Chapter 3

DESCRIPTION OF METHODS AND VARIABLES USED

3.1 INTRODUCTION

In this chapter the methods used to analyse adoption and levels (categories) ov livestock veterinary technologies are discussed. The methods used with the selection of the variables, their justification, as well as the way the data was collected, analysed and modelled will also be attended to in this chapter.

In the first section of this chapter a short justification of the different dependent variables and a conceptualisation of the explanatory variables are given. This is followed by a short description of the survey, which includes a short discussion of the study area, sources of information used, the development of the questionnaire, the sampling technique used and the data collection. The chapter concludes with a description of how the data was processed, which includes the methods followed in the selection of the possible predictors and a brief description is given on the discrete choice models used in this study with the determination of predictors.

3.2 SELECTION OF VARIABLES

No precedent exists to provide a guide in the selection of relevant variables (predictors) to either replicate or refute previous results on livestock veterinary technology adoption.

This necessitated the use of a larger number of explanatory variables considered in the models than would have been done under normal circumstances, with previously available information from reference studies. Most of the variables included in the different adoption models considered in this study were selected from the literature in Chapter 2. Unfortunately, most of the existing diffusion/adoption studies on new agricultural technologies are on crop production (Feder, Just & Zilberman, 1985; Grisley & Shamambo, 1990; Henry, Klakhaeng & Gottret, 1995; Lin, 1995; Nichola, 1994; Park & Kerr, 1990), except for the research done by Bhattacharyya *et al.* (1997), which refers to the adoption of a vaccine (against Trichomoniasis) on range beef cattle in Nevada.

The limited number of reference studies compelled the author to construct a panel of experienced specialists to identify adoption categories and variables which may probably affect the adoption of livestock veterinary technologies. The panel consisted of five veterinary surgeons, three animal scientists and four extension officers (some of which were previously involved in the diffusion of livestock programmes in Qwaqwa up to 1994). The hypothesised variables are discussed in the following section.

3.2.1 Dependent variables

The dependent variables tested in this study can broadly be divided into two categories, namely adoption of veterinary surgeon services technology and medication technologies. The medication technologies are further divided into four major groups of medicine, namely external parasite remedies, internal parasite remedies, antibiotics and vaccines. Different categories (levels) of livestock veterinary technologies were generally identified as follows:

- ***Non-adopters****:* Farmers who do not use a specific livestock veterinary technology at all.
- ***Adopters****:* Farmers who use a specific livestock veterinary technology.
- ***Full adopters****:* Farmers who use a specific medication technology at a recommended level.
- ***Partial adopters****:* Farmers who use a specific medication technology, but at a lower level than recommended.
- ***Over-adopters****:* Farmers who use a specific medication technology at a higher level than recommended.

- ***Potential adopters:*** Farmers who are non-adopters of a specific livestock veterinary technology, but want to use it or would have used it had it been available and/or accessible.
- ***Wrong adopters:*** Farmers who only use wrong medication technologies for a certain disease.

For each of the livestock veterinary technologies studied, the farmers were classified into the different general adoption categories mentioned. A more specific definition for the different adoption categories will be given in Chapters 5, 6 and 7 for each of the livestock veterinary technologies. The adoption categories were grouped for each of the livestock veterinary technologies and their characteristics (variables) compared under the hypothesis that they differ significantly.

3.2.1.1 Veterinary surgeon services

Veterinary surgeon services in this study refer to the services rendered by a veterinarian to the farmer. These services must include a clinical intervention by the veterinarian directly on small ruminants at the farm or at any other place where the veterinarian was visited.

Three categories of adoption can be identified for veterinary surgeon services, namely (i) **non-adopters** and (ii) **adopters**, as described by most researchers in conventional adoption studies (Feder *et al.*, 1985; Lin, 1995; Park & Kerr, 1990) and (iii) **potential adopters** for a less elastic/inelastic supply of inputs or conditions of services (adapted definition), as suggested by Bhattacharyya *et al.* (1997) and Nichola and Sanders (1996), as it is hypothesised to be the case in Qwaqwa[1].

