these spillover effects. This calls for collective decision- making and regulatory activities in order to minimize the negative externalities and effectively internalize those that cannot be avoided, particularly with regard to the risk of developing tick resistance to acaricides. Hand spraying involves the washing of individual animals with an acaricide formulation, with farmers being the main actors in product administration. Farmers who fail to pay for the product are denied access (high excludability) and no two farmers can benefit from the product at any one time (high rivalry). Purchase of acaricides, diluting of the acaricide formulation and maintenance of hand pumps are all private goods and should therefore be delivered by the private sector. However, it is critical for the farmers to have advice on the correct formulation of acaricides, the appropriate chemical to adopt should the one in use fail to work, and the frequency with which to change from one chemical to another in order to avoid the risk of developing tick resistance to acaricides. This calls for public sector participation for equity considerations to ensure that all farmers have access to information on appropriate use of acaricides. Pour-ons are also private goods with high excludability and high rivalry whose benefit depends on their proper use.

Vaccination against ECF has largely private good characteristics, which call for delivery by the private sector. However, vaccination in a given area can have potential wider epidemiological benefits by establishing endemic stability[4] and consequently reducing the risk of acute ECF challenge. Delivery of this technology requires public sector intervention to monitor quality control, assess the need for vaccination (using epidemiological surveillance in an area) and ensure that potential positive externalities are effectively captured.

3.7. Key problems

Previous sections have compared current delivery systems with the model of perfect competition while pointing out any deviations, and subsequently explained how transaction costs associated with TTBD control technologies were derived using technical characteristics. Economic characteristics were used to suggest appropriate roles of different sectors in delivery. This section discusses in detail problems identified with current delivery systems and suggests possible strategies to address them.

3.7.1. Information asymmetries and quality control

Farmers who decide to use a service provider lack perfect information about service providers and their actions, which gives the service provider a scope for opportunistic behavior and incentives to provide low quality services. For example, the cold chain requirement with ITM immunization presents a potential for moral hazard problems since it is impossible for farmers to determine the quality of the vaccine at the time of immunization, which forces them to engage a service provider under uncertainty.

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[4] Endemic stability refers to an epidemiological situation in which "…a large population of the cattle population in an area are immune to the disease". In the case of ECF, animals can become immune by six months of age (Norval et al. 1992), having been exposed to some challenge of the disease without suffering clinical signs.

In the delivery of TTBD control products and associated services, a wide range of service providers are involved, including those without formal veterinary training, and consistent with earlier work (Leonard 1993), this study found that farmers have difficulty differentiating the different service provider types, all of whom are often known locally as "doctors". Bergen et al. (1992) suggest three ways that the principal (in this case the farmer) can overcome problems of information asymmetries: screening of agents (in this case service providers), providing opportunities for self-selection, and using signals from potential agents. The first is very costly for smallholder farmers, as there are currently no standardized mechanisms to provide them with information on the types of services, scope of practice or the expected quality of services from the different types of service providers, and farmers generally rely on experience and reputation of such agents. The second approach, self-selection, is largely a function of the density of the service providers in a given area. For example, in rural areas with low distribution of qualified service providers, farmers have limited choices that result in local monopolies due to low competition. Signalling by the agent is probably the most applicable in smallholder systems where agents are aware that clients have difficulty telling them apart, and will use such signals as local advertising, offering credit and free technical advice, and participating in farmer field days. Unfortunately, signalling offers possibilities for opportunistic behavior in that an agent may not provide the expected quality of services since there are few, if any, performance evaluation mechanisms that farmers can use for quality control of the services given.

Information asymmetries can be partially offset by external quality control. Quality control calls for a regulatory mechanism that allows certification of service providers, making them accountable for the quality of services they deliver and preventing them from engaging in opportunistic actions. Public sector involvement is necessary to address the problems of moral hazard and equity considerations, although this threatens extending the already overburdened public funding and may encourage cheating by public agencies. One way to address these issues is by having shared responsibility between the public and private sectors with private funding coming through KVA and KVB. This can be achieved through a policing body, such as the Licensed Veterinary Inspectors (LVI) suggested by Holden (1999), to supervise practitioners in the field, protect farmers from abuse and exploitation, and ensure that animals are getting the correct medication and dosage. Such a body should be composed of certified private veterinarians who are answerable to the KVB, and acting on behalf of the government. LVI would pay random supervisory visits to practitioners and provide a voice mechanism for farmer complaints. One disadvantage of this body is that it may introduce opportunities for rent seeking, but this could be addressed by offering the LVI members a competitive, renewable contract with the government with adequate remuneration.

Quality control for tick control products merits special attention due to the negative externalities associated with the risk of resistance. With market liberalization, farmers are now faced with a wide range of acaricide choices including counterfeit products, and selecting an appropriate product is difficult for a farmer lacking professional advice. Once they fail to get full satisfaction with a product, farmers are likely to continuously change from one acaricide to another, increasing the risk of developing tick resistance to acaricides. These costs can be minimized by marketing channels that offer technical advice in addition to sale of products, as is typically done by qualified service providers. Lessons can be borrowed from delivery of services through community-based animal health services (CAHS) in pastoralist areas (Catley 1997; Leyland and Akabwai 1999), where the community selects individuals to be trained, often by private veterinarians, on ethical standards and basic animal health services, including vaccinations. These models may work in the supply of tick control products where agents who wish to sell tick control products could undergo a short course (with full cost recovery) in order to address information costs. One disadvantage is that the individual who undergoes training may not always be the one selling the products (as majority of the stores selling tick control products are private businesses selling a variety of non-veterinary products). The process of applying for training may also turn out to be rather political. A more viable alternative is to have an increased involvement of paravets, who represent the majority of service providers, by expanding their scope of private practice as discussed in the next section.

3.7.2. Farmer access to services and the paravet issue

Consistent with earlier work (Leonard 1993), the present study shows that although paravets constitute the largest number of service providers across the study areas irrespective of market access, legislation presents entry barriers to their participation in private practice. This raises unnecessary transaction costs not only for the farmer but also along the marketing chain. Due to the low number of veterinarians particularly in rural areas, farmers face high transaction costs to access quality services and have a higher probability of engaging an unqualified service provider. Using the more available paravets could reduce these types of transaction costs, but only if a sufficiently high standard of training is assured. Currently, the system under-utilizes paravets and fails to take advantage of their service potential. Before liberalization, the state was solely responsible for service supply, and the majority of service providers were state-employed. Roles of the different cadres were also well defined: veterinarians were in charge of discharging animal health services, while paravets assisted them in such duties as diagnosis and treatment of minor diseases, deworming, immunizations and reporting of more complicated cases. This vertically integrated governance structure acted as a public "firm" to reduce a variety of transaction costs for both the farmer and other actors in the delivery channel. There were minimal information costs for the farmer who knew where to seek for services, and that the quality of services provided by the "doctor in charge" was superior. Service and product prices were also standardized across production systems regardless of the level of training of service providers supplying them. With government offices at divisional level, the state achieved not only a geographically equitable supply of services, but also quality control through the supervisory roles of the veterinarians. Disadvantages with this institutional arrangement include lack of incentives for service providers to perform well, leading to opportunistic behavior. Rather than being demand-driven, service delivery involves a top-down mechanism in which the economic actors in the lower end of the chain have no "voice". This arrangement also tends to favor veterinarians than other cadres of service providers, thereby creating disincentives for the latter.

Following liberalization, the government has increasingly reduced public provision of services and encouraged the development of the private sector to improve competition. A policy that previously allowed automatic public recruitment of new graduate veterinarians was ended in 1988, and special financial incentives have been availed through the KVA-Privatization Scheme (KVAPS) for veterinarians to set up private practices (Wamukoya et al. 1995; Tambi et al. 1997). Presently, service supply is more market-oriented, with increasing private services creating competition at farm level. The advantages of this arrangement are that it is more demand-driven, with incentives to improve performance by actors, thereby enhancing efficiency as opposed to the hierarchy form of contracting. Additionally, KVA and KVB have adopted a self-policing role to ensure professionalism and quality control, although the degree to which they manage to achieve this is unclear. However, as postulated by Hubbard (1997) regarding the role of politics, the development of these institutions has probably been motivated largely by a perceived need to protect the interests of veterinarians over those of other types of service providers. Membership to KVB and

KVA is limited exclusively to veterinarians, creating barriers to the effective utilization of paravets, whose role in the market system is not well defined. The market system also achieves less equitable supply of services to farmers due to the unequal geographical distribution of service providers, resulting in higher information costs for farmers to access services.

How can the market take advantage of the qualities of paravets who have a more rural distribution and tend to live within the farming communities? One alternative is to integrate them fully into the practitioners' guild and allow them to compete with veterinarians in a free market. This would create competition by sheer numbers and achieve a more equitable distribution of services. The main problem with such a system is that quality control is much more difficult to enforce and in the long run, may result in adverse selection against veterinarians. The alternative is a more vertically integrated system in which veterinarians assume a supervisory role over paravets, permitting paravets to have a wider range of responsibilities, particularly in rural areas. Such systems would be similar to the 'clinical runs' that were operated by government services prior to liberalization. These market systems would achieve quality control more effectively and minimize a number of transaction costs not only for the rural farmer (particularly information and quality control) but also for the market system in enhancing equity in the distribution of services. However, this would require a regulatory role for the state to clearly define the scope of functions that paravets can perform to control service quality more effectively. One main disadvantage of such a system is the risk of opportunistic behavior by veterinarians who would be positioned to exploit paravets. This can be addressed through forming a paraveterinarians' association, which would provide them with a voice and offer guidelines on their scope of practice to ensure professionalism and provide a mechanism for links between veterinarians and paravets.

3.7.3. Farmer enforcement

A serious gap existing in the delivery of TTBD control products and services is that livestock owners are not recognized as major stakeholders and their role in delivery is often not appreciated. Farmers lack channels that provide them with a "voice mechanism" in cases of dissatisfaction, and are essentially limited to "exiting", refusing to engage in future a service provider whom they find unsatisfactory. In areas with low density of service providers, farmers have low bargaining power and official governance channels through which they can raise complaints are lacking, as the present systems remain "top-down" oriented. One alternative is to address this through an LVI-type body discussed earlier, where farmers would present problems encountered in negotiating and enforcing contracts with their agents. Such problems can be raised through the farmer associations or directly to LVI. Additionally, farmers should have representation in KVB, and have a say in governance laws associated with delivery of animal health services. Currently KVB appears biased towards the interest of veterinarians and the degree to which this body protects farmers' interests is not clear.

3.8. Conclusions

This study has evaluated current delivery systems using an innovative conceptual framework that combines two economic analytical approaches: SCP to compare performance of service delivery against the model of perfect competition and NIE to study transaction costs associated with the products and services being delivered. To our knowledge, this is the first time that SCP has been used to evaluate livestock health delivery systems. The approach does offer certain insights but does not appear to be useful as with more atomistic markets, such as grain markets. Additionally, the importance of transaction costs, which tend to be rather high in developing country markets, is overlooked by SCP, necessitating the use of NIE as a complement.

Although transaction cost analysis has received a lot of attention in the last fifteen years, its development remains mainly theoretical, with empirical measurement mostly limited to industrial studies (Rindfleisch and Heide 1997). There being no standardized methodologies for the measurement and analysis of transaction costs, TTBD control technologies were characterized into their technical and economic characteristics in order to identify sources and types of transaction costs and evaluate the effectiveness of the different channels in minimizing them. The study has not only demonstrated the utility of this using a transaction costs "lens" in order to identify potential inefficiencies, but has also highlighted the role of transaction costs as an important constraint in the delivery of animal health services to farmers. The challenge of future research is the measurement of transaction costs using specific indicators in a more direct manner.

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Chapter 4

Constraints to smallholder dairying in Kenya: transaction costs and the use of animal health services

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Abstract

Despite the existence of various technical packages to improve disease control, their utilization remains poor among livestock keepers in developing countries. Using the application of the New Institutional Economics framework, this study examines the role of transaction costs on the choice of animal health services by smallholder dairy farmers in the central highlands of Kenya.

Two separate choice models are tested using a multinomial probit analysis, namely the use of a veterinarian and that of a para-veterinarian by a sample of 344 dairy farmers. Explanatory factors include farmer, farm and community-level characteristics, a number of which represent farm-specific transaction costs. The most important variables in the utilization of health services are gender of the household head, ethnicity of the nearest service provider, service provider density around each farm, quality of services offered by the nearest vet / paravet and travel time from the farm. The implications of these results are that uptake of livestock disease control technologies can be enhanced by designing policies that would minimize transaction costs.

4.1. Introduction

Animal health services in developing countries are characterized by poor uptake of existing control technologies, resulting in poor disease control and contributing to continued low livestock productivity. This means that despite the availability of technologies to alleviate disease problems, farmers are not accessing them effectively. Studies have traditionally focused on the supply side with the objective of evaluating factors that help to explain this low uptake in order to identify opportunities for improving delivery systems and access to available technologies. Research efforts have for the last decade been directed towards improving the delivery of animal health services through privatization (Leonard 1987, 1993; Holden et al. 1996) while others have argued for finding the right balance between public and private delivery (Umali et al. 1992; Schillhorn van Veen and de Haan 1995; Ekboir 1999). Although this approach has been invaluable in focusing attention on the role of weak and inappropriate delivery systems in constraining the use of technologies, the picture is not yet complete. A few studies have looked, instead, on the demand side and examined the role of farmer socio-economic characteristics in explaining low adoption, such as, for example, the low demand for private veterinary services in Kenya (Tambi et al. 1999) and that for pour-on treatment for tsetse control in Ethiopia (Swallow et al. 1995; Wangila et al. 1997), and others have highlighted the importance of price (Echessah et al. 1997). These studies help to explain initial adoption or non-adoption of technologies or services, but offer little insight regarding subsequent under-utilization of those technologies or services. Alternatively, the problem can be viewed as one of farmer access that requires a better understanding of farmers' decision making when faced with animal health choices and identifying, from the farmer perspective, those factors that limit the use of available control technologies. An interesting approach to evaluate such constraints has been suggested in recent work by Leonard et al. (1999) and Leonard (2000) who use the New Institutional Economics (NIE) framework to argue for the importance of transaction costs in explaining under-utilization of livestock health services. Although such costs affect delivery of services all along the distribution chain, their effects are felt much more at the producer level. However, no empirical evidence has been provided to support this hypothesis. It is therefore necessary to examine the factors affecting farmers' decision making with a particular emphasis on the role of transaction costs in animal health choices, which is the subject of this paper.

Although NIE has been applied to categorize livestock services by their economic characteristics and subsequently identify the appropriate sector - public or private - for their delivery (Umali et al. 1992; Holden 1999), a major dimension of the NIE that has been less utilized is understanding the role of transaction and information costs in farmer access to animal health services and products. The transaction costs economics (TCE) approach argues that there are many different types of costs beyond price, both pecuniary and non-pecuniary, associated with arranging and carrying out a market exchange (Nabli and Nugent 1989; Toye 1995; Hubbard 1997). These have been categorized into i) information costs which arise prior to the exchange and include costs of price discovery and searching for and screening potential trade partners, ii) negotiation costs, encompassing those costs arising during the actual transaction such as the physical transfer of the product or service and iii) enforcement costs which occur after the transaction and involve monitoring and coordinating the terms of the exchange (Hobbs 1997). A major shortfall of the TCE approach is that despite substantial progress in developing its theoretical base over the last decade, few studies exist that have actually attempted to quantify the effects of transaction costs. This can be attributed not only to the, as yet, limited recognition of this theory within mainstream economic theory, but also to the practical problems associated with quantifying transaction costs. Moreover, as pointed out by Staal et al. (1997), the costs of executing an otherwise advantageous exchange may be so high relative to the net benefits realized that they may prevent the transaction from taking place altogether, in which case the transaction costs are unobservable.

Because there is no clearly defined way of collecting information on and measuring the effects of transaction costs, previous studies have generally used indirect approaches with econometric analyses. Goetze (1992), for example, uses a number of variables including ethnicity (as a proxy for access to information), infrastructure, distance to market and transport ownership to capture the influence of transaction costs on

Senegalese farmers' decisions to participate in coarse grain markets. Hobbs (1997) considers the transaction costs faced by cattle producers with two outlets for selling their beef cattle in a United Kingdom market. She uses an innovative approach to collect data by applying a number of objective and subjective indicators to measure a wide range of transaction costs. Objective indicators include time spent at the auction and speed of payment while subjective indicators include farmer perceptions on, for example, the risk of not selling the cattle, and the weight loss from transport and waiting time, both scored on a scale of one to five. These are then included as explanatory variables in an econometric model of farmer's choice of an outlet.

More specific to animal health services, transaction costs have been specifically identified as a constraint relevant to state-delivered services, creating disincentives and distortions for government veterinarians, and consequently reducing efficiency of service provision (Leonard 1993, 2000; Leonard et al. 1999). However, there is limited empirical work addressing the role of transaction costs from the producer perspective, and the few available studies have tended to focus on distance as a single measure to represent all transaction costs. While distance is a useful proxy that can represent a number of transaction costs such as transportation, time opportunity costs and access to service information, it does not permit distinguishing the different types of costs and their relative importance. Examples of empirical studies that have used distance to measure the effects of transaction costs on the utilization of livestock services include Oruko (1999), who finds distance inconsistently significant in the demand for veterinary services in two districts of Kenya. Woods (2000) presents the effects of distance and gender in the utilization of veterinary services in Zimbabwe and concludes that travel time and transport are negatively related to the use of services. Thus, although these studies have highlighted the importance of distance and other socio-economic factors in the farmers' choice of animal health services, the role of different types of transaction costs in this choice remains unclear.

We hypothesize that high transaction costs faced by smallholder farmers in accessing disease control technologies and services influence farmer decision - making, and may help to explain their low uptake. For example, a Kenyan farmer who is faced with a suspected case of East Coast fever (ECF), a debilitating tick-borne disease of cattle that is often fatal if not treated early, faces a variety of transaction costs. Such a farmer not only incurs the transport, time and opportunity costs to fetch quickly a service provider to administer treatment and avoid losing the animal, but also other costs associated with the characteristics of the service provider. A service provider who is slow to respond may bring about wasted time and loss of money for the farmer as a result of delays of treatment administration and possible loss of the animal. Slow service may also require the farmer to make additional trips to remind the service provider, or to look for alternative treatment. In addition, there are risks that the service provider does not administer the correct formulation and dosage of the treatment package or uses ineffective or expired drugs. Effective response to ECF therefore necessitates identification of service providers who offer timely and efficient services matching the expected level of quality.

There is therefore need to better understand the role of transaction costs in farmers' utilization of animal health services in order to identify policies and interventions to reduce their impact. This paper examines the impact of household level transaction costs using a set of direct and indirect indicators, on the choice of animal health services by smallholder dairy farmers in the central highlands of Kenya.

4.2. Methods

4.2.1. Conceptual model

Our study involves evaluating the factors that determine the utilization of animal health services by smallholder dairy farmers during one year preceding the survey. Farmers are faced with several choices in the utilization of services, which are a function of various factors such as the type of disease problem and whether or not this requires urgent treatment, and availability of and access to services. A farmer who faces the problem of perceived disease risk makes a decision of whether or not to use preventive services (used to protect animals from getting sick, either through vaccinations, tick control or check-ups), while the farmer who encounters an actual disease event decides whether to use the curative services of a service provider or handle the case him / herself. Thus, services may be curative (which are required for already sick animals) or preventive depending on farmer perceptions of risk of disease and / or actual occurrence and type of disease. In Kenya, available options of service providers (SPs) include degree-level professional veterinarians (vets), diploma-level livestock officers (LO), paraveterinarians (paravets) who usually hold a certificate training ranging from a few months to three years and may be animal health assistants (AHA) or junior animal health assistants (JAHA). Still others may have acquired their skills by years of experience rather than through formal training, and include village health scouts (*Wasaidizi*) and traditional healers.

The complexity of farmer choice arises because over a given period of time, the farmer faces different types of animal health situations, and utilization of these sources of services may vary. For example, a farmer who encounters the problem of disease may choose to use the curative or preventive services of any of the available SPs or not, while a farmer who is faced with only perceived disease risk may either choose to use preventive services (from any of the SPs) or not. Thus, within a period of one year, one farmer may use the services of only one type of SP, another may use those of more than one type of SP while yet another may decide not to use any of these services. What factors determine the use of a given service? Our hypothesis is that transaction costs play a major role and that farmers will choose the options involving minimum transaction costs. However, modelling all these choices at the same time over different sets of disease risks and events becomes complicated. We limit our focus on the use of the most common types of services, namely vets and paravets.

Out of the sample of farmers interviewed, only a proportion used veterinary services within the recall period, making the data censored with respect to service utilization. This means that farmers who have not used a service provider will be recorded as non-participants without any indications of how close they came to participating in such services, or the contribution of the explanatory variables to this choice. Although this choice of non-participation can be attributed to a mix of decisions not to use preventive measures or to the absence of health problems requiring attention, Goetze (1995) attributes it to the higher transaction costs faced by non-participants, whose threshold can only be achieved at a cost that exceeds the net benefits of participating. In such cases, ordinary least square (OLS) estimates yield biased parameter estimates, and limited-dependent variable methods provide a solution to obtain unbiased parameter estimates (Green 2000).

Ideally, the problem of the choices that a farmer makes could be approached as a nested (sequential) decision, which would require data on each individual transaction that a farmer carried out. However, the only data available comprised of retrospective information on use of service providers over the previous one year, which could not be linked to the occurrence of disease for any individual transaction made by farmers. Thus, the question being addressed is not which type of service provider (vet or paravet) that a farmer chose, but rather, whether they used a SP or not. We have therefore modelled the use of a vet and that of a paravet as two separate equations.

Let

V_{ijk} = level of expected utility of the i^{th} farmer selecting a SP *j* for a given health event *k* (preventive or curative), where *j* = *v* for a vet, *p* for a paravet and *0* for neither of these SPs. The basic assumption is that for a given health event, farmers will use that SP for which V_{ij} will be highest in order to maximize their expected utility (or expected profit). Thus, a farmer will use a vet if $V_{ivk} > V_{ipk} > V_{i0k}$ and use a paravet if $V_{ipk} > V_{ivk} > V_{i0k}$. Let

Y_{ijk} = 1 if a household has used a SP and Y_{i0k} = 0 be otherwise. For a given event, then, the probability of using a vet, Prob (Y_{ivk} = 1)

= Prob ($V_{ivk} > V_{ipk} > V_{i0k}$) Equation 1

and that of using a paravet, Prob (Y_{ipk} = 1)

= Prob ($V_{ipk} > V_{ivk} > V_{i0k}$).

Now consider whether the farmer used a SP at some point over the recall period (one year in this case). Let Y^*_{ijk} = 1 if $\sum_k^K Y_{ijk} > 0$ (to represent the farmer having used that type of SP at least once during the recall period). Then Prob (Y^*_{iv} = 1) = Prob ($\sum_k^K Y_{ivk} > 0$), and by extension, Prob ($V_{ivk} > V_{ipk} > V_{i0k}$) for some $k \in K$

Thus, considering only the case of vets, for Y^*_{iv} = 1, for some $k \in K$ equation 1 above would yield:

$$= \chi_i \alpha_v + \varepsilon_{iv} > \chi_i \alpha_p + \varepsilon_{ip} > \chi_i \alpha_0 + \varepsilon_{i0} \qquad \text{Equation 2}$$

where χ_i is a vector of exogenous variables explaining farmer *i*'s choice of using a given type of SP (in this case vet *v*), and ε_i is a stochastic component of the utility with zero mean. Re-arranging equation 2 gives the following:

Prob (Y^*_{iv} = 1) = Prob [$\chi_l (\alpha_v - \alpha_p - \alpha_0) > (\varepsilon_v - \varepsilon_p - \varepsilon_0)$]

= Prob ($\chi_l \beta > \mu_l$)

= $F(\chi_l \beta)$ Equation 3

where F is the cumulative distribution function for μ_l and β_l is an unknown parameter vector of χ_l variables to be estimated. Some knowledge of the distribution of F is necessary in order to estimate $F(\chi_l \beta)$, which depends on the distribution of μ_l, the random error term (Green 2000). The probit model is found appropriate because it assumes μ_l to be normally distributed with zero mean.

4.2.2. Empirical model

The empirical specifications for both the decision to use a vet or to use a paravet are similar. This section describes the set of variables included in the analysis, which are also summarized in Table 4.1.

Dependent variables

For the two separate equations, we have used binary responses as dependent variables coded '1' for those who used a vet (and in the second equation, a paravet) and '0' for non-users over the one year preceding the survey. The vet has a higher training and is expected to be more professional and to provide a wider range and higher quality of services than a paravet. However, farmer perceptions of services from each of these types of SPs are varied, and will determine their use of these types of services.

Explanatory variables

The two models are presumed to be a function of the farmer, farm and community-level characteristics, a number of which can be interpreted as representing farm-specific transaction costs.

i. Farmer characteristics

Farmer characteristics are represented by a number of socio-economic factors associated with the household head, and include age in years (AGE), gender (F_GENDER) and level of education (EDUC). Other human capital attributes are captured by the number of years since the farmer became a decision maker (DM_EXP), whether or not the household head is the main decision maker for animal health and husbandry issues (VDM), main occupation (OCCUP - whether or not the household head is involved in full-time farming), and the farmer's level of information (INFO), given by a score derived from a set of questions on farmer perceptions of ticks and their association with disease.

The relationship between farmer age (AGE) and use of services is an empirical question as farmer's age has been found to have varying influence on adoption decisions. While some studies report older farmers to be less likely to adopt newer technologies (Nicholson et al. 1999), others have found it to have no significant role (Adesina and Zinnah 1993; Bester et al. 1999; Tambi et al. 1999). Gender of the household head (GENDER) may also have varied effects on use of service providers. Male farmers are likely to have more access to inputs, capital and information (through farmers networks and contact with extension agents) than female farmers (Dey 1981). However, some recent studies on animal health choices found gender to play little or no role among smallholder farmers in Kenya (Tambi et al. 1999; Heffernan and Misturelli 2000; Randolph and Ndung'u 2000).

Table 4. 1. Descriptive statistics of variables used in the animal health use model

Variable	Description	Proportion (for categorical) or Mean (se) for continuous variables)	Expected sign Vet model	Expected sign Paravet model
VET_USE	Dependent variable. Has farmer used a vet in the last one year? 1 = yes, 0 = no	1 = 40% 0 = 60%		
PARA_USE	Dependent variable. Has farmer used a paravet in the last one year?	1 = 67% 0 = 33%		
AGE	Age of household head in years	51.88 (14.45)	+/-	+/-
F_GENDER	Gender of household head: 1 = male; 0 = female	1 = 84.30% 0 = 15.70%	+/-	+/-
EDUC	Education level of the household head: 0 = none 1= completed primary 2 = secondary and above	2 = 21.93% 1 = 62.87% 0 = 15.20%	+/-	+/-
VDM	Is head also the veterinary decision maker? 1= yes, 0 = no	1 = 76.76% 0 = 23.24%	+	+
DM_EXP	Experience of the decision maker	18.84 (12.32)	+	+
OCCUP	Main occupation of the household head	Farming = 79.07% Formally employed = 14.83% Informal employed = 6.10%	+	+
INFO	Farmer knowledge of ticks and relationship to disease; range = 0-23	13.81 (5.24)	+/-	+/-
FMSIZE	Farm size (acres)	11.09 (16.87)		
ASSETS	Aggregate score based on number of assets owned: range = 26 - 21500	1472 (2393)	+	+
CATTLE	Breeding herd: number of cows & heifers	3.40 (3.13)	+	+
REGION	Regional dummy for the three survey districts	Kiambu = 28% Nyandarua = 37% Nakuru = 35%	+/-	+/-
DSE_RISK	Cattle disease risk: ratio of number sick/ total at risk in a division	0.22 (0.06)	+	+
ECF_RISK	ECF disease risk: ratio of number sick with ECF/ total at risk in a division	0.054 (0.046)	+	+
SAME_GPV	Does vet belong to farmer's ethnicity?	1 = 82.93% 0 = 17.07%	+	-
SAME_GPP	Does paravet belong to farmer's ethnicity?	1 = 89.82% 0 = 10.18%	-	+
EMPLOY_V	Employment of vet: 1 = private, 0 = otherwise	1 = 80.00 0 = 20.00	+	-
EMPLOY_P	Employment of paravet: 1 = private, 0 = otherwise	1 = 81.94% 0 = 18.06	-	+
QUALITY_V	Service quality (farmer perceptions): -1, 0 or 1	-1 = 14.29% 0 = 31.43% 1 = 54.29%	+	-
QUALITY_P	Service quality (farmer perceptions): -1, 0 or 1	-1 = 2.78% 0 = 45.83 1 = 51.39%	-	+
V_PROF_SC	Performance index - professional perceptions: -1, 0 or 1	-1, 0 or 1	+	-
P_PROF_SC	Performance index - professional perceptions: -1, 0 or 1	-1, 0 or 1	-	+
V_DENSITY	Vet density within a radius of 30 minutes travel time from each farm	1.92 (2.61)	+	-
P_DENSITY	Paravet density within a radius of 30 minutes travel time from each farm	2.66 (3.68)	-	+
TTIME_V	Travel time nearest vet (minutes)		-	+
TTIME_P	Travel time nearest paravet (minutes)		+	-
PERIOD_V	Period (years) vet has been in location	5.43 (3.69)	+/-	+/-
PERIOD_P	Period paravet has been in location	5.46 (5.72)	+/-	+/-

se = standard error

Education (EDUC) has been included to represent quality of human capital, as it is thought to be largely responsible for improving access to new technology and general economic welfare (Schultz 1990). Experience (DM_EXP), which can be considered as "on-the-job" training, has been shown to contribute substantially to human capital (Bryant et al. 1981). Educated and experienced farmers are more likely to understand the need to use modern management techniques including animal health services for increasing their dairy production. Knowledge on improved animal husbandry has been found to have a positive relationship with the demand for veterinary services (Tambi et al. 1999). The variables EDUC and DM_EXP are therefore hypothesized to positively influence the choice of use of a service provider. Rather than measuring experience directly, we have used the period of experience since the farmer became a decision maker, as it has been found to be a useful measure (Mueller and Jansen 1988). We have also included a more direct measure of who is responsible for decision-making in each household, specifically for animal health decisions (VDM), as this may differ from the decision making related to general farming and crop management, particularly where cattle are kept for market-oriented dairying. When the household head is responsible for decisions relating to animal health issues, he / she is more directly in touch with the management of the herd and will make decisions that will maximize dairying profits. The expected sign on the variable VDM is therefore positive. The farmer's main occupation (OCCUP) is also hypothesized to play a role in health choices. Those involved in fulltime farming are expected to have more experience with dairying and are consequently much more conversant with raising a healthy herd. Such farmers are also likely to be more committed to livestock production than farmers who carry out farming on a part time basis. However, off-farm income could also serve to finance the use of animal health services. The expected sign on the variable OCCUP is therefore considered an empirical question.

ii. Farm characteristics

Characteristics associated with the farm include total assets owned by a farm, which is represented by an index derived from the estimated market value of a set of indicators (ASSETS), size of the breeding herd composed of the total number of heifers and cows (CATTLE) and livestock management practices indicated by the feeding system for each farm, where stall-feeding is distinguished from open grazing (FEEDING, a binary variable). Asset ownership is expected to positively influence the use of health services as farmers with more assets have better ability to pay. Since vets tend to charge higher professional fees than paraprofessionals, ASSETS is expected to have a positive sign particularly in the use of health services from a vet. Feeding systems vary across the three survey sites. Stall feeding systems (assigned a value of one) involve more intensive production, are more common in more market oriented peri-urban areas (Staal et al. 1998) and require higher inputs including animal health services due to the high value of the animals. FEEDING is therefore expected to have a positive sign in health choices.

iii. Community level characteristics

Community level factors are given by a number of variables associated with the characteristics of the nearest vet (or paravet) to the farm, most of which are also indicators of various types of transaction costs. They include the employment status of the SP (EMPLOY), with privately-employed individuals (value of one) being distinguished from those employed by the government and co-operatives (zero value), a quality index derived using farmer perceptions of the performance and quality of the service provider (QUALITY), and a professional index derived using perceptions of peers of the vet or paravet (PROF_SC). All three variables are expected to have positive signs in the equation. Private service providers are more business-oriented and are under competitive pressure to provide efficient services to farmers in order to maximize their profits and ensure obtaining future contracts. On the other hand, government-employed vets in Kenya often lack means of transportation to the farms and essential drugs for treatment and are often viewed by farmers as offering less efficient services than their private peers (Leonard 1987, 1993). The quality of services provided depends on consumer satisfaction, which is driven by consumer expectations and their perceptions, and determines whether or not farmers will choose to use the same services in the future. The type of employment and quality of services may be expected to be correlated, although a recent study in India finds no significant differences in quality between services supplied by the government and those by the private sector (Ahuja et al. 2000). SAME_GP describes whether or not the service provider belongs to the same ethnic group as the farmer. When both are from the same group, they will share the same vernacular language, and may be expected to contribute to better communication and information networking on animal health and husbandry measures. SAME_GP is therefore hypothesized to influence the use of health services positively. In addition, a variable that describes the period that a service provider has been working in the same locality (PERIOD) is also included, as more information about the person's performance would then be available, reducing one possible source of information asymmetries. The effect on use of the service provider is indeterminate, though, since the additional information afforded by a longer period may be negative or positive, and so will be an empirical question specific to the individual.

Two crude measures of general disease risk and specific ECF risk are also included. ECF is a generally recognized life-threatening disease for cattle, for which farmers are more likely to seek professional treatment. The risk measures are derived using the total number of cattle experiencing any type of sickness (and as a separate factor, perceived ECF cases) divided by the total number of cattle at risk in the households sampled for each administrative division within the period of one year prior to the survey (DSE_RISK and ECF_RISK, respectively). These variables are expected to influence health choices positively.

Additional community-level factors include travel distances and the density of service providers around each farm. Using GIS software (ARC/INFO ESRI 1998) and a modification of the method described by Staal et al. (submitted), distances to all service points from each farm were calculated and the service provider with the least travel time identified (TTIME_V and TTIME_P for vets and paravets, respectively). Mean population density of service providers within a given radius of travel time around each farm, was also calculated (V_DENSITY and P_DENSITY, respectively) and travel time radii of 30, 60 and 90 minutes tested. Travel time is expected to influence health choices negatively since the longer the travel distances, the less likely the farmer is to use a SP. Densities for vets (paravets) are hypothesized to positively (negatively) influence the vet choice and negatively (positively) influence the choice of a paravet.

4.2.3. Estimating marginal probabilities

The size and magnitude of the estimated regression coefficients provide an indication of the impact of each variable on the use of each type of service provider. We can also use the marginal probability approach in order to predict the effect of a change in an explanatory variable on the probability of using a service provider. Marginal probabilities are calculated by multiplying the coefficient estimate of the variable by the standard normal density function of the probit results evaluated at the mean values [dF/dx($\overline{X}_h$ β_i)$\times \beta$]. Different levels of the various variables can then be inserted into the formula to evaluate their effects. In the case of dummy variables taking the value of 0 or 1, the marginal effects are calculated using the difference between predicted probabilities at 0 and 1 (StataCorp 1999; Green 2000). For example, the marginal probability of gender of the household head is given by F($\overline{X}_h \beta_i$) at $\overline{X}_{gender}$ = 1 minus F($\overline{X}_h \beta_i$) at $\overline{X}_{gender}$ = 0.

4.2.4. Data sources

Data were collected in a cross-sectional survey from a total of 344 farms in three smallholder dairy zones of Central Kenya using a structured questionnaire. The three zones were selected on the basis of tick-borne disease risk and a gradient of market access, and included Kiambu (peri-urban with high market access), Nyandarua (rural with low market access) and Nakuru (a transition zone having medium market access). In addition to human resource and farm characteristics, information collected included availability and use of veterinary services using farmer recall over a period of one year prior to the survey. Data collected also included a number of proxies for transaction costs that were expected to influence the choices that farmers made with respect to the use of animal health services. These included farmer perceptions of disease risk, knowledge concerning ticks and their relationship with disease, farmer perceptions of service providers and reasons for their choices of specific service providers among those available. This farm-level phase of data collection was followed by an exhaustive survey of all service providers delivering veterinary services and products to farmers in the same areas. Data collected at the service provider level included personal details, qualifications and level of training, types of services delivered, types of disease cases encountered and professional perceptions of competitors. All households and service provider points were geo-referenced, and this information consequently used to derive, using GIS software (ESRI 1998), the variables for travel time and density of service providers described above[5].

[5] These two variables were obtained based on the available road networks - road sections were assigned a quality variable using assumed travel speeds of 60, 30 and 5 Km/ hour on three types of roads: all weather, bound surface (tarmac); all weather, loose surface (murram); and dry weather only (earth) roads respectively, a slight modification from the

The regression models were estimated by an iterative Maximum Likelihood (ML) procedure (StataCorp 1999). A bivariate probit was initially applied in preliminary trials in order to take into account the obvious potential correlation between the two choice models, for vets and paravets. However, the correlation between the two equations was statistically insignificant and the individual single-equation probit models were found to be more appropriate.

4.3. Results

4.3.1. Availability and farmer use of animal health services

Table 4.2 summarizes the availability of SPs and their use by farmers across the three survey sites. A total of 107 service providers were interviewed, comprising 35 vets and 72 paravets. Vets tend to be located in peri-urban areas: of the total SPs in Kiambu near Nairobi, 40% were vets compared to only 20% of those found in the more rural Nyandarua district. In contrast, Nyandarua had the highest concentration of paravets (80% of the total number of SPs in the district) compared to the proportions found in Nakuru and Kiambu (60 and 63% respectively), although these proportions were not found to be statistically significant using Tukey's and Scheffe's tests of significance (StataCorp 1999). These SPs are the principal sources of animal health services for the 344 farmers interviewed in the three survey districts. Of the total number of farmers, 40% had used the services of a professional vet, 67% used a paravet, and 27% used both, while 19% used neither of these services within the one year preceding the survey. A higher proportion of farmers in Kiambu (57%) used a vet than those in the other two districts (32% and 34% in Nakuru and Nyandarua, respectively). In contrast, a higher percentage of farmers from Nyandarua used

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methodology described by Staal et al. (submitted). It was assumed that "earth" and feeder roads are traveled by foot while other road types are traveled by vehicle.

paravets than did those from Kiambu or Nakuru, consistent with the proportionate availability of the two types of animal health services.

Table 4. 2. Summary of availability and use of animal health services by region

	Kiambu	Nakuru	Nyandarua	All districts
Number of vets	17	11	7	35
Number of paravets	25	19	28	72
Number of farmers interviewed	103	119	122	344
Proportion of farmers using a vet	57.3%	31.9%	33.6%	40.1%
Proportion of farmers using a paravet	51.5%	72.3%	74.6%	66.9%
Proportion of farmers using neither	21.4%	18.5%	27.1%	19.2%
Proportion of farmers using both vets and paravets	30.1%	22.7%	18.9%	26.7%

4.3.2. Empirical probit estimates

The probit models for each type of service provider were first estimated using the full set of factors hypothesized to influence the choice of animal health services. General disease risk (DSE_RISK) was found to be highly collinear with ECF risk (ECF_RISK) as were SP performance judged by peers (PROF_SC) with farmer perceptions of service quality (QUALITY)[6]. DSE_RISK and PROF_SC were subsequently dropped from the analysis to avoid the problem of multicollinearity. The modified probit models were re-estimated and the results of the vet and paravet models are presented in Table 4.3. The estimated models fit the data well as depicted by the χ^2 statistics and the overall fit, which was significant for both models at $p < 0.0003$, as well as the positive and negative predictive values of 74% and 81% respectively[7].

[6] ECF_RISK vs DSE_RISK: r = 0.70; PROF_SC vs QUSALITY: r = 0.6
[7] The lstat command in Stata for Windows is used to test for the predictive ability of the model after estimation. Here, the model's overall ability to correctly make predictions of positive and negative responses is 78.3%.

Table 4. 3. Probit model estimates of variables hypothesized to affect animal health choices

Variable	1. Use of a vet			2. Use of a paravet		
	Coefficient	se	Marginal probability	Coefficient	se	Marginal probability
Farmer characteristics:						
Age of farmer	NA			-0.022[a]	0.008	-0.006
Gender (1 = male, 0 = female)	0.475[a]	0.253	0.149	0.399[b]	0.229	0.134
Age of farmer	NA			-0.022[a]	0.008	-0.006
Education of farmer	0.192	0.167		-0.428[a]	0.166	-0.149
Is hh head the vet decision maker (1 = yes, 0 = no)	0.271	0.224		NA		
Experience of decision maker	0.011[b]	0.007	0.004	0.009	0.009	
Main occupation	0.258	0.257		0.289[d]	0.226	0.129
Information level	0.018	0.017				
Farm characteristics:						
Farm size	-0.004	0.007		0.008[d]	0.006	0.001
Natural logarithm of total farm assets	0.304[a]	0.144	0.101	NA		
Breeding herd	NA			-0.039	0.033	
Feeding systems (1 = stall feeding, 0 = otherwise)	0.408[b]	0.242	0.126	-0.157	0.221	
Community-level characteristics:						
Kiambu district dummy	-0.239	0.292		-0.627[a]	- 0.243	-0.243
Nyandarua district dummy	-0.399[b]	0.244	*	0.114	0.230	
Divisional ECF risk	-10.171[a]	2.561	-3.141	NA		
1. Characteristics of nearest vet:						
Does vet belong to farmer's ethnic group?	0.431[c]	0.285	0.165	0.116	0.272	
Employment type	0.269	0.330		NA		
Service quality (farmer perceptions)	0.370[a]	0.169	0.130	-0.384[a]	0.147	-0.109
Density of vets	0.158[a]	0.051	0.046	NA		
Travel time	-0.003[b]	0.002	-0.002	-0.002	0.002	
2. Characteristics of nearest paravet:						
Service quality (farmer perceptions)	-0.498[a]	0.168	-0.162	0.032	0.159	
Does paravet belong to farmer's ethnic group?	0.907[a]	0.403	0.217	-0.503[c]	0.343	-0.134
Employment type	NA			0.235	0.218	
Density of paravets	-0.061[a]	0.032	-0.016	NA		
Travel time	-0.001	0.002		-0.002[d]	0.002	-0.001
Years in the same location	0.034[a]	0.017	-0.007	-0.019[d]	0.138	-0.007
Constant	-3.220	-3.364	NA	2.314	0.654	NA
Log Likelihood	-151.122			-169.008		
Pseudo R^2	0.2734			0.1192		

se = standard error NA = Not applicable
[a]Significant at < 0.05 [b]Significant at < 0.1 [c]Significant at < 0.15 [d]Significant at < 0.2
* Nyandarua district dummy was not significant in the restricted model of significant variables and its marginal probability was therefore not estimated.

4.3.2.1. Model of use of a vet

Among the statistically significant socio-economic factors in the farmer's use of a vet are gender of the household head ($p < 0.05$) and experience of the main decision maker ($p < 0.15$), both of which have a positive influence on using a vet (Table 4.3). This implies that more experienced male - headed households are more likely to use a vet. Total farm assets, which include the number of dairy cattle owned by the household, is positive and significant ($p < 0.05$), suggesting that wealthier households exhibit a higher probability of using a vet, and low levels of asset ownership present barriers to market participation by the more resource-poor farmers. Farmers practicing stall- feeding for their dairy herds are also more likely to use a vet than those carrying out open grazing ($p < 0.1$).