Both adoption definitions (conventional and adapted) were tested and compared, using logit models, to determine predictors for the adoption of veterinary surgeon services. These discrete choice models have been widely used by several other researchers in

[1] Fully subsidised government veterinary surgeon services were available free of charge at the sheering sheds up to 1994. Only a private veterinary surgeon is at present available in Phuthaditjhaba for three hours per week where transportation cost is up to R250 (100 km @ R2,50/km). If a farmer has to travel to Harrismith to the private veterinary clinic, the transportation cost doubles to R500 per trip.

studies on the adoption of agricultural technologies (Bhattacharyya *et al.*, 1997; Feder *et al.*, 1985; Lin, 1995).

Two logit models are constructed, one in which potential adopters are grouped with non-adopters and compared with adopters (conventional definition), and another model where potential adopters are grouped with adopters and compared with non-adopters (adapted definition).

3.2.1.2 Adoption of medication technologies

The medication technologies considered in this study, are divided into four basic groups or types of medication, namely (i) **external parasite remedies**, (ii) **internal parasite remedies**, (iii) **antibiotics**, and (iv) **vaccines**. The *IVS Desk Reference Book* (1998) was used to classify the medicines reportedly used by the farmers in the four medication groups considered. If remedies which have a simultaneous effect on more than one group (e.g. Ivermectine 1%) are used, then farmers are considered adopters of both medication groups (external and internal parasite remedy).

3.2.1.2.1 Adoption of external parasite remedies

In this study external parasite remedies refer to medication drugs used to control skin parasites like ticks, mites (scab) and lice. According to Agri-Mark's annual sales figures of Qwaqwa, external parasite remedies have the **highest** sales of the four medication groups discussed in this study (Venter, 1998).

Different numbers of applications of external parasite remedies are recommended for different regions of the country, depending on the local conditions. The categories of adoption of external parasite remedies can be defined as, (i) **full** and **over-adopters** and (ii) **partial adopters**. Over-adoption of external parasite remedies have no major consequences, besides being a waste of money that could be used in other technologies (Erasmus, 1998; Naude, 1998). As this study deals with the identification of predictors contributing to adoption and is not an economically viable study on technologies, it was decided to group this category with that of full adoption. The usage of wrong remedies (e.g. HI-TET) in combination with a correct remedy for external parasites, according to Erasmus (1998), is not a major issue, therefore these cases will be classified as adopters.

3.2.1.2.2 Adoption of internal parasite remedies

Internal parasite remedies, in this study, refer to livestock medication drugs used to control internal parasites such as roundworm, tapeworm, nasal worm and liver fluke. These drugs (applied by injection or dosed orally) have a therapeutic effect over already present parasites; however, when used regularly and in an adequate programme, they may have a preventative effect on internal parasite diseases (Van Schalkwyk, Van Wyk & Viljoen, 1995). According to Agri-Mark's annual sales figures of Qwaqwa internal parasite remedies have the **third highest** sales of the four medication groups discussed in this study (Venter, 1998).

A certain number of applications of internal parasite remedies are recommended over a year for different regions of the country, depending on the local conditions. Three adoption categories can be distinguished for this dependent variable, namely (i) **partial adopters**, (ii) **full adopters** and (iii) **over-adopters**. The incorrect use of internal parasite remedies (partial or over-adoption) may have serious implications as the induction of resistance against these drugs (Vermunt, West & Pomroy, 1996). For this reason it is very important to analyse the characteristics of these adoption categories separately.

3.2.1.2.3 Adoption of antibiotics

Antibiotics in this study refer to systemic and local antibiotics used to treat sick animals, including eye and wound remedies containing antibiotics. Antibiotics have a therapeutic effect and may be of great importance in lessening the mortality rate among sick animals. According to Agri-Mark's annual sales figures of Qwaqwa antibiotics have the **second highest** sales of the four medication groups discussed in this study (Venter, 1998).

Antibiotics are recommended in only visibly affected animals for infectious conditions caused or aggravated by most bacterial diseases. Three adoption categories with regard to the dependent variable have been identified, namely (i) **non-adopters**, (ii) **partial adopters** and (iii) **full adopters**. For this medication group it makes no sense to consider an over-adoption category, as there are no recommended programmes for the usage of this medication.