Most of the significant variables in the decision to use a vet are at community-level. Among the regional dummies, only Nyandarua district is significant ($p < 0.1$), with its negative coefficient implying that farmers from Nyandarua are unlikely to use the services of a vet, consistent with the lower access to markets and infrastructure in this district. The divisional ECF risk variable gave a surprising result, having a negative and highly significant coefficient ($p < 0.0001$). The possible explanation for this is that farmers who do not use a vet have a high probability of ECF, while those who have access to a vet better manage their animals and have fewer cases of the disease.

Several variables associated with the characteristics of service providers and which also represent a number of transaction costs are important in the farmers' use of a vet. Among the characteristics of the nearest vet, four such variables are significant, including whether the vet belonged to the same ethnic group as the farmer (SAME_GPV), service quality as perceived by farmers (QUALITY_V), density of vets (V_DENSITY) and travel time to the nearest vet (TTIME_V), all possessing the hypothesized signs. As expected, travel time to the nearest vet turns out to be negatively correlated with using a vet, meaning that the longer the distance that a farmer needs to travel to seek a vet, the less likely he / she is to use a vet. Also, higher density of vets in a given radius around a farm increases the likelihood for that farm to use a vet. The coefficient on QUALITY_V suggests that farmers' evaluation of the performance of a given SP significantly influences their choice decision. Farmers are more likely to use a vet if their perception of the performance of the nearest vet is high and as hypothesized, if he / she belonged to the same ethnic group as the farmer.

Four characteristics of the alternative service available represented by the nearest paravet are also important in the use of a vet, namely the ethnicity of the nearest paravet (SAME_GPP, $p < 0.05$), his or her perceived service quality (QUALITY_P, $p < 0.01$), density (P_DENSITY, $p < 0.1$) and the period that the latter has been in the area (PERIOD_P, $p < 0.05$), all possessing the hypothesized signs, except ethnicity which could not be explained. This implies that with a well known, higher quality paravet nearby and a higher density of paravets around a farm, the farmer is less likely to choose to use a vet.

Table 4. 4. Transaction costs and the use of a vet

Variable	Coefficient	SE	Z - score
Service quality (farmer perceptions)	0.207^{+}	0.108	1.907
Density of vets	0.117*	0.030	3.950
Travel time to nearest vet	-0.004*	0.001	-3.330
Does vet belong to farmer's ethnic group?	0.604*	0.218	2.766
Log likelihood	-199.298		
Pseudo R^2	0.1124		
LR $chi^2(3)$	50.49		

se = standard error * significant at $p < 0.01$ $^{+}$ significant at $p = 0.05$

Of all the significant variables in the vet model, the most important ones are travel time, density of vets, quality of vet services and ethnicity of the vet, which collectively explain almost half of the variability explained by the overall model according to the pseudo R^2 measures (Table 4.4). This is consistent with our hypothesis that transaction costs present a significant constraint to smallholder farmers' choice of health services.

4.3.2.2. Model of use of a paravet

Fewer factors are found to explain the farmer's choice of using a paravet, as evidenced by the low pseudo R^2 (0.1192) and the smaller number of significant variables (Table 4.3). Among the socio-economic variables, farmer's age and education both negatively influence this choice ($p < 0.01$) while being male (GENDER) and carrying out farming as a main occupation both have a positive influence ($p < 0.1$ and 0.2 respectively). This implies that younger, less educated and male-headed households that are involved in full time farming are more likely to use a paravet. The Kiambu district dummy is highly significant ($p < 0.001$) and negative in this model, implying that farmers from Kiambu district are less likely to use a paravet than are those from Nakuru and Nyandarua districts due to the relatively high access to markets in Kiambu than in the other districts.

Among the transaction costs proxies, perceived quality of the services of the nearest vet (QUALITY_V) and travel time to the nearest paravet (TTIME_P) turn out to be statistically significant ($p < 0.01$ and 0.2 respectively) and negative in this model. Farmers are less likely to use a paravet with increasing travel times to the nearest paravet and with higher quality of the services of the nearest vet. But when the nearest vet is not perceived to deliver high quality professional services, farmers are more likely to use a paravet. The variable PERIOD_V performs poorly and is excluded from this model. The ethnicity of the nearest paravet (SAME_GPP) and the length of stay of the nearest paravet in the location (PERIOD_P) both give a negative coefficient, suggesting that a farmer is less likely to use a paravet if the nearest paravet has stayed in the area for a long period and also belongs to his / her ethnic group. The paravet may have earned negative publicity among farmers, which may be perceived as poor services. However, the unexpected sign on SAME_GPP could not be explained.

4.4. Transaction costs and use of a vet

Among the important factors determining the utilization of veterinary services are transaction costs faced by each household. Only 40% of the total number of farmers interviewed reported to have used a vet within the year preceding the survey, which is comparable to the model's overall predicted probability of 0.37 of choosing to use a vet if all the variables are held constant at their mean values. The probit model can also be used as a tool to predict the probability under scenarios with varying sets of variable levels, as well as evaluating the marginal effects of individual variables. The marginal probability values for the significant variables are presented in Table 4.3[8].

Two variables have been used in this study to represent information costs in terms of access to information: gender and ethnicity, each of which shows relatively high marginal effects. The marginal probability of producer's gender is 15%, which translates to the increase in the probability of using a vet by a male-headed household versus a female-headed household while holding all the other variables constant at their mean values. The lower likelihood for women to use a vet can be attributed to the higher information costs female farmers may face compared to their male counterparts. Gender bias in, for example, extension services, may result in limited access to information on animal health management and early disease detection by female farmers. The marginal effect of ethnicity of the nearest vet is also significant. The probability of using a vet is only 0.25 when vets belong to a different ethnic group

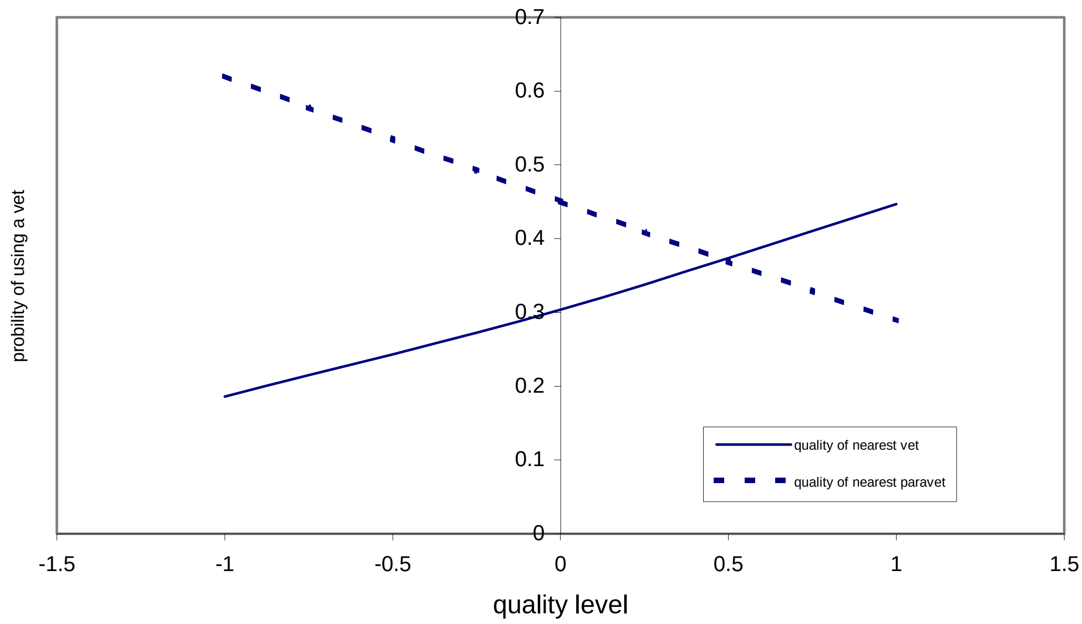
[8] Marginal probabilities were calculated for only those variables that were found significant in the overall model. Nyandarua district dummy was not significant in this restricted model and was dropped in subsequent predicted probability estimates.

from that of a farmer, *ceteris paribus* versus a probability of 0.39 when they are of the same group. Gender and ethnicity represent a number of transaction costs, mostly associated with high information asymmetries when the vet belongs to a different ethnic group from the farmer due to lack of effective communication and trusting relationships.

Lack of information on the location, availability and past performance of the service provider may lead to higher risks for farmers to enter into inappropriate contracts with unsatisfactory performance outcomes. Hidden information turns out to be very expensive for farmers not only during the screening process, but also, and more importantly, due to consequences of hiring the wrong agent (Bergen et al. 1992). For example, because service providers possess better information than farmers do in the treatment of ECF, a service provider selling services and drugs to a farmer may still go ahead and administer expensive curative drugs to a cow with advanced ECF knowing full well that the chances of recovery are low. Such a transaction turns out to be very expensive for the farmer who will incur the double loss in ineffective services and the death of the cow. Costs related to information asymmetries therefore are key factors that prevent more dairy farmers from using a vet, and which, if minimized, would have a significant impact on the demand for veterinary services.

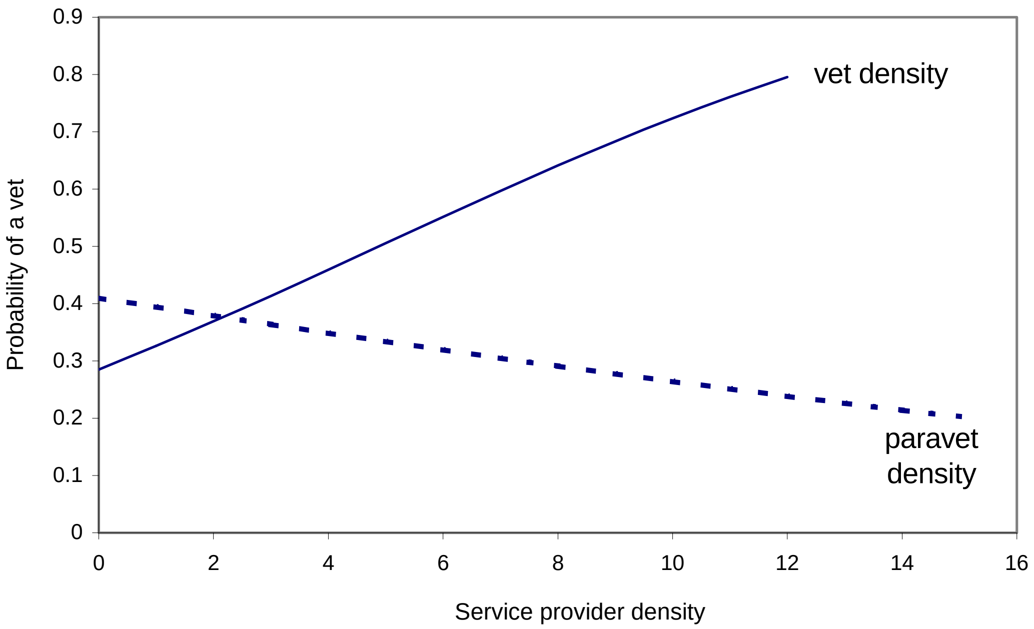
Besides information costs, the model also highlights the role of other transaction costs. Figures 4.1 – 4.3 show the marginal effects on the predicted probability of using a vet as quality scores of the nearest vet and paravet, density of vets around each farm and travel time to the nearest vet are varied. The variable QUALITY represents a range of transaction costs such as, for example, the negotiation costs of services being satisfactorily provided "as advertised" and the availability of a service provider when required, as well as the enforcement costs of minimizing the risk of having to re-contact the vet as a result of unreliable services. Few studies have attempted to empirically measure animal health service quality, mainly due to conceptual problems and lack of defined indicators for evaluation. One such study by Ahuja et al. (2000) recently examined the quality of veterinary services from three categories of service providers in three provinces of India using two indicators: degree of accuracy in diagnosis and prescription, and the success rate of the services measured by the proportion of total SP visits that result in the animal's recovery. Results showed no significant differences among government, private and co-operative services, and the study concluded that service provider characteristics do not explain variation in quality.

Figure 4.1. Effect of service quality on the probability of using a vet



This surprising result could be explained by the fact that service quality as evaluated by the study does not vary across service providers. Although the indicators used in the Indian study provide a crude measure of quality, this may not be entirely reliable as farmers may have decided not to call the service provider back due to the added costs associated with their further visits. Additionally, other transaction costs such as travel time and time opportunity costs may have prevented farmers from seeking service providers. Kleemann (1999) suggests a different approach to measure service quality, which he defines as the consumer's judgment combining the evaluation of the outcome and the process of delivery. He proposes three principles for measuring service quality: customer perceptions and satisfaction, self-evaluation by the service provider and evaluation by external agents, for example peers. Kleemann (1999) suggests that these can be evaluated using such indicators as confidence in supplier, provider responsiveness, reliability and competence.

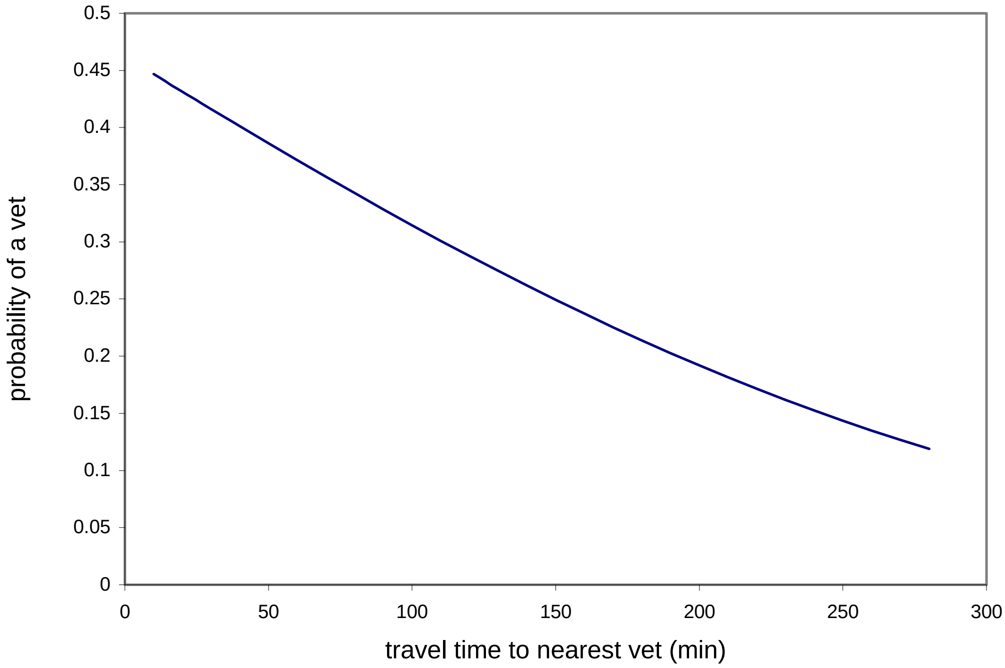
Figure 4.2. Effect of vet and paravet density on probability of using a vet



The present study uses farmer perceptions of service providers and a combination of factors such as reliability, past performance, level of trust and use of appropriate drugs, to calculate a quality index which represents service quality at three levels: low, average and high. However, the econometric model treats these as a continuous variable, where a one-unit increase in quality from low to average or from average to high brings about a 15% increase in the probability of choosing to use a vet. Moreover, holding all other variables constant at their means and evaluating the effect of quality at the three levels gives the probabilities of 0.19, 0.30 and 0.45 respectively (Figure 4.1). This translates to a substantial increase of 26% in the probability of choice of veterinary services when their quality is improved from low to high. Thus, management training of service providers to improve their level of quality in, for example, reliability, professionalism, reputation and trustworthiness will be positively perceived by farmers and result in a higher demand for veterinary services. And as would be expected, the quality of the services of the nearest paravet has a negative effect on the choice of a vet. With low paravet quality, the predicted probability of choosing to use a vet is 0.62, presumably because more farmers will prefer the services of a vet, which re-enforces the importance of high quality services. This probability reduces to 0.29 if the nearest paravet service quality is high.

Figure 4.2 plots predicted probabilities with increasing density of vets around each farm. The probability of using a vet increases with each vet increment until the highest observed density of 12 vets is achieved, at which point it is 0.80. On the other hand, travel time to the nearest vet has the opposite effect on choice (Figure 4.3): lower travel time is associated with an increase in the probability of using a vet. These results show that vet density and travel distances are major limiting factors to utilization of vet services by smallholder dairy farmers. This is consistent with results of a recent study among poor farmers in Kenya (Heffernan and Misturelli 2000), which found accessibility of services to be a major constraint to uptake of veterinary services, with farmer perceptions indicating proximity to be the most important feature determining service use. Such transaction costs become compounded in thin markets with particularly low distribution of vets. For example, a rural farmer in Nyandarua district will face higher costs associated with long travel distances to fetch a service provider than a peri-urban farmer. In such rural areas, service providers experience low competition due to limited numbers of qualified vets, and may therefore not be under pressure to perform to expected service quality, increasing the risk of providing poor quality services to farmers. In such situations, farmers tend to use the more available paravets who are either in government services or more often in the 'informal' private sector as indicated in a recent study (Oruko et al. 2000).

Figure 4.3. Effect of travel time to nearest vet on probability of using a vet



The model therefore suggests that designing policies that would reduce transaction costs associated with density, travel time and quality of services would achieve great impacts in the utilization of veterinary services by smallholder dairy farmers. For example, varying only one of these factors results in a substantial change: increasing the current mean density of vets from 2 to 5 would result in a 37% increase in probability of choosing to use a vet. Adjusting service quality to 1, density to 5 and travel time to 20 minutes yields a predicted probability of 0.66, a 79% increase from that obtained at their means. These results provide evidence that transaction costs indeed play a major role in the farmers' choice of veterinary services.

What policies would encourage vets to set up more private clinics, particularly in rural areas where farmers tend to be sparsely distributed and vets themselves face high transaction costs associated with distance in service delivery? One possibility of increasing the vet density and reducing farmers' travel distances would be contracting out of services by the government to private vets as has been often suggested (McLeod and Wilsmore 2002), or allowing state-employed vets to engage in private practice (Leonard et al. 1999). These vets would be ensured of having a minimum income of their salary from the government and supplementing this with private work, which would effectively minimize their transaction costs associated with thin markets while at the same time achieving a more equitable distribution of vets among smallholder farmers.

Secondly, studies have consistently shown that the distribution of paraprofessionals exceeds that of vets among smallholder farmers (de Haan and Bekure 1991; Leonard 1993; Leonard et al. 1999; Oruko et al. 2000). However, although paravets live closer within the farming communities and are therefore more accessible to farmers than vets, they are only allowed to deliver a limited range of services and legislation presently creates entry barriers to their participation in private practice. One way to utilize their service potential more effectively is to better develop their interface with vets as a way of increasing penetration into rural communities and improving service quality. Vets would have their clinics in their preferred locations and support paravets in the more rural areas, where they would visit to supply paravets with drugs and attend to any cases that require their expertise. Such market systems would also minimize transaction costs associated with service quality through the supervisory role of vets. However, to address the potential of exploitation of paravets by vets, the state would need to carefully re-define the role and functions of paravets as well as facilitate the formation of a professional paravets' regulatory association such as is reported to be happening in Senegal (Leonard 2000). This welfare body would offer guidelines for the scope of practice of paravets, oversee their registration and provide the necessary vet-paravet networks through the vets' professional body.

4.5. Conclusions

Empirical measurement of transaction costs remains problematic, not only because by their nature they are difficult to conceptualize, but also because transaction costs have not been well integrated into mainstream economics. As such there are few precedents for data collection strategies and or attempts to actually measure transaction costs. This paper provides evidence of the utility of using direct and indirect methods of measuring transaction costs.

Results presented here highlight the importance that smallholder farmers give to non-price factors in their choice of animal health services, and that transaction costs help to explain the low utilization of these services. This provides opportunities for improving delivery of animal health services by focusing on measures that minimize transaction costs, such as government contracting of private vets or allowing state-employed vets to carry out private work during non-working hours. Such policies would encourage vets to operate private clinics in the rural areas so as to increase their density and reduce travel time for rural farmers. Delivery can also be improved by facilitating the development of vet-paravet networks to increase vet penetration into farming communities and at the same time improve service quality through the supervision of paravets by vets. Additionally, management training of service providers would help to highlight the importance of service quality.

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Chapter 5

Identification of optimal pathways for the delivery of ECF vaccines to smallholder dairy farmers in Kenya

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Abstract

This paper assesses both supply and demand issues to identify the most appropriate pathways to deliver East Coast fever (ECF) vaccines to smallholder dairy farmers in the Central highlands of Kenya. Supply-side analysis uses the New Institutional Economics (NIE) approach to identify transaction costs associated with delivery and the appropriate roles of the public and private sectors. The main issues arising from the supply side and that require appropriate policies include the high information asymmetries that farmers face, lack of appropriate quality control measures and the limited accessibility to products and services by farmers.

Demand-side analysis evaluates the variability of actual and perceived ECF risk based on a cross sectional survey of 344 smallholder farms in Kiambu, Nakuru and Nyandarua districts selected on a gradient of market access. Results indicate that ECF risk varies with feeding systems and agro-ecological zones, and farmer perceptions indicate a high willingness to use ECF vaccines. Potential demand for ECF vaccines is relatively high in both Nakuru and Nyandarua districts, and relatively low in Kiambu district where zero-grazing reduces risk substantially. The study suggests utilization of para-veterinarians for ECF vaccine delivery as a particularly effective means of reducing a number of transaction costs by increasing service penetration, especially among rural communities with low densities of veterinarians.

Key words

Delivery systems; livestock health services; transaction costs; tick-borne diseases

5.1. Introduction

Delivery systems for new disease control technologies, such as vaccines, are typically considered only once the new technology has been developed. Yet the impact of a new technology depends on the existence of channels that will effectively deliver it to the end users. Thus, even if a product has successfully been developed, it may have little impact if systems to deliver it to farmers are poor or non-existent (Perry et al., 2001). A good starting point is therefore to evaluate both the delivery systems and the technology *a priori*, in order to ensure that the technologies are not only adapted to the production systems for which they are intended, but that there are suitable pathways in place for their delivery. Such an evaluation can assist policy makers, researchers and other players to target new technologies to the most effective and appropriate systems and ensure impact at the level of the intended end users.

This paper examines potential delivery of a new vaccine for the control of East Coast fever (ECF) in smallholder dairy systems of Kenya, with the first part utilising economic analysis. In the second part, epidemiological tools will be used to characterize the variability of ECF risk in the study areas, with the goal of understanding the potential impact of ECF control, in order to target ECF vaccines to those areas and types of farmers for whom they are likely to result in high impact.

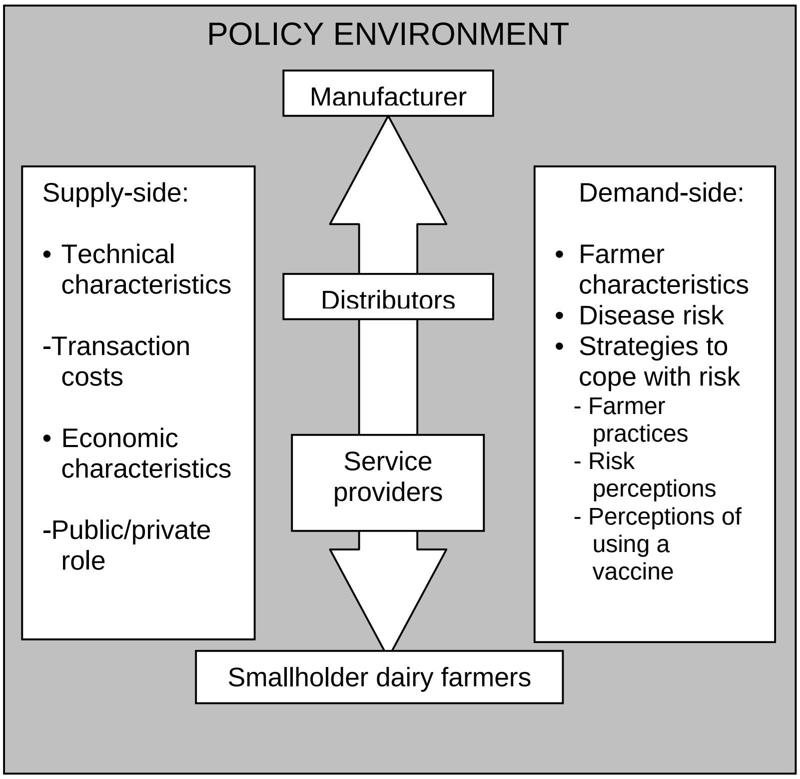
ECF, caused by the protozoan parasite *Theileria parva* and transmitted by the tick vector, *Rhipicephalus appendiculatus,* is the most important tick-borne disease of cattle in eastern, central and southern Africa. Several options are available for ECF prevention and control, including grazing management strategies, tick control by acaricide application and drug therapy of sick animals. Drug therapy and the use of acaricides are both associated with high costs. For a long time, it has been considered that the most cost-effective control measure would be immunization. Currently, only one vaccine, the infection and treatment method (ITM) of ECF immunization is available for use in the ECF-endemic region (Morzaria and Williamson, 1999). Application of ITM, which induces a life-long immunity, is considered technically demanding since it comprises live parasites whose viability must be maintained using liquid nitrogen, and its use requires monitoring of cattle after immunisation. Researchers at the International Livestock Research Institute (ILRI) are developing a recombinant ECF vaccine candidate that is intended to be cheaper and less cumbersome (CCER, 2000; ILRI, 2000; McLeod and Randolph, 2000).

No ECF vaccine is currently available for use in smallholder systems in the central highlands of Kenya, where ECF is a major threat to dairy production. Although ITM has been field-tested and used in the coastal part of the country, it has not yet obtained regulatory approval for use in the rest of the country. The sub-unit vaccine being developed by ILRI and partners will not be available until 2008 at the earliest (CCER, 2000; McLeod and Randolph, 2000). In anticipation of future use of both of these vaccines in smallholder dairy systems of Central Kenya, this study evaluates the efficiency of current delivery systems and identifies important elements in eventual pathways that will ultimately be used to delivery both ITM and the anticipated recombinant ECF vaccines to smallholder farmers.

5.2. Conceptual framework

The overall objective of this study is to identify ways of maximizing the performance efficiency of delivery systems for ECF vaccines. A typical delivery system is composed of various players who take part in the exchange of a product at different levels of the marketing chain (producer to consumer), all operating under state regulatory policies (Figure 5.1). This study hypothesizes that transaction costs are a major constraint in delivery, and that farmers will use those pathways (channels) that are associated with the lowest costs. New institutional economics (NIE), a branch of economic theory that gives attention to transaction costs and the institutions that evolve to minimize these (Hubbard, 1997), provides the framework for the analysis. At the same time, demand-side factors that influence delivery also need to be taken into consideration in structuring the various channels through which the ECF vaccines will reach producers in different production systems. This requires characterizing the variability, if any, of ECF risk and of the willingness of different types of farmers to pay for the vaccines. How these factors vary will determine the marketing strategies that potentially can be used in the delivery of the vaccines to farmers in different production systems.

Figure 5.1. Application of NIE for the delivery of ECF vaccines



The analysis in this paper therefore uses a combination of economic and epidemiological approaches to assess these supply and demand issues. The supply-side component uses NIE to characterise ECF vaccines first according to their technical characteristics in order to identify the sources and types of transaction costs, and second by their economic characteristics, which will determine the appropriate roles of the public and private sectors in delivery. The demand-side component then evaluates the variability of actual and perceived ECF risk as well as the strategies that farmers currently use to manage this risk. The results are used to make recommendations on appropriate strategies that could be used to deliver ECF vaccines to smallholder dairy production systems.

5.3. Materials and methods

5.3.1. Data collection

The study was conducted in three smallholder dairy zones in the central highlands of Kenya (Figure 5.2) selected on the basis of differing tick-borne disease risk and a gradient of market access. These included the districts of Kiambu (peri-urban with relatively good market access), Nyandarua (rural with poor market access) and Nakuru (transition zone with medium market access). Data were collected at the farm, service provider and institutional levels. At the farm level, 115 farms were selected randomly in each district using a list frame from a previous study characterising dairy activities in Kenya (Omore et al., 1999), with particular attention being given to proportional representation of the major agro-ecological zones (AEZ)[9] in the district (Figure 5.2). Information was collected from each farm using a structured questionnaire that covered farmer and farm demographics, perceptions of disease risk and the use of disease control technologies, feeding management practices, tick control practices as well as the number of ECF cases occurring within the previous year. At the service provider level, information obtained included types and sources of the products and services sold to farmers, transaction costs associated with product procurement and disease constraints encountered. Finally, key informant interviews were carried out focusing on identifying national level policies and institutions influencing delivery systems.

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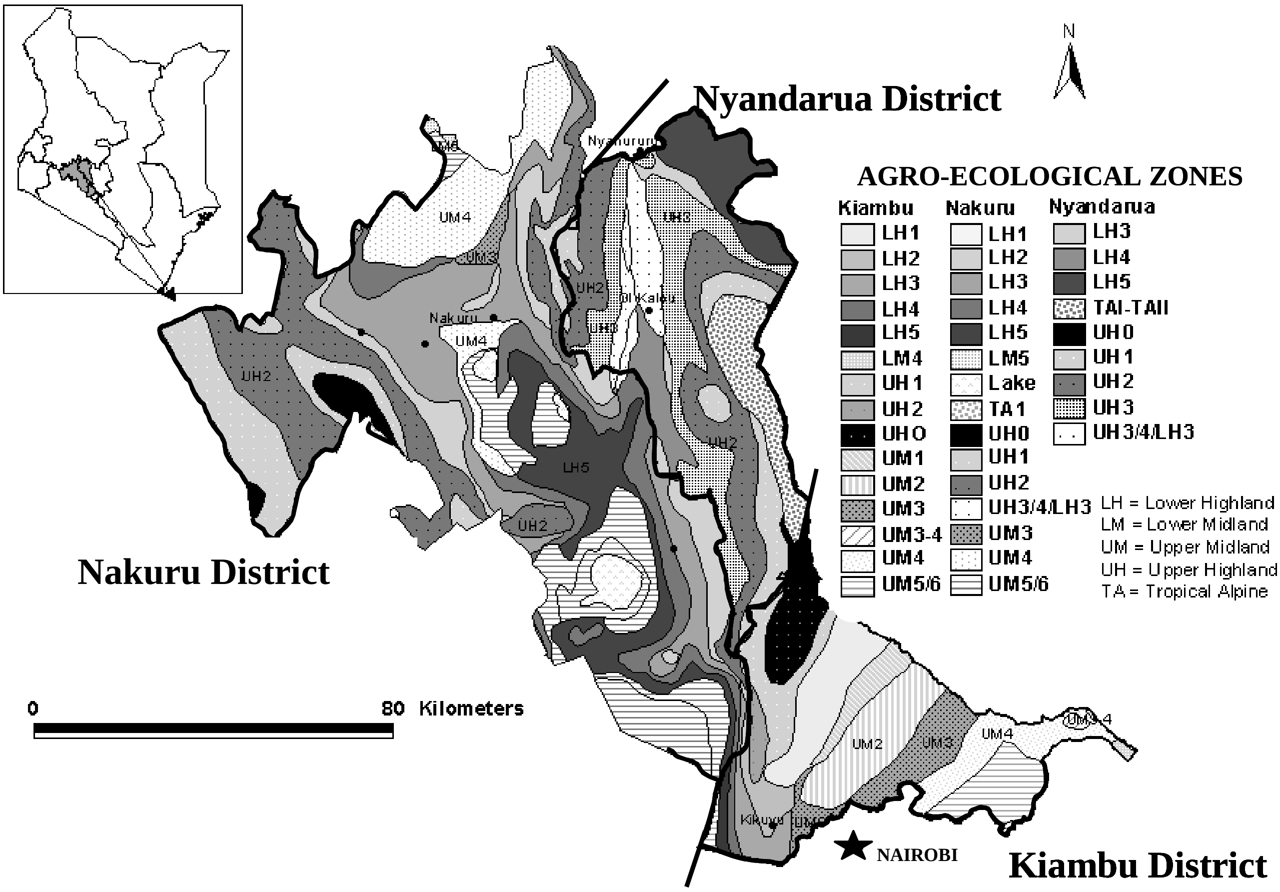
[9] AEZ is a classification of geographic regions based on agro-climatic characterization using a combination of moisture availability, climate and soil pattern, all of which determine the land use potential for both crops and livestock (Jaetzold and Schmidt 1983).

Figure 5.2. Map showing the three survey districts and the distribution of agro-ecological zones



5.3.2. Statistical analysis

ECF incidence was calculated by dividing the number of reported ECF cases by the total number of cattle at risk (including those that had died the previous year), and stratified across districts using AEZ, feeding systems and tick control practices which were expected to influence ECF occurrence. Variability in reported ECF cases across the different factors was tested by a Poisson regression using the iterative maximum likelihood (ML) method, with the total number of cattle at risk as an offset and adjusted for within-herd correlations. The analysis was carried out using Stata for Windows (StataCorp, 1999).

5.4. Current TTBD delivery systems in Kenya

It is anticipated that ECF vaccines will be delivered to farmers as a component of different tick and tick-borne disease (TTBD) control technologies and therefore channels of delivery will be similar. A review of the currently available pathways for TTBD control delivery in smallholder dairy systems in Kenya is therefore necessary in order to evaluate the areas that could accommodate future delivery of ECF vaccines. Although each product will have its own specific delivery chain, the structure of a typical delivery system consists of one or more central manufacturers who produce and supply the product through distributing channels to service providers, who then sell it together with associated services to farmers. TTBD service providers include degree-level veterinarians (vets), diploma-level livestock officers and individuals trained in related professions, certificate-level para-veterinarians (paravets), individuals with no formal veterinary training referred to as *Wasaidizi* (meaning 'helpers' in Kiswahili), experienced farmers and store-owners selling products, all competing to supply services and products to farmers. Results from an earlier study (Ndung'u et al., 2000) showed a general existence of a considerable degree of competition in service provision at the farm level, but farmers may be getting different quality levels of services due to the uneven distribution of service providers. For example, vets were shown to have a more urban and peri-urban distribution, stores were more important in rural areas and paravets were the most important service provider type across the market gradient.

At the different levels of the marketing chain, the various actors are subject to government rules and regulations. For example, only vets who register with the Kenya Veterinary Board (KVB) and are members of the professional body, Kenya Veterinary Association (KVA), are eligible to operate a private clinic. As was the case before liberalization of veterinary services in the early 1990s, paravets are expected to operate under the supervision of a vet and cannot be licensed for private practice. However, although paravets continue to be trained, only a small proportion are now absorbed into state employment, with the rest operating privately in an informal manner. The legal status of paravets is currently unclear since they are not formally integrated into the KVB.

5.5. The NIE of vaccine delivery and utilization by farmers

The different components of the analysis are summarized in Figure 5.1. In the following section, NIE is applied to offer insights on important factors influencing the delivery of the anticipated vaccine products to farmers. The technical and economic requirements for the two vaccines are examined, pointing out the transaction costs that farmers are expected to face in their acquisition, and identifying supply-side issues that would need to be addressed in the delivery of the vaccines for their effective utilization by smallholder farmers.

5.5.1. The Infection and Treatment Method (ITM) and transaction costs

ITM was developed in the 1970s and shown to effectively protect cattle from ECF if used properly, but its widespread adoption by farmers has not been realized to date due to a combination of technical and policy limitations associated with a variety of transaction costs that constrain its delivery (summarized in Table 5.1). These costs can be categorized into information (those occurring prior to the contract), negotiation (occurring during the actual exchange) and monitoring costs (after the contract) (Hobbs 1997). Currently ITM use is restricted to a single geographic region, the Coast Province, and farmers in other parts of the country know little about it; when it is eventually released in the central highlands, it will be perceived as a new technology. This restriction also means that farmers located outside Coast Province have no legal access to the product.

One of the main technical characteristics of ITM is its strain-specificity, which, for farmers, translates into information costs on its ability to effectively protect their animals, as they are not expected to understand its lack of complete cross protection against all strains or the risk of disease in a small proportion of immunized animals. Associated with the use of live organisms maintained through a strict cold chain are a variety of transaction costs, particularly information on product quality in cases of non-compliance with the cold chain leading to vaccine failure, which is not detectable prior to use of the vaccine. In cases of product failure, farmers would face enforcement costs related to liability and compensation claims. In addition, a high product price is brought about by the need for service providers to own liquid nitrogen canisters and the means to transport them to the site of immunization. Further enforcement costs are associated with the requirement for repeated farm-visits by the service provider to monitor post-immunized animals and treat any reactors. This not only increases the vaccine's effective price but may also reduce farmers' confidence in the product as well as in the service provider supplying it, whose services may be viewed as poor and ineffective. Additionally, the vaccine is packaged in 20 doses, which must be used up within four hours once the product has thawed. For smallholder farmers, the majority of whom own only 1-4 animals, this translates to additional negotiation costs of having to organize vaccination for a larger group of farmers to avoid wastage. However, one cost that is effectively minimized by ITM is its ability to give life-long protection to immunized animals, thereby requiring farmers to vaccinate their cattle only once. Current policy regulations restrict vaccination with ITM to only one type of service provider, the vet, and even among these, only those trained on product handling and its special requirements. This implies that farmers in areas with low vet density, as is the case in most rural areas throughout the Developing World, will face higher transaction costs in obtaining vaccination services from a vet.

Table 5. 1. Technical characteristics of ITM and recombinant vaccines and associated transaction costs

ITM technical characteristics	ITM transaction costs	New vaccine's expected technical characteristics	How transaction costs are addressed by the new vaccine
Technology is relatively new	*Information costs* • Access to info about the new technology • Lack of experience for various actors	Technology is new	*Costs that need to be address* • Information on benefits of new vaccine • Lack of experience for various actors
Strain specific	*Information costs* • Imperfect info on ability of vaccine to protect *Negotiation* • May not cross- protect for some strains • May introduce new strains to new areas	Use of antigens conserved across strains	*Costs already addressed:* • Vaccine is not strain specific - protects across strains
95% protective	*Information costs* • Access to info on level of risk of breakthroughs *Enforcement* • Liability issues in cases of failure	95% protective	*Costs that need to be addressed* • Access to information on level of breakthroughs • Liability issues and farmer compensation
Involves live organisms preserved in liquid nitrogen	*Information costs* • Farmers may not favour use of live organisms *Enforcement* • May cause ECF in immunized animals	Composed of schizont + sporozoite antigens	*Costs already addressed* • No live organisms, therefore vaccine not infective • Does not cause adverse reactions • Does not require post-immunization monitoring
Requires cold chain in form of liquid nitrogen	*Information costs* • Access to info on product quality *Negotiation costs* • Requires liquid nitrogen canisters and transport *Enforcement* • Breakdown of cold chain hard to detect • Who compensates farmer in cases of failure?	Vaccine is stable at $\geq 4^{0}$C for $\geq$ 2 years	*Costs already addressed* • Does not require stringent cold chain for freezing • Quality control is easier to maintain *Costs that need to be addressed* • Requires refrigeration / cooling along the chain

Table 5.1. (continued)

ITM technical characteristics	ITM transaction costs	New vaccine's expected technical characteristics	How transaction costs are addressed by the new vaccine
Post-immunization monitoring is required to detect reactors	*Information costs* • Vaccine may appear experimental *Enforcement* • Need to treat reactors increases effective price • Reactor rates may be attributed to poor services		*Costs already addressed* • Does not require post-immunization monitoring - no need for repeated farm visits
Administration of product to animals limited to vets	*Information costs* • Are service providers trained on vaccine use? *Negotiation* • Limited distribution of vets: risk of missing vet • Product availability when needed not assured *Enforcement* • Liability issues in cases of failure		*Costs already addressed* • Product is more user-friendly, easier to handle • Can be used by paravets and some farmers *Costs that need to be addressed* • Actors have limited info - need for training on use • Need for clear policy on vaccine distribution • Clearly define actors' roles to address liability
Estimated cost of US$ 16 - 20	*Information costs* • Price discovery for product and services *Negotiation costs*: • High administration costs raises effective price	Estimated cost of US$ 4.36	*Costs already addressed* • New vaccine is cheaper and more affordable • Provides potential for reduced costs - less drug treatment and tick control
Other costs	*Negotiation costs* • Offers life- long protection • Packaged in 20 doses	Requires two vaccinations at one month and a booster at 1-3 years	*Costs already addressed* • Vaccine is safe to use for all ages *Costs that need to be addressed* • Uncertainty costs on value of boosting

5.5.2. Technical characteristics, transaction costs and the sub-unit vaccine

This section describes the technical characteristics of the envisaged recombinant vaccine and, using lessons learnt from ITM, identifies its associated potential costs and how these can be minimized by the current systems. A product profile of the ideal characteristics of the sub-unit vaccine has been recommended (CCER, 2000; McLeod and Randolph, 2000). The vaccine will comprise recombinant schizont antigens either alone or in combination with sporozoite antigens, which will be delivered to the animal using a commercially available expression system. The product is expected to be stable at $\geq 4^0$ for over two years and provide 95% protection to immunized animals, which should receive two vaccinations after the age of one month followed by a booster at 1-3 years.

These characteristics are associated with specific transaction costs, which are compared in Table 5.1 with those for ITM, pointing out those that are not satisfactorily addressed by the new vaccine. Like ITM, the recombinant vaccine will be new to the market and the various players involved in its delivery are expected to face information costs on particular aspects including the benefits of vaccinating and the level of protection expected. Farmers and service providers will face imperfect information on the benefits of using sub-unit vaccines, and limited experience with the product may lead to low confidence among the players. The new vaccine will hopefully be stable at 4^0C, thereby minimizing the negotiation costs of the high capital and transport requirements associated with liquid nitrogen canisters, although a certain degree of refrigeration will still be required to keep the product cold, necessitating the availability of appropriate institutional structures to be in place. Results from a recent study on the role of the cold chain in the distribution of cattle vaccines suggests that there are adequate cold chain networks in place to handle the future delivery of subunit vaccines in Kenya (Wyrick et al., 2002).

The vaccine protects across several *Theileria* strains and no adverse reactions result in immunized cattle, which do not need monitoring through repeated farm visits. Such a product is easier to standardize and quality control easier to achieve, improving farmer (and service provider) confidence. Unlike ITM, whose administration requires vets, the new product should be user friendly and may not require any special handling procedures. Therefore, rather than restricting vaccine supply to a limited number of vets, these services can more easily be provided by the more widely distributed paravets or even experienced farmers, both of whom would require some form of training. However, the vaccination schedule requiring repeat injections is expected to lead to uncertainty costs, both in terms of the willingness of farmers to repeat the schedule and in terms of farmer access to the product for the later injections. Care should therefore be taken in channelling the vaccine to those pathways that will ensure information dissemination, as farmers are not expected to understand the importance of repeat administration of the same vaccine, and may consider it unnecessary to vaccinate their animals more than once. The second issue relates to suitability of delivery systems and is addressed in the following section.

5.5.3. Economic characteristics and institutional context

The principles of rivalry and excludability can be used to classify the various aspects of the vaccines into public, private, common pool and toll goods, and to suggest the appropriate actors for their financing to ensure their effective supply (Picciotto, 1995; Holden, 1999). A product has high rivalry (or is said to be subtractable) when its consumption by one user reduces its availability to other users, while high excludability means that individual consumers, usually non-payers, can be prevented from benefiting (Umali et al., 1992; Holden, 1999). Private goods, for example, have high rivalry and high excludability while the opposite is true for public goods.

Economic characteristics of the vaccines, including associated services, are summarized in Table 5.2, while recommendations for the most appropriate sector for their delivery are presented in Table 5.3. Production of the sub-unit vaccine, the sale of both vaccines to consumers, and the administration of vaccines to animals, are all private goods and individual consumers can capture their full benefits. These can therefore be supplied and financed more efficiently by the market-oriented private sector. Aspects of the vaccine falling into the public good category and which require a role, though certainly not exclusively, for the public sector, include quality control, the generation and dissemination of information, and ensuring that end users have equitable access to the product. The quality of a vaccine and its administration cannot be easily and visibly evaluated by farmers, creating opportunities for service providers to supply sub-standard goods due to possibilities of moral hazard problems (Umali et al., 1992). This therefore calls for a regulatory role of the public sector. In addition, the private sector may find it unprofitable to supply the vaccine to dispersed and resource-poor end users who are also disadvantaged by poor infrastructure, such as some rural smallholder farming communities. In such cases, vaccine delivery becomes a public good, and the public sector has a role in ensuring that such farmers are not excluded from benefiting.

ITM production is a toll good involving high fixed costs and economies of scale, meaning that per unit production costs fall with higher production volumes. However, the current geographic restriction of immunization to a single location has limited the market for this product, keeping production costs high. These issues may bring about under-investment by the private sector and therefore a likelihood of market failure. The high initial investment costs call for a form of subsidy for establishing the facilities, which can then be managed by the private sector with a possible continued regulatory role for the state. The state should also address any inappropriate policies of vaccine distribution, including regulations on appropriate service providers for delivery (Table 5.3). Situations may arise where vaccination will be effectively carried out throughout an area resulting in endemic stability of ECF[10], in which clinical disease is scarce despite high levels of infection (Norval et al., 1992; Coleman et al., 2001). Immunization would result in reduced disease cases and

Table 5. 2. Economic characteristics of ECF vaccines

Rivalry

Low (Rivalry)	*High* (Rivalry)	**Excludability**
Public goods • Quality control of vaccines • Vaccine and service provider information • Equitable distribution	**Common pool goods** • ECF immunization to establish endemic stability in an area	*Low*
Toll goods • Production of ITM	**Private goods** • Sub unit vaccine production • Vaccine sales • Cattle administration of both vaccines	*High*

Adapted from Holden, 1999

consequently lower the number of infected ticks, which would translate into lowered disease incidence within the general cattle population, benefiting the non-immunized animals as well. This situation represents a type of common pool good, whose low excludability would again lead to under-investment from a social welfare perspective and once again suggesting the need for a public sector role, possibly achieved through sub-contracting of services to the private sector. Delivery could therefore be

[10] Endemic stability is defined as "a climax relationship between host, vector and environment in which all co-exist with the virtual absence of clinical disease…in the case of *T. parva*, the large majority of the cattle population becomes immune by six months of age" (Norval et al 1992).

facilitated through collaboration between the various stakeholders in both public and private sectors and the farming communities who would stand to benefit.

Table 5. 3. Public and private sector roles in the delivery of ECF vaccines

Private sector	Private, with some public subsidy	Public, sub-contracted to private	Public sector
Sub-unit vaccine production	Production of ITM	Quality control of both vaccines	Certification, registration and regulation
ITM and sub-unit vaccine sales		ECF immunization for endemic stability	Vaccine and service provider information
Cattle administration of both vaccines			Service infrastructure for equitable distribution to farmers

Modified from Holden, 1999

5.6. Factors likely to influence smallholder farmer demand for ECF vaccines

Next we shift the focus to the demand-side, with the objective of assessing demand-related issues that suppliers need to consider in proposing appropriate delivery channels. This necessitates characterising the variability of both the actual and perceived ECF risk, and the practices that farmers have adopted as strategies to manage this risk. These factors will serve as proxies for assessing the willingness of farmers to insure against ECF risk, and will therefore help to understand to what degree ECF vaccines may require specific marketing or targeting strategies.

Previous studies have found the prevalence of ECF in smallholder dairy systems to be quite heterogeneous as a result of various factors influencing ECF risk, including agro-ecological zones (AEZ), feeding systems, cattle breeds and farmer practices of tick control (Perry and Young, 1995). *Theileria parva* antibody prevalence was found to vary with AEZ and type of feeding systems in longitudinal studies in Muranga district and coastal Kenya (Deem et al., 1993; Gitau et al., 1997; Gitau et al., 1999; Maloo et al., 2001). In Kiambu district, feeding systems and tick control practices were found to significantly affect ECF risk while the AEZ effect was more homogeneous (O'Callaghan, 1998). These studies found farms that practiced open-grazing to have a higher ECF incidence than those with stall-feeding (locally referred to as zero-grazing), and some AEZs provided a higher risk. This variability suggests that farmer demand will vary significantly in relatively small regions, and targeting will need to be considered as a strategy for delivery of future technologies. Such strategic promotion will help increase the vaccine's reputation, consequently raising the demand among farmers as their perceptions of the product attributes and the visible positive results are known to influence future decisions of adopters (Adesina and Baidu-Forson, 1995; Adesina and Seidi, 1995).

Table 5.4. Farmer characteristics and farm demographics in 344 farms

Variable	Mean (se[#])		
	Kiambu (n=103)	Nakuru (n=119)	Nyandarua (n=122)
Farm size (acres)	2.82 (2.79)	8.00 (10.11)	12.50 (16.56)
Number of cattle	3.95 (2.91)	5.74 (6.05)	5.13 (4.55)
Household members	5.40 (2.34)	6.27 (2.50)	6.01 (2.45)
Age of household head	51.13 (13.71)	52.27 (14.39)	52.12 (15.13)
Years of hh[+] head as decision maker	16.71 (13.40)	17.65 (9.55)	20.86 (12.87)
Wealth index (range: 240-23550)	2241 (2145)	2763 (3648)	2083 (2382)
TTBD information index (range: 1-23)	13.9 (5.2)	13.7 (5.0)	13.8 (5.5)
Av. daily milk production / cow (l)	9.3 (4.8)	4.4 (3.3)	6.6 (4.2)
Proportion of hh income from milk	0.45 (0.31)	0.41 (0.27)	0.46 (0.28)
Milk quantity consumed / hh (l)*	1.78	2.2 (1.0)	2.7 (1.6)
Milk prices / litre (KSh)*	27.5	12.5	13.5

[#] Standard error [+]Household
* Figures were obtained from the Smallholder Dairy Characterisation survey (Staal et al. 2001)

A description of 344 farmers in the study areas is presented in Table 5.4. As expected, average farm sizes were significantly smaller in peri-urban Kiambu than in rural Nakuru and Nyandarua (these two districts were not significantly different from each other). Other characteristics, including age of the household head, number of household members and wealth, as represented by an index derived from the estimated market value of a set of indicators, were not significantly different across districts. Neither was the TTBD information index, a score derived from a set of questions on farmer perceptions of ticks and their association with disease. Average daily milk production per cow and milk prices were highest in Kiambu and lowest in Nyandarua, while Nyandarua households tended to consume larger proportions of their milk production than the other two districts. However, the proportion of income derived from milk sales, which was used as an indicator of the amount sold by each household, was similar across districts.

5.6.1. Variation of ECF risk

Across the three districts, nearly all the animals kept were exotic breeds and their crosses (98%), with very few local breeds (2%), suggesting that the majority of animals in the study areas have a relatively high susceptibility to ECF. The proportional distribution of sampled farms by different risk factors across the three districts is summarized in Table 5.5. The AEZ belts were grouped into four main categories according to altitude[11] (see Figure 5.2). The majority of the sample farms in Kiambu fell under medium and low elevation while the majority of Nakuru farms and nearly all of Nyandarua farms were under medium-high elevation zones. A relatively high proportion of farms in Kiambu were in zero-grazing systems while nearly all the farms in Nyandarua and Nakuru practice open-grazing.

Due to insufficient information on measures of risk and incidence density, the number of cattle at the time of the survey and those reported to have died in the previous year were used to estimate a crude and imperfect measure of the number of cattle at risk. Reported ECF incidence was then calculated as the number of reported ECF

[11] All TA and UH0 belts were designated 'high elevation', all other upper highlands (UH) zones were grouped into ' medium-high elevation', all lower highlands (LH) as 'low-medium elevation' and all upper midlands (UM) as 'low elevation' zones.

cases from the previous year divided by the cattle at risk, and stratified by the various risk factors (Table 5.5). In peri-urban Kiambu, this proxy measure for ECF incidence was relatively low compared to the other two districts. Consistent with previous studies (Gitau et al., 1997; Gitau et al., 1999), open-grazing and semi-zero-grazing systems had a significantly higher reported incidence than zero-grazing systems in this district (p < 0.01 and 0.05. for open and semi-zero grazing, respectively), which translates to a high risk of contracting ECF. However, feeding systems did not significantly affect reported incidence in rural Nyandarua and transition zone Nakuru, owing to the low proportions of farms carrying out zero and semi- zero-grazing (Table 4.5). The proxy measure for ECF incidence was also found to vary with AEZ strata.

Table 5.5. Proportional distribution of risk factors and ECF risk in three districts

Factor	Kiambu (n=103)		Nakuru (n=119)		Nyandarua (n=122)	
	Farms No. (%)	ECF risk*	Farms No. (%)	ECF risk*	Farms No. (%)	ECF risk*
District average ECF risk		2.0%		7.2%		6.7%
Cattle breed		NT		NT		NT
Exotics and crosses[#]	99 (96.1)		117 (98.3)		120 (98.4)	
Local zebus[#]	5 (4.9)		4 (3.4)		2 (1.6)	
AEZ[+]						
High elevation	11 (10.7)	0%	0	-	11 (9.0)	0%
Medium-high elevation	17 (16.5)	2.2%	61 (51.3)	6.3%	109 (89.4)	7.0%
Low-medium elevation	30 (29.1)	3.6%[1]	41 (34.5)	6.9%	2 (1.6)	0%
Low elevation	45 (43.7)	1.2%[2]	17 (14.2)	1.1%[2]	0 (0)	-
Feeding systems:						
Open grazing	30 (29.1)	4.1%[1]	81 (68.1)	7.1%	103 (84.4)	6.6%
Semi - zero grazing	17 (16.5)	2.7%[1]	18 (15.1)	5.7%	13 (10.7)	1.2%
Zero grazing	56 (54.4)	0.5%	20 (16.8)	9.6%	6 (4.9)	0%
Tick control practices:						
Method used						
Spraying	74 (71.8)	NT	104 (87.4)	NT	105 (86.1)	NT
Dipping	7 (6.8)	NT	12 (10.1)	NT	6 (4.9)	NT
None	22 (21.4)	NT	3 (2.5)	NT	11 (9.0)	NT
Frequency of acaricide use						
Intensive	27 (27.2)	2.7%	71 (59.7)	8.5%	45 (36.9)	6.8%[2]
Regular	26 (25.2)	2.7%	28 (23.5)	2.6%[2]	53 (43.4)	5.3%[1]
Occasional	27 (26.2)	0.8%	17 (14.3)	12.3%	13 (10.7)	2.0%
No acaricide use	22 (21.4)	1.5%	3 (2.5)	14.3%	11 (9.0)	30.8%

[#] Three farms had a mixture of zebu and grade cattle
[+] High elevation = all tropical alpines and UH0 zones; medium-high elevation = all other upper highlands; low-medium elevation = all lower highlands; low elevation = all upper midlands
* Risk was calculated as (ECF cases / total cattle at risk including those that had died within the year)
NT: Not tested NS: Not significant
[1] Significant at p < 0.05 [2] Significant at p < 0.10 (using Poisson distribution)

Farms located in low and low-medium elevation AEZs of Kiambu and the low elevation zones of Nakuru had significantly higher risk than those at higher elevations. In Nyandarua, there was little variation in AEZ as nearly 90% of the farms fell under medium-high elevation zones. However, the proxy for ECF risk was still relatively high in the medium-high elevation zones of both Nyandarua and Nakuru, although this was not found to be significant. Nearly all the farms in these two districts were in the high-risk zones using the criteria of AEZ.

5.6.2. Farmer risk perceptions and management strategies

5.6.2.1. Farmer perceptions of risk

Although there were differences in actual risk across the three districts, there were no differences in farmer perceptions of ECF, vaccines, general use of current vaccines and their willingness to use a hypothetical ECF vaccine. Of the total number of disease cases reported over one year, a substantial proportion was attributed to ECF, particularly in Nakuru and Nyandarua districts (Table 5.6). In each district, over 60% of the farmers identified ECF as an example of a disease brought about by ticks. On the main advantages of a vaccine, nearly all farmers cited ability to protect against disease, and over 75% indicated that they would be willing to use a hypothetical ECF vaccine, and the majority would be willing to pay for it. These perceptions suggest that smallholder farmers in the Central Highlands perceive ECF to be an important constraint to their cattle production, and express a willingness to insure against this risk.

5.6.2.2. Farmer risk management practices

Although zero-grazing systems have evolved as part of increasing intensification due to higher land pressure particularly in peri-urban areas, farmers have come to associate them with reduced ECF risk. In Kiambu, where zero-grazing predominates, 48% of the farms relied on little or no acaricides (Table 5.5). Even so, 39% of the zero-grazing farms were still carrying out acaricide application. This reflects the willingness of these farmers to further reduce their ECF risk using more direct and reliable control measures in addition to indirect measures such as feeding management. On the other hand, 41% of the semi-zero and 83% of the open-grazing farms carried out intensive and regular acaricide application, indicating that ECF was perceived as a greater risk in these systems than in zero-grazing ones and farmers were undertaking tick control measures as a strategy to manage this risk. In Nyandarua and Nakuru where nearly all the farms were under open-grazing, over 80% of the farms used acaricides regularly (Table 5.5) and acaricide use was found to significantly reduce ECF incidence in these two districts (p = 0.05 and 0.1 for Nyandarua and Nakuru, respectively) but not in Kiambu district.

Table 5.6. Farmer perceptions of ECF risk in 344 smallholder farms

Factor	No. of farms (proportion)		
	Kiambu (n=103)	Nakuru (n=119)	Nyandarua (n=122)
ECF cases / total no. cases*	8/83 (8%)	48/142 (34%)	41/167 (25%)
ECF deaths / total no. deaths*	3/28 (11%)	20/65 (31%)	32/79 (51%)
Example of disease resulting from ticks:			
ECF	66 (64%)	87 (73%)	65 (53%)
Anaplasmosis	11 (24%)	5 (4%)	25 (20%)
Non-TTBD	1 (1%)	3 (1%)	1 (1%)
Don't know	25 (24%)	24 (20%)	31 (25%)
Main vaccine advantage:			
Protects from disease	99 (96%)	114 (96%)	113 (93%)
Cures sick animals	1 (1%)	1 (1%)	0 (0%)
Don't know	3 (3%)	4 (3%)	9 (7%)
Willingness to use an ECF vaccine:			
Yes	79 (77%)	94 (79%)	101 (83%)
No	24 (23%)	25 (21%)	21 (17%)
Willingness to pay for ECF vaccine:			
Yes	79 (100)	92 (98%)	97 (96%)
Yes, if cheap	0 (0%)	2 (2%)	4 (4%)

***** Figures are given for cattle and not farms (out of a herd of 409, 671 and 611 head of cattle for Kiambu, Nakuru and Nyandarua, respectively).

5.6.3. Considerations for ECF vaccine supply

How are these demand-side issues related to vaccine supply? In theory, a commercial supplier would need to be assured of sufficient demand for the product, and have an indication of whether delivery would be homogeneous across different geographic areas and farmer types, or whether variability exists, thus requiring the development of different marketing strategies. For ECF vaccine supply, the analysis shows that the variability in risk translates to different levels of demand. Although farmer perceptions in these areas are consistent with the level of risk, their use of tick control measures vary across the market access gradient, and can be used as an indicator for their willingness to adopt new ECF control measures. An estimate of the potential demand for ECF vaccines can therefore be calculated based on the combination of the proportions of cattle at risk using the two main risk factors (feeding systems and AEZ strata), and farmer use of current tick control measures.

Table 5.7 shows the proportions of farmers falling into the four possible combinations of potential ECF vaccine demand across the three districts (defined as 'high risk-high use', 'high risk-low use', 'low risk-high use' and 'low risk-low use'). While 65% of the farms in Kiambu district fall under low ECF risk, nearly half of these farms use acaricides, indicating their willingness to further reduce their ECF risk. However, of the 35% farms in Kiambu falling under high risk, an estimated one third do not use acaricides, and are defined as the 'high risk-low use' group. The picture is different for Nakuru and Nyandarua districts where over 80% of the farms are under high risk. Over 70% of the farms in Nakuru and nearly 80% in Nyandarua fall under the 'high risk-high use' category (Table 5.7). These four categories of demand may be expected to respond differently to the introduction of the two ECF vaccine products.

Table 5.7. Estimation of vaccine demand using 344 farms in three districts, Kenya

Risk level / acaricide use level	Kiambu (Total district herd size = 175,000)		Nakuru (Total district herd size = 351,070)		Nyandarua (Total district herd size = 270,470)	
	No farms (% total)	Vaccine demand*	No farms (% total)	Vaccine demand	No farms (% total)	Vaccine demand
High/high	23 (22.4%)	39,200	86 (72.3%)	253,830	97 (79.5%)	215,020
High/low	13 (12.6%)	22,100	13 (10.9%)	38,270	8 (6.6%)	17,850
Low/high	30 (29.1%)	50,900	13 (10.9%)	38,270	1 (0.8%)	2,170
Low/low	37 (35.9%)	62,800	7 (5.9%)	20,700	16 (13.1%)	35,430
Totals	103 (100%)	175,000	119 (100%)	351,070	122 (100%)	270,470

* Demand derived by multiplying the district herd by the proportion of farms under each category of risk/use. For example, the demand for the 'high risk-high use' group in Kiambu was obtained by (175,000 x 22.4%)

5.7. Implications for optimal delivery pathways for ECF vaccines

Several transaction costs associated with ITM immunization could likely be minimized by the use of appropriate changes in the technology and policies. This has been demonstrated in Tanzania, where ECF vaccinations are mainly carried out by paravets and reactor rates have been substantially reduced by use of a stronger antibiotic - 30% instead of the conventional 20% oxytetracycline level (ILRI, 1999; Di Giulio et al., 2000). While several transaction costs constrain the delivery of ITM, the envisaged sub-unit vaccine could minimize a number of these. For example, quality control for ITM needs continuous monitoring all along the delivery chain, but with the sub-unit vaccine this is more likely to be a one time issue to be addressed mainly at the point of production. However, the public sector could have a regulatory role to play in ensuring that the main actors adhere to the appropriate product quality. Quality control and information asymmetries can be addressed by having shared responsibilities between the public and the private sectors with public funding through state-contracting of private veterinarians or through a policing body such as the Licensed Veterinary Inspectors (LVI) suggested earlier (Holden, 1999). However, this requires stringent government regulation to ensure that the service providers perform effectively and supply the product optimally, and may be difficult to fund.

At the farm-level, product information becomes more crucial and will determine the decisions that farmers make as to whether or not to vaccinate their animals. Although information dissemination is fundamentally a public good due to its low excludability and low rivalry, shared roles between the public and the private sectors may be appropriate, in order to balance the self-promoting functions of private sector dissemination. Targeting the most effective delivery channels would ensure that farmers obtain the necessary information on, not only the product, but also the availability and types of service providers who should carry out the vaccinations. A recent study evaluating the effect of extension in smallholder dairy systems in Kenya found producer organizations (referred to as farmer co-operatives) to be the most effective channels of communication with dairy farmers (Wambugu, 2001). These can achieve substantial impact in reaching farmers, particularly in Kiambu and Nyandarua districts where farmer co-operatives play an important role among dairy farmers not only in milk collection, but also in service delivery (Omore et al., 1997; Owango et al., 1998). Other important channels included contact with a private vet during farm visits to treat sick animals, as well as government extension agents. Private vets are an important potential channel of information dissemination, particularly in peri-urban areas such as Kiambu where the distribution of private vets tends to be higher (Oruko, 1999; Ndung'u et al., 2000), whereas government extension agents have been found to be less effective in reaching the majority of the farmers (Wambugu, 2001). The Wambugu study ranked field days, which bring together both government and private extension agents, as the most effective method of extension. This channel therefore should be given priority for passing vaccine information to farmers across the market gradient in a more effective manner.

With supply channels in place, the next important issue is to evaluate where ECF vaccines are likely to be taken up and the factors that need to be taken into consideration in their delivery and marketing within smallholder systems. Measures of economic value of the dairy animal suggest no differences across the three districts (Table 5.3). The only differences are observed in average milk production levels and milk prices, which are higher in Kiambu (which is better placed for sale of milk to the major market, Nairobi, where the demand for dairy products raises the milk prices) than in the other two districts (Staal et al., 2001). Farmers in Kiambu therefore have higher incentives to increase their production through intensification and feeding, as well as to consume less and sell more of their milk production, although they may also face higher input and labour costs. In contrast, Nyandarua farmers are faced with poor infrastructure and low market access, bringing about higher home consumption and lower sales.

Results presented here suggest that ECF risk varies across different production systems and types of farmers, and farmers use certain measures as risk management strategies. The main factors influencing risk in Kiambu are AEZ and feeding systems, while AEZ is the main driving factor in both Nakuru and Nyandarua. The current analysis and earlier work (Gitau et al., 1997; Gitau et al., 1999) suggest that farms falling under zero-grazing and the upper elevation zones have a low ECF risk while all the other types of AEZ as well as open and semi-zero grazing systems present a high ECF risk. Combining effects of these factors with the level of acaricide use gives different scenarios for the demand of ECF vaccines (Table 5.7).

Cattle population estimates from an earlier study (Peeler and Omore, 1997) were used in combination with the data from the 344 farms sampled (see Table 5.7) to get an indication of the potential size of the target population for ECF immunization for the three districts. Based on current acaricide use and farmer perceptions in the study areas, the expected rate of adoption for ECF vaccines is assumed to be 100% of the cattle population falling under 'high use' and 0% of those under 'low use' categories. For example, in Kiambu district with an average herd size of 2.9 per farm, the total herd of 175,000 yields 39,200 head of cattle under the 'high risk-high use' category and 50,900 head under the 'low risk-high use' category while the Nyandarua figures (with an estimated total herd of 270,470 head) for these two groups are 215,000 and 2,200 respectively. Nakuru district has an estimated herd of 253,800 in the 'high risk-high use' and 38,300 in the 'low risk-high use' categories (Table 5.7).

Although the 'high use' groups are expected to exhibit relatively high potential demand, the demand for the 'low risk-high use' group is likely to decline with time and strategies such as adjusting the vaccine price may be required to maintain demand. The 'high risk-high use' group perceives ECF as a threat and exhibits a high level of willingness to insure against it, and is therefore likely to sustain high adoption rates. However, a marketing strategy that could help reduce their ECF risk would be the delivery of an integrated control package, consisting of the vaccine together with accompanying tick control recommendations. Of particular concern is the 'high risk-low use' category of farms, which despite having a high risk (and consequently a good market potential for ECF vaccines) is predicted to have a low adoption rate and is therefore relatively difficult to reach with ECF control interventions. The main focus of delivery for this group, particularly in the more market- and profit-oriented smallholder systems, should be to support decision-making at farm-level through increased access to information on risks, available control measures and management skills so that farmers are better able to make an informed decision on the different options (McDermott et al., 1999).

Zero-grazing, particularly in peri-urban areas, reduces ECF risk for the 'low risk-low use' group and these farmers have no perceived need for use of ECF control measures. However, when ECF does occur in intensive systems (such as when animals are fed with fodder collected off-farm that harbours infected ticks), case fatality rates can be quite high (McDermott et al., 1999). Immunization can be promoted as a type of insurance which covers the animals against the morbidity and mortality risks of ECF, and this would particularly benefit risk-averse farmers falling under this category. With the current tendency for farms to intensify, the proportion of farms falling under the 'low risk-low use' category is likely to increase in the future.

How will the vaccine reach the target population? Under current policies, ECF vaccines are to be delivered to farmers only by vets. Although accurate figures for the total current number of vets in the three districts are not available, these can be estimated from previous work (Ndung'u et al., 2000; Ndung'u et al, submitted)[12]. Thus, 25 vets are expected to vaccinate the estimated total herd of 90,100 under the 'high risk-high use' and 'low risk-high use' categories in Kiambu district. With the current estimate of 3.9 cattle per household in Kiambu (Table 5.4), the number of households over which this herd is distributed is approximately 23,100. This means that for the sub-unit vaccine, each vet should reach an average of 924 households annually for the purpose of ECF vaccination only, making a series of three visits to each farm: an initial visit to administer the first dose, followed by a second visit for the second dose, and a third visit for the booster a few months later, as required. This picture is even more unrealistic in Nyandarua district where the density of vets is much lower than in Kiambu. Here, an estimated 42,580 households fall under high risk, and each vet would therefore be expected to reach 4,260 households and

[12] The total number of vets interviewed in these studies was 17, 11 and 7 for Kiambu, Nakuru and Nyandarua respectively. Allowing an error level for those that may have been missed and including estimates for divisions that were not included in the survey gives 25, 18 and 10 vets for the respective districts.

vaccinate an estimated 21,700 animals, making the necessary three visits for each household to meet the vaccine's technical requirements! Clearly the available number of vets is not enough to reach the target cattle population and satisfy the demand for ECF vaccines, and other alternative delivery pathways must be explored.

The obvious alternative is to use the more widely distributed channels of service provision, specifically paravets, in order to improve farmer access to ECF vaccines. As has been suggested, paravets could be entrusted with preventive and promotive services while being allowed to practice curative services under the supervision of a vet (Leonard, 2000). Although vets might need to remain the primary service provider type for ITM due to the possibility of reactors, paravets who are willing and able could be trained to handle the product under supervision. In the case of the sub-unit vaccine, paravets, who constitute a higher proportion of available service providers than vets do regardless of market access (Ndung'u et al., 2000), can easily achieve a high service penetration. This would lower the transaction costs associated with long travel distances to reach the majority of the farmers, particularly in more remote rural areas with poor infrastructure. However, this would require policy reform to clearly define and expand the scope of practice that paravets are allowed to undertake. In areas such as Kiambu and Nyandarua where member organizations are well established, vaccine delivery can also be enhanced by use of farmer co-operatives.

5.8. Conclusions

This article has approached the identification of optimal delivery pathways using a framework based on two separate analytical components: supply and demand issues, with the supply side evaluating current systems and their potential to deliver

ECF vaccines and the demand side assessing how variability of ECF risk may condition demand in a variety of smallholder production systems.

Two issues emerge from the supply-side analysis. The main types of transaction costs that farmers face are information costs, which may be experienced either at the beginning by first-time adopters or later as recurrent costs in accessing ECF products and services. Costs expected initially are related to imperfect information on the benefits of using ECF vaccines vis-à-vis other types of ECF control measures, and recurrent costs include maintaining access to the product and someone licensed to deliver it. Uncertainty costs arise regarding the value of boosting and liability for compensation in cases of vaccine failure. The second main supply issue is product accessibility by farmers. Vets, who are the only type of service provider licensed to deliver ECF vaccines, are few in number and not evenly distributed at adequate density in the target areas, particularly in more remote rural areas. Rural farmers therefore face higher transaction costs associated with distance to access to the services of a vet, and may easily be excluded from benefiting under the current legislation.

On the demand side, ECF risk varies with feeding systems and AEZ strata across different production systems and farmer groups, as does farmer use of current ECF control measures. The potential demand for ECF vaccines is relatively high in Nakuru and Nyandarua districts, where the majority of farms fall under the 'high-risk-high use' category of demand, as opposed to Kiambu district where zero-grazing reduces ECF risk substantially. Translated into cattle numbers, the high vaccine demand in Nakuru and Nyandarua requires a large number of service providers to reach the farms, which may not be feasible with the current number of vets, with the result that a large proportion of farms may not be reached.

The issue of farmer access therefore becomes crucial on both the supply and demand sides. This study suggests a re-examination of the current policy for legislation of paravets, whose service potential can be utilized to reach a large majority of smallholder farmers. Large impacts can be achieved by use of paravets to deliver ECF vaccines across all farming systems, and the Kenya Veterinary board (KVB) can play a pivotal role in clearly defining their role. Additionally, although they are yet to be evaluated, reports on ITM delivery in Tanzania suggest institutional changes evolving naturally to minimize a number of transaction costs, and the experience can be used as lessons for ECF vaccine delivery in Kenya and elsewhere.

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Chapter 6

General summary

6.1. Study design

6.1.1. Problem statement and objectives

Since disease control in developing countries remains poor as a result of under-utilization of control measures by farmers, improvement of delivery of animal health services continues to receive attention. However, the main research focus has been directed towards privatisation and finding a balance between public and private sector delivery, with little or no attention being given to the efficiency of the delivery systems. This study was carried out to address the issue of efficiency of delivery of TTBD control technologies from both a supply and demand perspective. On the supply side, the main objectives were to characterise current systems and evaluate their effectiveness to deliver TTBD technologies to smallholder farmers, while the demand side identified constraints affecting smallholder farmer demand for these technologies. Results from the supply and demand sides were then used to identify appropriate systems to deliver new ECF vaccines as well as make recommendations for the delivery of existing ECF vaccines.

6.1.2. Overall approach

The analytical approach addressed the question of efficiency also from the supply and demand sides. On the supply side, the analysis focused on the market structure for the different types of technologies including types of actors, conditions of entry and exit, conduct of the actors at the different levels and transaction costs, all of which would affect the level of competition and the efficiency of TTBD control delivery. SCP was used as a tool to evaluate the performance of existing systems and compare these to a perfectly competitive model, while NIE was used to study transaction costs and their role in TTBD control delivery. The demand side focused on consumer decision-making, with an emphasis on the role of transaction costs in their utilization of services of the available service providers, analysed using NIE.

The analysis focused on the delivery systems for TTBD products and services in three study sites within the main smallholder dairy production zone of Kenya. These areas were selected based on TTBD risk and a gradient of market access, with Kiambu district representing high market access, Nyandarua representing low access and Nakuru district representing medium market access. Data collection was planned in three phases to collect information at the different levels of the delivery chain. Farms were selected using a stratified random sampling from a list obtained from a major survey that had been carried out by the Smallholder Dairy Project at ILRI to characterise dairy activities in Kenya (Staal et al. 1998; Staal et al. 2001). The characterisation survey selected sites representing a combination of market access and dairy production potential. The present study paid particular attention to AEZs to represent TTBD risk by giving them appropriate weight in farm selection, which was achieved by estimating the proportional land cover of each AEZ in each district, division, location and sub-location. And our interest being smallholder dairy farming, we excluded farms that did not own dairy cattle and randomly selected the specified number of farms from the list of dairy farms for every sub-location.

The cross-sectional farm survey provided a comprehensive list of all the service providers supplying products and services in the farming systems, which was made exhaustive by obtaining the names of competitors from every service provider interviewed at the next phase. The third phase then entailed working backwards from each level in the marketing chain to trace all the suppliers and therefore identify the structure of the market chain and actors involved in the delivery of each product type.

6.2. General summary of results

The summary of results presented here follows the supply and demand side dichotomy, with the first section focusing on the supply side to characterize current delivery systems from a market efficiency perspective, and the second section addressing the demand side to identify factors affecting farmer decision-making with regard to utilization of TTBD control.

6.2.1. Supply side - characterisation of current TTBD pathways

Current TTBD technologies include treatment packages, tick control by acaricide application and ECF immunization. Delivery of these technologies was characterized using both SCP and NIE. SCP was used to characterise the general market structure including types of actors at the different levels of the marketing chain, their behaviour and how this affected the efficiency of the systems. NIE provided a framework for characterising TTBD technologies into their technical and economic characteristics, and how these influenced the levels and types of transaction costs that the different actors, particularly farmers, faced in accessing TTBD technologies.

SCP analysis shows the existence of competition in the delivery of treatment and tick control packages, but inefficiencies exist with ITM delivery involving a monopoly of supply that may bring about conflict of interest. Market conduct, including the pricing behaviour and buying and selling practices, is suggestive of a competitive market. At the service provider level, paravets are the most important type of qualified service provider (35% of the total number), while stores and shops (33%) hold a substantial market share of product sales to farmers, particularly tick control types. Vets (18% of the total) have a higher density in peri-urban areas than the more rural ones. Other sources of services for farmers are personnel trained in professions related to veterinary medicine such as extension workers and animal productionists.

The analysis using NIE first categorized the various TTBD technologies into their technical and economic characteristics, which were then used to identify the associated types of transaction costs and how these contribute to inefficiencies in the delivery of TTBD technologies. The most important transaction costs involve information asymmetries that farmers face in accessing both the products and services of a service provider, and in evaluating their quality. And because there are no supervisory bodies to ensure that farmers get the appropriate quality of products and services expected, farmers incur high search and screening costs to identify the appropriate service providers. Costs associated with quality are particularly high for tick control products whose supply is largely dominated by unqualified service providers, who are unlikely or unwilling to advise farmers on their appropriate use. An issue closely associated with this is that farmers have no voice mechanism that gives them leverage to raise complaints in cases where they receive poor or unsatisfactory services. The present systems are more top-down oriented and do not recognize farmers as stakeholders in delivery. And despite the fact that paravets constitute the highest proportion of service providers across the three survey sites, policy restricts their participation in the private market, and creates confusion regarding their permitted scope of practice. This limits farmer access to services from a qualified service provider and raises unnecessary transaction costs both for the farmer and the market system.

6.2.2. Demand side - farmer access and transaction costs

In chapter 4, econometric procedures are applied to model the use of animal health services by 344 smallholder farmers in the study areas in the year preceding data collection. Two separate models are tested using probit analysis, namely the use of a vet and that of a paravet, with explanatory variables including a variety of farmer, farm and community-level characteristics. A number of these variables represent transaction costs ranging from information costs (represented by gender of the household head and ethnicity of both the service provider and the farmer) through negotiation, to enforcement costs (such as service quality, travel time and density of service providers around each farm).

The most important explanatory variables in both models (use of a vet and use of a paravet) can be interpreted as representing a number of transaction costs, among which are information, the level of service quality, travel time and the density of service providers around each farm. Female farmers face higher information asymmetries than do male farmers in accessing animal health extension information that would be expected to improve their management and disease detection skills. These information asymmetries are minimized when the farmer and service provider belong to the same ethnic group, as they are better able to communicate and develop more trusting relationships. Other important transaction costs include quality of services provided, density of service providers in a given radius around each farm and travel time, all of which play a significant role in the use of animal health services by farmers. Farmers have a higher likelihood of using a vet if the nearest vet has a high level of service quality and vice versa. A farmer is also likely to use a vet as the density of vets around his / her farm increases, and with reducing travel distance to the nearest vet.

6.2.3. Delivery pathways for ECF vaccines

Chapter 5 identified optimal delivery pathways for an ECF vaccine using a framework that combined two separate analytical components, namely supply and demand. The supply side drew upon Chapter 3 and utilized NIE and transaction costs analysis to evaluate current systems and their potential to deliver ECF vaccines to smallholder dairy farmers, while the demand side used an epidemiological approach to assess the variability of ECF actual and farmer-perceived risk in a number of smallholder dairy production areas.

Currently there are no ECF vaccines available to smallholder dairy farmers in the Kenyan Central Highlands, but there are anticipated vaccines in the future; in the short term, ITM, which is currently permitted to be used in the coastal part of the country, and in the long term, a sub-unit vaccine in preparation at ILRI. The main constraints associated with the technical characteristics of ITM include strain specificity, use of live organisms for immunization and the requirement of a cold chain, continuous monitoring of post-immunized animals in order to treat any clinical reactors, and the policy restriction of vaccine administration to vets. The sub-unit vaccine will minimize many of the transaction costs associated with technical characteristics of ITM, but additional costs that will need to be addressed for its effective delivery include information costs that farmers are expected to face, ensuring that the cold chain is maintained and that farmers can access the product in an equitable manner.

On the demand side, ECF risk varies with feeding systems and agro-ecological zone strata across the market access gradient, and farmers use different regimes of tick control by acaricide application as strategies to cope with their ECF risk. Based on the level of risk and use of tick control measures, farmers can be categorized into four combinations of vaccine demand groups ranging from 'low risk-low use' to 'high risk-high use'. Kiambu district has a significantly lower risk than the other two districts, as more than half of Kiambu farms are under zero grazing systems. However, a substantial proportion of farmers here fall into the 'low risk-high use' group, indicating that they are willing to further reduce their ECF risk through more direct measures of control rather than relying only on feeding systems alone. The majority of the Nyandarua and Nakuru district farms fall under the 'high risk-high use' category, which translates to a high demand for ECF vaccines. However, with the current legislation that permits only vets to deliver ECF vaccines, this demand will be difficult to meet with the low density of vets in these districts. The study proposes the involvement of paraprofessionals (paravets) in the delivery of ECF vaccines, as these consist of the highest number of service providers, and would achieve a high service penetration among farmers, particularly in rural areas.

6.3. Evaluation of the study

A major achievement of this study has been the application of an innovative conceptual framework that combines two economic analytical tools, SCP and NIE, to study delivery systems and propose measures that could be used for their improvement. However, one limitation associated with the use of SCP in this study is lack of quantitative data at the different levels of the market chain, particularly since it involved the marketing of multiple products and their associated services, necessitating the use of a more descriptive approach rather than the standard quantitative ones.

Conceptualisation and measurement of transaction costs was problematic for lack of generic methods. This study has demonstrated that a promising approach to obtain empirical measurements of transaction costs in a developing country context is by first identifying the technical and economic characteristics of product or service under study. However, there is need to apply more direct measures by better defining types of transaction costs and then collecting the appropriate primary data.

One of the weaknesses of cross-sectional surveys that this study may have faced is the possibility of introducing bias through unreliable responses, as actual farmer practices may sometimes differ from what they report in a single visit survey. One way that this could have been addressed is by incorporating a component of active monitoring of a proportion of the farms using a longitudinal study, although this would increase the financial costs of the survey substantially. Such follow-up would have been more accurate in verifying issues such as tick control practices and disease occurrence. Additionally, biological sampling of serum antibodies for example, would have provided more accurate measures of ECF incidence rates rather than relying only on reported cases, which are subject to the weaknesses of farmer recall and accurate diagnosis.

6.4. Policy recommendations

Several key problems have been identified as contributing to inefficiencies in the delivery of TTBD control and limiting their improvement. Firstly, farmers are faced with high information costs in accessing products and service providers whose quality is not standardized and cannot always be evaluated or assured. Secondly, due to the low number of vets compared to other types of service providers, farmer access to high quality services is limited, particularly in more remote rural areas where the density of vets is low. Thirdly, farmers have no voice mechanism for leverage in cases where they receive poor quality services or products. Thus, transaction costs have emerged to be a major constraint to the utilization of TTBD services by smallholder farmers.

In order to address the problems of information symmetries and quality control of both products and services being sold to farmers, this study recommends exploring the use of a policing body, such as the Licensed Veterinary Inspectors (LVI) (Holden 1999). This body should be composed of certified private vets on government contract through Kenya Veterinary Board (KVB), who would pay random visits to practitioners in the field to make sure that farmers are getting the appropriate quality of products and services. LVI would also ascertain that farmers are not exploited by service providers who often have more information than farmers do.

Farmers should be recognized as stakeholders and their role in delivery should be increased by having them represented in KVB. This would empower them, giving them a voice by which they can have leverage to complain in cases of dissatisfactory services or products, either directly, through LVI or through their member organizations.

This study has highlighted the crucial role that transaction costs play when farmers make their animal health choices. There is therefore a need to address transaction costs when structuring delivery of technologies, with careful attention being given to measures that minimize such costs in order to enhance farmer uptake of the technology and services. Management training of service providers is recommended so that they may recognize the need for and returns to improving their service quality. And to increase service provider density, more involvement of paravets in delivery is recommended, as they compose the highest proportion of service providers in all the districts surveyed. This can be achieved through vertically integrated systems involving vet-paravet networks, with vets retaining their supervisory role and paravets getting more responsibilities with clearly defined roles such as vaccinations and treatment of minor cases, with major cases being handled by vets. However, to prevent the potential exploitation of paravets by vets, the role of paravets would need to be carefully re-defined, with the need to facilitate the formation of their own professional regulatory body equivalent to KVA. These measures would reduce transaction costs not only for the farmer in obtaining services of a qualified service provider, but also for the delivery system through increased service penetration by taking advantage of the paravet service potential.

6.5. Suggestions for future research

Use of a hybrid conceptual framework that combines the application of SCP and NIE has provided insights for ways of improving delivery of TTBD technologies to smallholder dairy systems in Kenya. Application of this methodology to other production systems such as the agro-pastoral areas of Kenya as well as the wider dairy production areas at a regional level would help identify specific measures to improve delivery and identify optimal systems to deliver future technologies. Additionally, the methodology should also be applied on different types of technologies such the control of trypanosomiasis, helminthiasis and integrated control measures.

The study provides evidence of the powerful framework provided by transaction costs in identifying and evaluating constraints to delivery and farmer access to animal health technologies. However, there being no standardized categorization of transaction costs or ways of collecting data to measure them, we have used indirect methods, combined with a few direct measures associated with distance. The challenge remains to develop more direct measures of transaction costs.

Farmer perceptions of ECF risk and use of acaricides for tick control as a strategy for coping with ECF risk have been used as indicators of the willingness of farmers to use ECF control measures and consequently as proxy measures of the potential demand for ECF vaccines. However, there is need to carry out farmer adoption studies that will better evaluate the demand for ECF vaccines in a more direct manner.

Tanzania provides a rich experience in the delivery of ITM where the antibiotic cover in the immunizing package has been stepped up from 20% to 30% oxytetracycline, reducing reactor rates to levels that have minimized transaction costs associated with monitoring of immunized animals. This experience demonstrates that where sufficient will exists to promote a technology, changes, which effectively minimize transaction costs, will also be made. Additionally, paravets are the main service provider here, making it possible to reach a large number of farmers than would otherwise be possible with the limited density of available vets. Lessons can be drawn from this experience, with research being focused on utilization of paravets for ECF vaccine delivery and the possibility of using antibiotic levels that would reduce the level of reactor rates and minimize transaction costs associated with repeated farm visits for monitoring of immunized animals.

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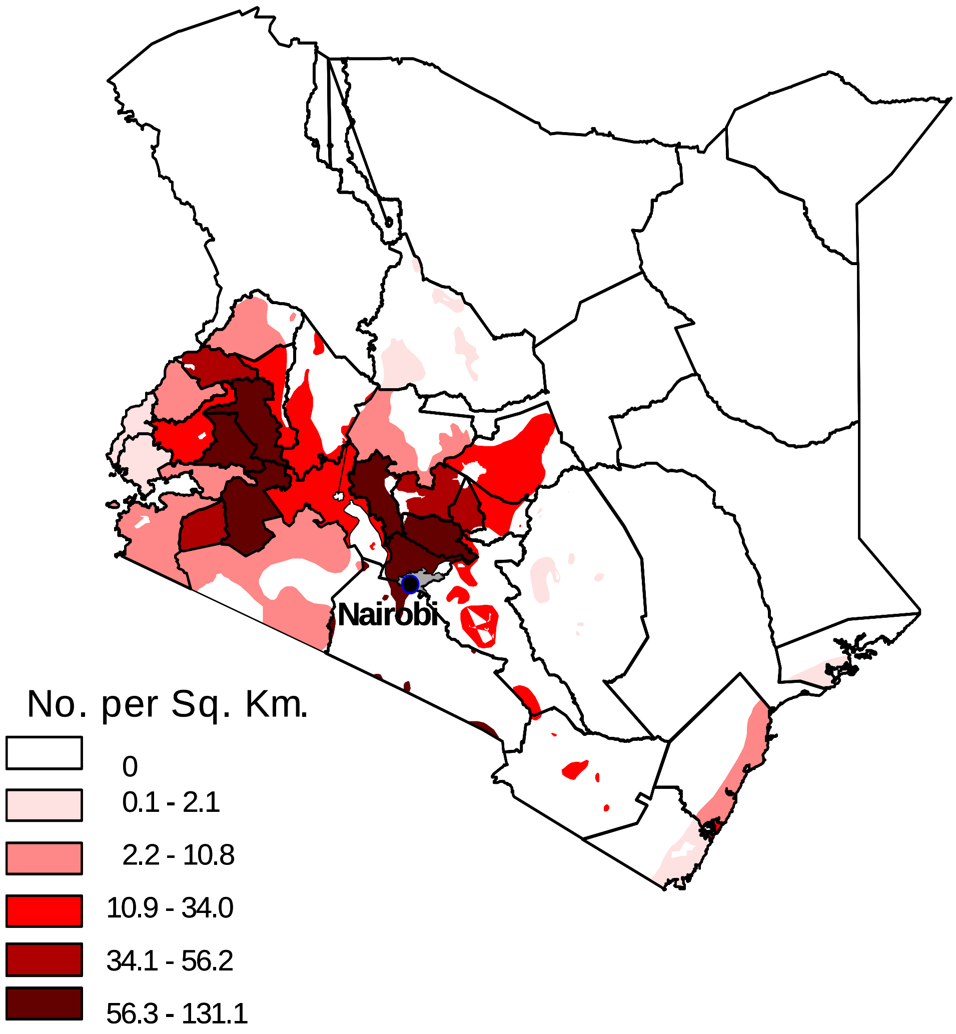
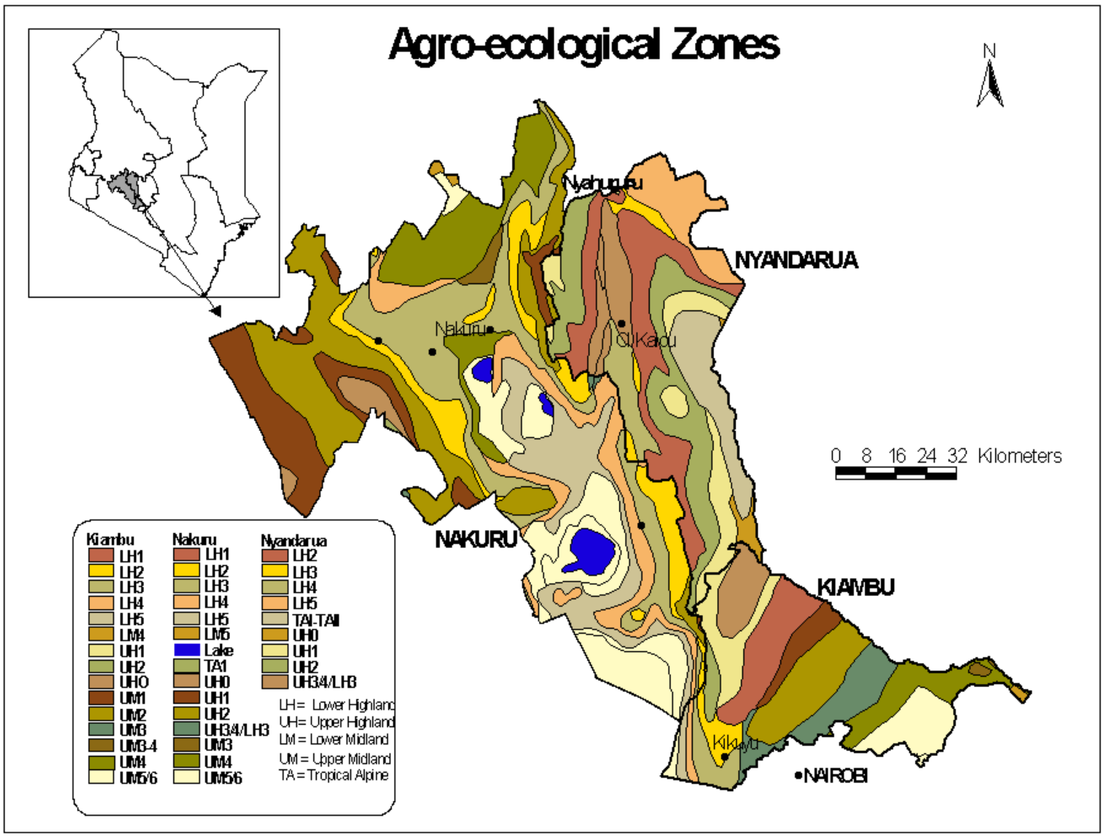
Appendix 1: Maps

1.1. Distribution of smallholder dairy cattle in Kenya

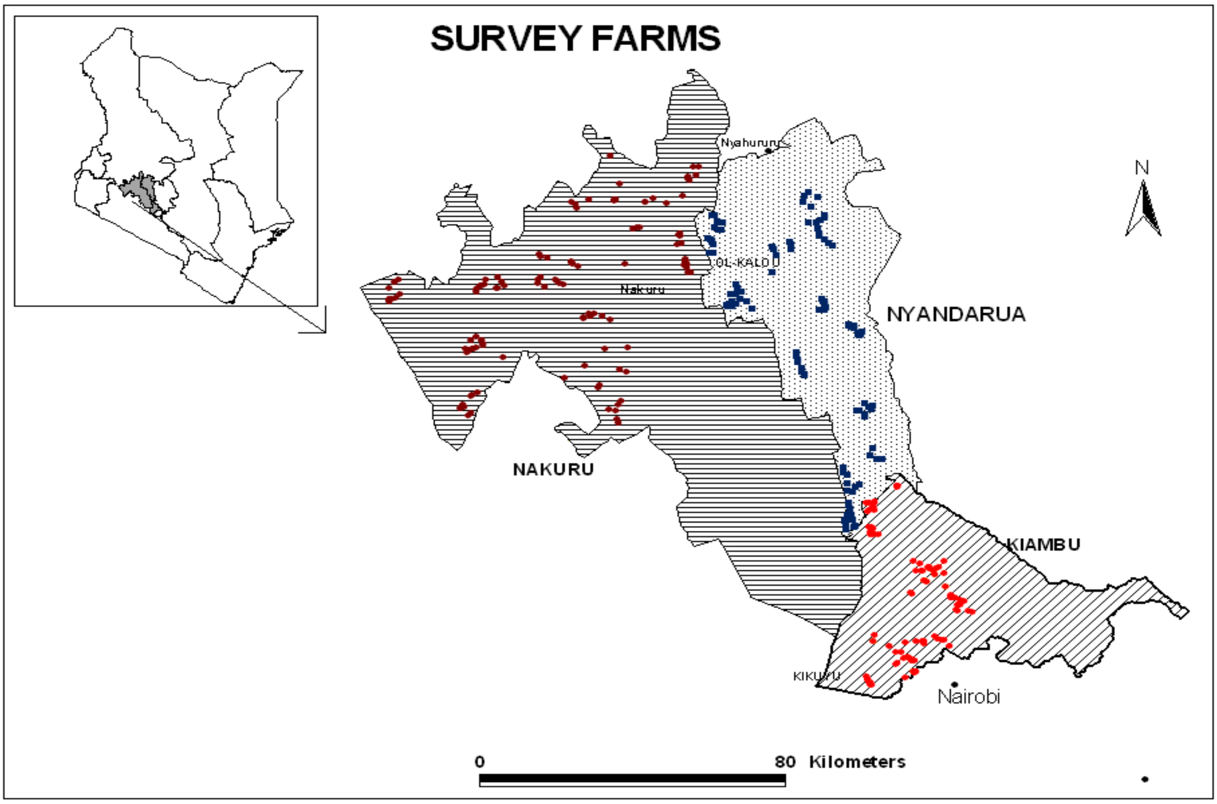


Adapted from Peeler & Omore, 1997

1.2. AEZ distribution in survey districts



1.3. Distribution of sample farms in three districts



Appendix 2: Household questionnaire

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

Division _______ Location _______ Sub-Location _______ Village Name _______________ **Start time _______**

SECTION A FARMER CHARACTERISTICS

A/1 Household members in the last 12 months

No*	Name of member	Age in years	Sex 1=M, 2=F	Ethnicity	Level of educ.	Educ. level complete? 1=Y, 2=N	Relationship to household head	Occupation		No. of months resident on farm	Type of residence
								main	other		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											

* *Please circle the number corresponding to name of hh head; an X at the number corresponding to name of respondent*

Ethnicity
1 = Kikuyu
2 = Luhya
3 = Luo
4 = Kisii
5 = Kalenjin
6 = Maasai
7 = Other (specify)_____

Level of education
0 = No formal educ
1 = Adult literacy
2 = Primary school
3 = Secondary sch. (O'/A Level)
4 = Technical /teacher college
5 = University
6 = Other (specify)___________

Relation hh head
1 = Self
2 = Wife
3 = Son
4 = Daughter
5 = Farm worker
6 = Grandson/daughter
7 = Other (specify) ____

Occupation
1 = Farmer
2 = Civil servant/teacher
3 = Student
4 = Business person
5 = Farm worker
6 = Retired
7 = Other (specify) ____

Type of residence
1 = Full-time
2 = Most times
3 = Sometimes
4 = Rare

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

A/2 Indicate* who in the household is responsible for the following activities

ACTIVITIES:	Hh member(s) responsible
♦1. Who is considered the head of this household	
2. Manager of this farm	
3. Grazing/feeding of cattle	
4. Decisions on where/when to graze/feed cattle	
5. Milking	
6. Delivery of milk	
7. Supervision of milking and milk delivery	
8. Decisions on amount of milk to sell/consume at home	
9. Obtaining milk payments	
10. Spraying/dipping cattle	
11. Decisions to go for vet services & who actually seeks services	
12. Who pays for veterinary services	
13. Decisions on selling of cattle & who obtains payment	
14. Activities related to other livestock (sheep/goats, chicken etc)	
15. Land preparation / planting / weeding / harvesting crops	
16. Decision for sale of crops	
17. Obtaining payments for sale of crops	

* *Use numbers corresponding to the hh members on table A/1*

♦ Identify the two most important decision makers and ask how long they have been doing this

a ____ Period ______ years

b ____ Period ______ years

A/3.1 Are you are registered member of a dairy co-operative?
1 = Yes 2 = No

A/3.2 What is the name of your co-operative?
____

A/3.3 Are you currently delivering milk to the co-op?
1 = Yes 2 = No

A/3.4 What other services are you getting from the co-operative?

1 = Vet medicines 2 = Animal feeds
3 = Crop inputs 4 = Credit facilities
5 = AI 6 = Other (specify) ______

A/4.1 Are you a member of a Self- Help Group that collects milk?
1 = Yes 2 = No

A/4.2 What is the name of your Self-help group?
____

A/4.3 Are you currently delivering milk to any self help group?
1 =Yes 2 = No

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

SECTION B FARM CHARACTERISTICS AND ACTIVITIES

B/1 When did you start farming on this farm (year)? [ ]

B/2 Farm characteristics and location

Time	Total farm size	Land tenure	Other land elsewhere	Total land for cultivation	Total land for grazing / feeds
When established	_____ acres	_____	_____ acres	_____ acres	_____ acres
Present	_____ acres	_____	_____ acres	_____ acres	_____ acres

Land tenure
1 = Freehold (title deed) 2 = Traditional 3 = Rented 4 = Other (specify)___

B/3 Please answer the following questions

Place	Name	Distance from farm (Kms)	Normal mode of transport
1. Nearest town			
2. Nearest co-operative society			
3. Nearest self-help group			
4. Nearest market/trading centre			
5. Nearest main road (tarmac / all weather)			
6. A place where producers can deliver their milk			
7. A place where producers can buy fertilisers and animal feeds			

Mode of transport
1 = Walk
2 = Bicycle
3 = Motor cycle
4 = Public/own transport
5 = Other (specify) ___________

SECTION C FARM LEVEL RESOURCE BASE

C/1 What is your house constructed of?

Type of house

Roof: 1 = Thatch, 2 = Iron sheets, 3 = Tiles

Walls: a = Mud, b = Wood, c = Stone/bricks, d = Iron sheets

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

C/2 Indicate the presence of the following assets in the household

Household assets	***Present?***
Piped water	***Y N***
Electricity	***Y N***
Telephone	***Y N***
Working radio	***Y N***
Working TV	***Y N***
Working clock	***Y N***
Armchair sets	***Y N***
Donkey-drawn cart	***Y N***
Bicycle	***Y N***
Motor cycle (**number**)	
Tractor (**number**)	
Cars/ pick up (**number**)	

C/3 For the following sources of income, estimate household income (per year or per month)

Income source	Amount per month (KSh)	Amount per year (KSh)
Sale of milk		
Sale of livestock		
Sale of crop produce		
Sale of poultry and eggs		
Sale of fodder		
Sale of manure		
Salaries / non-farm activities		
Remittances from absent family members		

C/4 Estimate your total household income per month

1 = < 5,000
2 = > 5,000 < 10,000
3 = > 10,000 < 20,000
4 = > 20,000 < 30,000
5 = > 30,000 < 50,000
6 = > 50,000

SECTION D LIVESTOCK FARMING ACTIVITIES

D/1 Type and number of animals kept by the household

Type of animal	Total number	Give reasons for keeping*	Used for ploughing (*circle*)	Used for transport (*circle*)
Cattle			Y N	Y N
Sheep & goats				
Chickens				
Pigs				
Donkeys			Y N	Y N
Other			Y N	Y N

**Rank reasons in order of importance*

Reasons for keeping animals

1 = Cash income
2 = Milk for sale / hh consumption
3 = Manure
4 = Traction
5 = Bulls for mating
6 = Social prestige
7 = Other (specify)________________

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

D/2 Please indicate the feeding systems practised on your farm for the following categories of cattle

Cattle category	Today	Time of farm establishment
Calves (less than 1 year)		
Adult zebu		
Adult grade and crosses		

Feeding systems
1 = Only stall-feeding
2 = Mainly grazing with some stall-feeding
3 = Mainly stall-feeding with some grazing
4 = Only grazing (free or tethered)
5 = Equal combination of stall-feeding & grazing
6 = Other (specify) ______________

D/3 For those who practice stall-feeding

Main source of fodder	Other sources of fodder	Season for stall feeding	Animals stall-fed

Source of fodder
1 = Own farm
2 = Roadside
3 = Own distant shambas
4 = From other farmers
5 = Other (specify) _________________

Season
1 = Throughout the year
2 = Dry season
3 = Wet season
4 = Other (specify) _________________

Animals stall-fed
1 = Whole herd
2 = Milking cows
3 = Other (Specify) ________

D/4 If you practice grazing for your cattle, please answer the following questions

Animals grazed	Frequency of grazing	Where grazing is done	Season of grazing	Grazing type

Animals grazed
1 = Whole herd
2 = Calves
3 = Zebu cattle
4 = Other (specify)______

Frequency
1 = Rarely
2 = Sometimes
3 = Often
4 = Always

Where grazed
1 = On-farm
2 = Road side
3 = Communal
4 = Own distant shamba(s)
5 = Other (specify) _______

Season
1 = Throughout year
2 = Dry season
3 = Wet Season
4 = Other (specify)________________

Grazing type
1 = Same paddock throughout
2 = Several paddocks in rotation
3 = Other (specify) ___________

(For those keeping zebus and zebu crosses)

D/5.1 Do you intend to improve your cattle into grade?
1 = Yes (***go to D/5.4***) 2 = No (***go to D/5.2***)

D/5.2 If you do not intend to improve, give reasons
1 = Animals already have 100% grade
2 = Animals tend to be susceptible to diseases
3 = Other (specify)___________________

D/5.3 For those who chose disease in D/5.2, please state which diseases. Disease 1 ____________ Disease 2 _____________

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

D/5.4 If you intend to improve your cattle, give reasons

1 = For more milk 2 = For larger animals
3 = For more prestige 4 = Other (specify)_________________

D/6 Herd composition and history over the last 12 months

Cattle category	No. of grades &crosses today	No. of zebus today	Total no. of animals bought	Reasons ♦ for buying	Total sold last 12 months	Reasons♦ for selling	Total slaughtered last 12 months	Reasons♦ for slaughter
Suckling Calves								
Bulls								
Cows & heifers								
Total								

♦ *State most important reasons*

Reasons for buying
1 = Replacement
2 = Increase milk prod^{n}
3 = Social prestige
4 = Other (specify)____

Reasons for selling
1 = To obtain cash income
2 = Poor performance
3 = Disease
4 = Other (specify)_____

Reasons for slaughter
1 = Disease
2 = For meat
3 = Old age
4 = Injury
5 = Other (specify)_____

D/7 For each cow* in the herd, give the following information

	Cow (name /no.)	Breed	Age (years)	No. of calvings	Date of last calving	Average milk production /day (units) = ___		
						at calving	today	drying off (last month of milking)
1								
2								
3								
4								
5								

* *If there are more than five cows, randomly select five, starting with the 'best' cow, then the 'worst' cow etc.*

Breed
1 = Frieshian
2 = Guernsey
3 = Ayrshire
4 = Jersey
5 = Boran/ zebu
6 = Other (Spec)____________

milk measure unit
1 = Liters
2 = Bottle (specify) ________
3 = Other (specify)________

D/8.1 Have any of your cattle been sick over the last 12 months?

1 = Yes 2 = No

D/8.2 Have any of your cattle died over the last 12 months?

1 = Yes 2 = No

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

D/8.3 Sick/dead cattle inventory

Cattle name/ID number	Sex 1 = M, 2 = F	Age category	When was sickness (month)	Name of disease	Main signs	outcome	If died, when (month)	Cause of death	If death due to ECF, state fate of carcass

Age category
1 = Suckling calf
2 = Heifer (before first calving)
3 = Adult cow
4 = Other (specify) _______

Main symptoms
1 = Diarrhoea
2 = Cough/ difficulty breathing
3 = Reduced milk
4 = Lack of appetite
5 = Swollen lymph nodes
6 = Other (specify)________

Sickness outcome
1 = Treated and died
2 = Treated and recovered
3 = Not treated and recovered
4 = Not treated and died
5 = Other (specify) ______________

Cause of death
1 = Don't know
2 = The disease
3 = Old age
4 = Poisoning
5 = Other (specify)___________

Carcass fate
1 = Slaughtered, eaten
2 = Slaughtered, sold
3 = Buried
4 = Other (specify) __________

D/9 If you looked for help to treat your sick cattle, who provided services? *(multiple answers allowed)*
1 = Self/neighbour 2 = Govt Vet / AHA
3 = Private veterinarian / AHA 4 = Co-operative
5 = Other (specify) ________

D/10.1 Did you buy any veterinary drugs for your sick cattle? 1 = Yes 2 = No

D/10.2 If the answer is **Yes**, from where did you obtain these products? *(multiple answers allowed)*
1 = Veterinarian/AHA 2 = Co-operative 3 = Agrovet shop
4 = Drug company 5 = Chemist 6 = Other (specify) ____

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

SECTION E TBD CONSTRAINTS AND FARMER PERCEPTIONS

E/1.1 Do you ever see ticks on the skin of your cattle?
1 = Yes (***go to E/2***) 2 = No 3 = Don't know

E/1.2 If you don't, give reasons
1 = No ticks in this area
2 = Cattle do not go anywhere near ticks
3 = Cattle are treated with acaricides
4 = Don't know
5 = Other (specify)_____________

E/2 If you see ticks on your animals, please answer the following questions

Tick location on animal	Tick colour	Tick numbers	Season when tick occurs	Month when tick numbers are largest

Tick Location
1 = Ears
2 = Neck & body
3 = Under the tail
4 = Chest/udder/scrotum

Tick colour
1 = Brown
2 = Dog tick –blue
3 = Colourful
4 = Other (specify) ____

Tick numbers
1 = < 5 (v. few)
2 = 5 –10
3 = 10-30 (many)
4 = >30(v. many)

Season
1 = Wet season
2 = Dry season
3 = Throughout the yr
4 = Other (specify)__

E/3 What do ticks do to cattle if allowed to stay on the skin?
1 = Don't know 2 = Make the animal sick
3 = Suck blood / weakens animal 4 = Damage the hide
5 = Other (specify)_____________

E/4 ***For those who think ticks cause disease(s)***,

E/4.1 Do **all ticks** cause disease? 1 = Yes 2 = No 3 = Don't know

E/4.2 Do **all** ticks cause **the same disease(s)**? 1 = Yes 2 = No 3 = Don't know

E/4.3 How many ticks are necessary to cause disease? 1 = One 2 = Only a few (< 10) 3 = Many (10 – 30) 4 = V. many (> 30)

E/4.4 Which diseases in this area are caused by ticks? (English/local names) 1 _________________ 3 _________________

E/5.1 Do you practice any tick control measures on your farm?
1 = Yes 2 = No

E/5.2 If you **do not** practice any tick control measures, give reasons
1 = Don't know ticks are harmful
2 = Cattle don't go near ticks
3 = No advantages for control
5 = Other (specify)__________

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

E/5.3 Tick control practices in the last 12 months

Control methods	Frequency of use	Major advantages	Problems with method	Chemicals used	Sources of chemicals
Removal by hand					
Oils/ disinfectants					
Grazing restrictions					
Use of dipping					
Acaricide spraying					
Other (specify) __					

Frequency of use
1 = Once a week
2 = Twice a month
3 = Once a month
4 = Once a year
5 = Other (specify) ___

advantages of method
1 = Prevents hide damage
2 = Protects from diseases
3 = Avoid trouble with govt
4 = Other (specify) _______

Problems
1 = Expensive
2 = Tedious
3 = Toxic/smell
4 = Other (specify) ___

Sources of chemicals
1 = Vet / AHA
2 = Co-operative
3 = Drug company
4 = Agrovet shop
5 = Chemist
6 = Other (specify) ____________

E/6.1 Have any livestock vaccines been used in this area in the last 12 months? 1 = Yes 2 = No

E/6.2 What livestock vaccines have been used on this farm in the last 12 months?

Livestock species	No. vaccinated	If vaccinated, what vaccines were used?
Cats and dogs		
Poultry		

E/7.1 Have your **cattle** been vaccinated in the last 12 months? 1 = Yes 2 = No 3 = Don't know

E/7.2 Cattle vaccinations on this farm

Vaccine	Against what diseases?	Who vaccinated?	vaccine source	Total cost - KSh./animal	Would you vaccinate again? 1 = Y 2 = N
1st vaccine					
2nd vaccine					
3rd vaccine					

Diseases
1 = Foot and mouth
2 = ECF
3 = Anthrax/Black leg
4 = Don't know
5 = Other (specify)___

Who vaccinated
1 = Self/neighbour
2 = Govt Vet/AHA
3 = Private vet/AHA
4 = Co-op
5 = Other (specify)__________

Source
1 = Govt vet /AHA
3 = Private vet /AHA
2 = Co-op
4 = Other (specify)______

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

E/7.3 Why did you vaccinate your cattle? 1 = Was told by govt/co-op 2 = I asked for it 3 = Don't know 4 = Other (specify) ___________

E/8.1 What are the advantages of a vaccine? 1 = Fattens the animal 2 = Protects from diseases 3 = Cures sick animals 4 = Don't know 5 = Other (specify)___________

E/8.2 Supposing the government did not announce for you to vaccinate your cattle, and there was a threat of a cattle disease such as ECF. If ECF had a vaccine, would you ask for it?
1 = Yes 2 = No 3 = Don't know

E/8.3 Would you pay for an ECF vaccine if there was a charge? 1 = Yes 2 = Yes, as long as its cheap 3 = No 3 = Don't know

SECTION F HEALTH SERVICES AND TRANSACTION COSTS

F/1 If you had these health and management scenarios, please answer the questions

Animal health /management scenario	Would you seek help immediately? 1 = Y 2 = N	Would you seek help later? 1 = Y 2 = N	If yes, where?	How do you expect vet help to be available here?
1. Difficult calving				
2. Worms				
3. AI				
4. Disease e.g. diarrhoea				
difficult breathing				
unable to stand				
not eating				
5. If your tick control measures were not working				
6. Livestock management/ health advice				

Where to seek for help
1= Self/worker/neighbour
2 = Govt vet/AHA
3 = Co-operative vet
4 = Private vet
5 = Extension worker
6 = Other (specify) ________

Availability of help
1 = Immediately
2 = Same day
3 = After a few days
4 = After several days
5 = Other (specify) ________

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

F/2 Please identify the service providers operating in your Location

Vet services	Name of service provider	Location	Distance (km) from farm	No. of contacts with SP in a year	Type of service offered	Would you use this SP (again) and why?	
						1 = Y	2 = N
Government office							
Private practitioners							
Agrovet shops							
Co-operative							
Other (Specify)							

Service type
1 = AI
2 = Clinical work
3 = Purchase of drugs
4 = Vaccinations
5 = Advice on health/management
6 = Other (Specify)__________

Yes reasons
1 = Reliable and dependable
2 = Always has medicines
3 = Reasonable charges
4 = Gives credit
5 = Does a good job
6 = Is near my farm
7 = Is trustworthy

No reasons
1 = Charges too high
2 = Unreliable –doesn't keep time
3 = Only interested in money
4 = Bad reputation
5 = Does not offer credit
6 = Too far from my farm
7 = Other (Specify) _______

End Time _______

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

	GPS READINGS	OTHER INFORMATION
1. Household ______________________		
2. Nearest town ______________________		
3. Nearest co-operative society ______________________		
4. Nearest self-help group ______________________		
5. Nearest market/trading centre ______________________		
6. Nearest main road (tarmac / all weather) ______________________		
7. A place where producers can deliver their milk ______________________		
8. A place where producers can buy fertilisers / feeds ______________________		

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
FARMER'S NUMBER _____ ENUMERATOR CODE _____ DATE ___/___/___

F/3 Conjoint analysis results **Start time** _____ **End time** ______

No.	Card number: farmer's ranking	No.	Card number: farmer's ranking
1.	(most preferred card)	11.	
2.		12.	
3.		13.	
4.		14.	
5.		15.	
6.		16.	
7.		17.	
8.		18.	
9.		19.	
10.		20.	(least preferred card)

REMEMBER!!!!!!!!!!!!!!!

At the end of the exercise please thank the farmer for his time and cooperation in a nice and polite way!

SECTION G ***To be answered privately by the enumerator immediately following the interview***

G/1 In your opinion, how did you establish rapport with this respondent
1 = With ease
2 = With some persuasion
3 = With difficulty
4 = It was impossible

G/2 How did the respondent give answers to your questions?
1 = Willingly
2 = With some persuasion
3 = With lots of persuasion
4 = It was hard to get answers

G/3 What was the knowledge of the respondent on the questions asked?
1 = Hardly knew the answers
2 = Knew some of the answers
3 = Knew most of the answers
4 = Other (specify) _______

G/4 How easily did the farmer understand the conjoint analysis exercise?
1 = With ease
2 = With some difficulty
3 = With lots of difficulty
4 = It was impossible

G/5 How often do you think the respondent was telling the truth?
1 = Rarely
2 = Sometimes
3 = Most of the times
4 = All the time

G/6 I certify that I have checked the questionnaire **two times** to be sure that **all** the questions have been answered, and that the answers are legible.

Signed ___________________________ Date ____/____/____

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
Service Provider No. _____ Enumerator code _____ DATE ___/___/___

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Appendix 3: Service provider questionnaire

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
Service Provider No. _____ Enumerator code _____ DATE ___/___/___

Division ______ Location ______ Town/Village name ______________ **Start time _______**

Contact Address: _________________________________
____
____

GPS code:

GPS readings:

A/1 Personal details

Name of service provider*	Sex 1=M, 2=F	Ethnicity	Education Level	Qualifications	Employment	Experience	
						Years	Yrs in this location

* *If the clinic / office has more than one sp, please give details of other service providers*

Level of education
1 = Technical college
2 = University
3 = Other (specify)__________

Qualifications
1 = Agric extension
2 = BSc animal science
3 = AHA
4 = Veterinarian
5 = Other (specify)__________

Employment
1 = Private
2 = Government (official duty)
3 = Government (private duty)
4 = Co-operative
5 = Other (specify)__________

A/2 Area of influence: Give major landmarks East _______________ West _______________ North _______________ South _______________

A/3.1 Client characteristics: Please give a description of your typical client.

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
Service Provider No. _____ Enumerator code _____ DATE ___/___/___

A/3.2 Of your clients, give an indication of the proportion that fit into the following descriptions

Client income group	Cattle type	Cattle feeding systems	Av. client farm size	Av. client herd size	Proportion of your clients
V. low (< 10,000)	Mainly grade	Mainly zero grazing	< 2 acres	1-3	
Medium 10,000–30,000	Mainly grade	Mainly zero grazing	< 5 acres	2-5	
High > 30,000	Mainly grade	Mainly zero grazing	> 5 acres	5-10	
Other (specify)					

Client income group	Cattle type	Cattle feeding systems	Av. client farm size	Av. client herd size	Proportion of your clients
V. low (< 10,000)	Mainly grade / crosses	mainly open grazing	< 2 acres	1-3	
Medium 10-30,000	Mainly grade / crosses	mainly open grazing	2 -10 acres	2-10	
High > 30,000	Mainly grade / crosses	mainly open grazing	10 - 50 acres	5-20	
Other (specify)					

SECTION B DISEASE PROBLEMS & ANIMAL HEALTH SERVICES

B/1 Which are the most important diseases / conditions affecting cattle in your area (*in order of importance*)?

B/1.1

From a producer's point of view	Dse 1	Dse 2	Dse 3
Disease of importance as a constraint to SHD production			
Disease of importance in terms of production losses			
Disease of importance in terms of mortality			

B/1.2

From a service provider's point of view	Dse 1	Dse 2	Dse 3
Disease of importance in terms of generating income			
Disease of importance in terms of mortality			
Disease of importance in terms of incidence			
Estimate total number of cases (by incidence) seen last 12 months			

Date of last case

Major diseases / conditions

1 = Anthrax
2 = Anaplasmosis
3 = Babesiosis
4 = Blackquarter
5 = Calf mortality
6 = Dystocias
7 = Downer cow syndrome
8 = East Coast fever
9 = Foot and mouth disease
10 = Footrot
11 = Helminthiasis
12 = Infertilities
13 = LSD (& other skin problems)
14 = Mastitis
15 = Milk Fever
16 = Pnuemonias
17 = Trypanosomosis
18 = Other (specify) _______

NOTES:

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
Service Provider No. _____ Enumerator code _____ DATE ___/___/___

B/2 Animal health services – efficiency indicators

Type of service	Proportion of income (%) derived from service	Est. number of cases annually	Clientele size / year (general)		Target client size (optimum operation)	Av. no. of visits / week		Max. (peak) no. of farm visits / wk	What causes peak	When is peak (Mo)
			No. using service	% of regular customers		Dry season	Wet season			
Diagnosis & clinical treatment										
A.I. & pregnancy diagnosis										
Surgery										
AH management & advice										
Selling of drugs										
Deworming										
Other (specify) ______										

B/3 Importance of TTBDs in your area of operation

Disease / condition	Does it occur here (Y, N)	Month w/ highest cases	month w/ lowest cases	no. of cases last month	Approx. date of last case	Notes	typical charges to farmer (KSh.) for:			Cost of treatment if several cases	Cost of drug
							Drug name	Treatment	Services		
ECF											
Anaplasmosis											
Babesiosis											
Heartwater											
Tick burden											

Several treatments

Reduced
Increased
Same

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
Service Provider No. _____ Enumerator code _____ DATE ___/___/___

SECTION C TRANSACTION COSTS ON PRODUCTS & SERVICES

C/1 Services and their characteristics

C/1.1 How do you set your prices for services?

C/1.2 Is price for your services affected by the following and how?
a. no. of animals seen per farm 1 = Y 2 = N **b**. seasonal effects 1 = Y 2 = N **c.** client concentration 1 = Y 2 = N

d. client resource endowment 1 = Y 2 = N **e**. distance from your location 1 = Y 2 = N

C/1.3 Is sufficient number of clients (to ensure business runs) a problem for you?
1 = Y 2 = N

C/1.4. Is non payment by farmers a big problem
1 = Y 2 = N

C/1.5 Which farmers tend to default payment most?

1 = The v. poor 2 = The average
3 = The rich 4 = Other (specify_______

C/1.6. How do you know when farmers need your help/ services?
1 = Reporting points 2 = Farmers usually fetch me
3 = Visits to farms 4 = Other (specify) _______

C/1.7. How do farmers know what range of services you offer?

C/1.8. What do you do about a client who complains of a bad service/ job?

C/2 Vaccinations

C/2.1 Have you heard of the ITM for ECF immunization?
1 = Y 2 = N

C/2.2 If yes, have you used ITM
1 = Y (vaccinated) 2 = Y (trained) 3 = N

C/2.3 Do you have any concerns about the technology? 1 = Y 2 = N If yes, please state them

C/2.4 Would you deliver ITM to your clients? 1 = Y 2 = N Give reasons

C/2.5 Where / from whom would you prefer to buy ITM?

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3

Service Provider No. _____ Enumerator code _____ DATE ___/___/___

C/3 TTBD products used in the last 12 months

Products	Types used	Manufacturer (company)	Supplier	Vols of existing stock	When (mo) this was bought last	Buying price		Vol bought then	How often product is bought	Month using peak vols	Month using least vols	Selling price
						Units	KSh.					
Treatment products (A)	1.											
	2.											
	3.											
	4.											
	5.											
	6.											
	7.											
Acaricides (B)	1.											
	2.											
	3.											
	4.											
	5.											
	6.											
	7.											
	8.											
Vaccines (all) (C)	1.											
	2.											
	3.											
	4.											
	5.											
	6.											

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
Service Provider No. _____ Enumerator code _____ DATE ___/___/___

C/4 Products and their characteristics from a service provider's perspective ***(*Refer to table C/3)***

Product	Is packaging easy to use? Y, N	Is size / vol appropriate Y, N	Is price appropriate Y, N	Does it give the expected results Y, N	Any side effects? Y (state), N	Is it a popular product? Y, N	Is it a risky product to use Y (how), N	Any restrictive regulations on its use or sale? Y (state), N	What aspect of this product would you prefer changed - how?
A 1									
A 2									
A 3									
A 4									
A 5									
A 6									
A 7									
B 1									
B 2									
B 3									
B 4									
B 5									
B 6									
B 7									
B 8									
C 1									
C 2									
C 3									
C 4									
C 5									
C 6									

KIAMBU = 1　　NAKURU = 2　　NYANDARUA = 3
Service Provider No. _____　　Enumerator code _____　　DATE ___/___/___

C/5 Please point out any government regulations / constraints affecting the following

a. Where you operate your business	
b. What products you can sell	
c. What services you can sell	
d. What professional requirements you should have	
e. Any reporting requirements – e.g. some diseases	
f. Complaints	
g. Other (specify)	

C/6.1 Supplier characteristics ***(*Refer to table C/3)***

Supplier / source	Location	Dist - kms	No. of visits / yr	How long have you used them?	How do you make orders	How do prdts get delivered to you?	Time taken from order - delivery	Form of pay -ment	Are their prices reasonab le (Y/N)	Do they have the products you want / need?	Have you had bad products (Y/N)	What do you do about any bad products	What do you like best about business w/ them?	What do you like least about business w/ them?

How do you order
1 = Go there in person
2 = By mail
3 = By phone
4 = Contract arrangement (specify)
5 = Other ________________

Product delivery
1 = Use my own transport
2 = They deliver w/ their transport
3 = They deliver by public transp
4 = Other ________________

Time to delivery
1 = Immediately
2 = Short delays
3 = Long delays - (need reminding)
4 = Other ____________

Payment arrangement
1 = Cash on delivery
2 = Credit available
3 = Contract (specify)
4 = Other ____________

Have products you want
1 = Always
2 = Often
3 = Sometimes
4 = Other ____________

Action on bad products
1 = They replace easily
2 = They replace w/ persuasion
3 = I have to file a court case
4 = Other ________________

C/6.2 Among these characteristics, which is the most important to you when you consider choosing a supplier?

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
Service Provider No. _____ Enumerator code _____ DATE ___/___/___

SECTION D SERVICE PROVISION COMPETITION

D/1 Please identify other service providers operating in your area

Vet services	Name of service provider	Contact / location	Qualifications	SP type	Employe ment type	Type of service offered	Why should farmer prefer		Desired relation with competitor
							you to them	them to you	
Government vets	1								
	2								
Private practitioners	1								
	2								
	3								
	4								
	5								
Agrovet shops	1								
	2								
	3								
Co-operative	1								
	2								
	3								
AHAs	1								
	2								
	3								
Other (Specify)	1								
	2								

Qualifications
1 = No vet training
2 = College Certificate
3 = College Diploma
4 = University degree
5 = Other (Specify) __________

SP type
1 = Farmer's neighbour
2 = Paravet/ AHA
3 = Inseminator
4 = Extension worker
5 = Veterinarian
6 = Other (Specify) ________

Employment type
1 = Private / self
2 = Government (official duty)
3 = Government (private duty)
4 = Cooperative
5 = Other (Specify) ______

Type of service offered
1 = A.I.
2 = Clinical work
3 = Selling of drugs
4 = Vaccinations
5 = Advice (health & mgt)
6 = Other (Specify) ________

D/2 Among these service providers, who is your principal competitor

a. in the diagnosis and treatment of TBDs? _____________

b. in vaccinations? ______________

End time _____

Appendix 4: Institutional interview guide

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
Service Provider No: _____ Enumerator code _____ DATE ___/___/___

Company Name **Respondent Name**

Contact **Title**

1. Overview of business

1.1 Type of company: 1 = Multinational 2 = National 3 = Local
4 = Distributing branch 5 = Other (specify) ____________

1.2 Objectives of firm relative to animal health

1.3 Overall company size

1.3.1 No of employees technical ____ support ____

1.3.2 Size of branches

1.3.3 No of branches ___

1.3.4 Overall sales value

1.4 Products dealt with

Range of products	% to total business	Where these are sold

1.5 Importance of animal health products - sales volumes

1.6 Relative importance (share) of TBD products to business (%)

1.7.1 What production systems are important to your business

1.7.2 Relative importance of production systems

Production system	Type	Gross % of business	No. of sales reps
LS dairy cattle production	commercial		
SS dairy cattle production	subsistence/commercial		
LS dairy - meat cattle production	pastoralism		
Other (specify)			

2.1 Popular product characteristics:

Product type	Product name	Who makes it?	Why popular
Acaricide			
Treatment drug			
Vaccine			

KIAMBU = 1 NAKURU = 2 NYANDARUA = 3
Service Provider No. _____ Enumerator code _____ DATE ___/___/___

2.2 Popular product handling chain (________________)

Level	(Source)				(Destination)
Ownership					
Specific costs					
Selling prices					
Turnover rates					
No of agents					
Payment arrangements (seller)					
Payment arrangements (buyer)					
Comments					

Payment arrangements
1 = Cash on delivery 2 = Cheques accepted
3 = Short term credit (1 week) 4 = Long term credit
5 = Contact arrangement 6 = Other (specify) ________

Cost types (as % of total costs?)
1 Storage a = Variable
2 Transportation b = Fixed
3 Loading
4 Labour
5 Marketing costs
6 Other (specify)

2.3 How has this chain evolved over past 10 – 20 years

2.4 Would you say the annual trends in sale volumes have been i) stable, ii) increasing or iii) decreasing? Why is this?

3 Expectations for newer distributors/firms

3.1 What is the criteria to be a distributor

3.2 Are you expected to have any initial investment costs

3.3 Are you expected to meet any working capital requirements?

3.4 Do you provide (or receive for distributors) any credit at the start of business?

4 Pricing behaviour

4.1 Who sets product prices?

4.2 Most important factors considered in price setting

4.3 Any formal or informal groups affecting price setting?

4.4 Any price trends through the year (seasonal effects)

4.5 How have these pricing practices changed over time?

5 Services rendered

5.1.1 Does company give products / services on credit (lending) to buyers

5.1.2 What are the credit conditions

5.1.3 Maximum and minimum credits

5.1.4 Conditions of repayment for credit offered

5.1.5 What happens with defaulters and what are the trends?

5.1.6 What TBD product quantities are on credit

5.1.7 What are the effects of **not** giving TBD products on credit on your business?

5.2.1 What are the conditions of providing commissions

5.2.2 What are the types of commissions (maximum and minimum)

5.3 Evolution of services over time

6.1 Availability of market information e.g. of product in 3.1 above. Two type of info: i) sales promotion and ii) appropriate application of products

Type of info	Sales promotion	Application of products
1. How do farmers get info on product		
2. How does company target info to potential clients (vets, storekeepers, farmers, others)		
3. How does company assess demand for or likelihood to use this product		
4. Does company obtain feedback info from clients / how?		

6.2 Is it necessary to have clients know composition of products? If yes how is this information disseminated?

6.3 How does company disseminate information on products requiring special handling e.g. cold chain

6.4 How has information flow (between company and client) changed over time (10 – 15 years)?

6.5 Who is responsible in cases of product failure

7 In the supply of your popular product _______________, who are your main competitors?

Competing company	Competing product	Why would a client prefer you to them	Why would a client prefer them to you

8 These questions are intended to identify the type of problems that you encounter which have the effect of raising costs for your business, costs that may have to be passed on to the client. They are also meant to identify ways of reducing these costs.

8.1 What action is (would be) taken on complaints (formal/informal) by clients?

8.2 What is the company policy on returned products?

8.3 Has company had any such matters that had to be solved legally

8.4 What kind of costs would the company have to face to handle legal matters?

9 Transaction costs: Certain issues came up when we talked to service providers in order to understand their problems and costs that they face in the delivery of products and services. The following are the issues that they mostly consider when they chose to use the services of a given supplier

Transaction cost	**All costs ignored**, rank what's imp to attract business,	**All costs considered** rank what's feasible to provide
1. Good quality products		
2. Delivery of products		
3. Availability and promptness		
4. Commission & discounts on products		
5. Popularity of company/ products		
6. Distance (near)		
7. Service efficiency		
8. Credit provision		
9. Wide variety of products		
10. Reasonable prices		

10 Product related transaction costs (cite specific products and service provider recommendations)

11 Any unethical trading practices observed (e.g. use of expired products, wrong products, overuse of antibiotics, other)

12 Give any government policies affecting the following:

12.1 Registration / licensing of products

12.2 Types of products you handle

12.3 How you do business

12.4 Cost of doing business:

12.4.1 What is needed for registration / licensing of your business

12.4.2 Do you pay any import taxes / handling taxes (e.g. VAT, forex restrictions) for the business

12.4.4 Are there any restrictions on product handling and transportation

12.4.5 Are you aware of any labour laws on hiring / firing of employees

12.4.6 Are there any quality control laws – inspection of premises and / or products

12.4.7 Any other restrictions

12.5 Policies related to the delivery of animal health services have been changing over time. Two main such policies are:

12.5.1 Privatisation of vet services. How do you view this and how does it affect your business

12.5.2 Liberalization of milk marketing and the downfall of KCC (with Co-ops becoming more decentralized). What is the effect on your business?

12.5.3 Evolution of other policies over time: Can you identify any other changes in policies that have affected your business, specifically delivery of TTBD products and services?