3.2.1.2.4 Adoption of vaccines

Vaccines in this study refer to biologic veterinary products that are used in animals as a preventive (prophylactic) measure to prevent disease. Vaccines are the only type of medication amongst the four medication groups considered in this study that has a prophylactic effect (Hunter, 1993). According to Agri-Mark's annual sales figures of Qwaqwa, vaccines have the **lowest** sales of the four medication groups discussed in this study (Venter, 1998).

According to Schwalbach (1998), each area of the country has a basic recommended annual vaccination programme, defined by veterinary services on the basis of the existing information on the local prevalence and incidence of diseases of economical importance. Two adoption categories with regard to this dependent variable have been identified, namely (i) **non-adopters** and (ii) **partial adopters**.

3.2.2 Explanatory variables

The purpose of this section is to describe the selected variables to be tested in the different livestock veterinary adoption models. All the explanatory variables selected from the literature that were measured in a slightly different way in this study, as well as all the variables (more related to livestock technologies for developing farmers) selected by the panel of livestock experts, are briefly discussed in this section.

It is possible to classify and use some variables either as **continuous** or as **categorical variables**, depending on how a variable is approached or measured. An example, for instance, is extension visits which can be classified as a continuous variable if number of extension visits per year is measured, or as a categorical variable if the researcher is only interested in whether the farmer received extension visits or not. The following explanatory variables were used to determine predictors contributing to adoption of the different livestock veterinary technologies considered in this study (veterinary surgeon services and four major medication groups):

3.2.2.1 Continuous variables

These variables take any numerical value in a real interval when measured accurately (Ramanathan, 1992):

- Age of the farmer.
- Number of people in household.
- Educational level of farmer.
- Years of farming experience with livestock.
- Farming efficiency (median weighted weaning percentage of small ruminants).
- Management skills – planning (median days planned ahead).
- Level of entrepreneurship.
- Livestock income per livestock unit (LSU).
- Herd size.
- Mortality rate* (mortality as percentage of total small ruminant herd size).
- Total indebtedness of the farmer irrespective of the origin of the debt.
- Number of extension officer visits per year.
- Reasons for farming*.
- Type of small ruminant farmer*.

* Variables identified by the panel of livestock experts.

3.2.2.2 Categorical variables

These variables take a numerical value of one or zero and are also called binary or dummy variables (Annexure B.4).

- Attitude of farmer towards risk.
- Literacy and arithmetic abilities of farmer.
- Gender.
- Traditional medication or remedies used (herbs and plants).
- Training sources approached on medication usage (extension sources, co-farmers, media and own sources).
- Record-keeping.

- Level of income and cost record-keeping.
- Availability of credit.
- Information sources approached to make technical decisions.
- Information sources approached to make financial decisions.
- Information sources approached to make marketing decisions.
- Sources approached to get information on new technologies.
- Availability and accessibility of roads.
- Availability and accessibility of transport.
- Availability and accessibility of telephone.
- Availability and accessibility of electricity.
- Availability and accessibility of local markets.
- Availability and accessibility of government and cooperative extension and agricultural research institutions.
- Availability and accessibility of suppliers of inputs institutions.
- Usage of mating seasons*.
- Usage of registered and grade rams*.
- Location of farmer/farm* – Old or New Qwaqwa.

  * Variables identified by the panel of livestock experts.

Some of the variables (e.g. age, education and extension visits) were used directly as identified from the literature on crop technology transfer and will not be discussed further in this chapter. Another group of variables selected from the literature, but measured in a different way (e.g. farm size/herd size, management skills, farming experience and farming efficiency) or others identified by the panel of livestock experts which need proxies to be quantified and those identified by the panel of experts referred to earlier, will be briefly described and discussed in this section.

❑ Human capital endowments

In this study human capital endowments include the following explanatory variables:

- Age.
- Family size.
- Education.
- Gender.
- Knowledge.
- Farming skills or experience.
- Farming efficiency.
- Management skills.
- Level of entrepreneurship and creativity.

The variable "**education**" is measured in terms of the highest grade the farmer has achieved in formal education. Gender will be included as a categorical variable, which is one if the farmer is a women and zero if otherwise. Knowledge is proxied as a categorical variable with literacy and arithmetic abilities. The specifications and dosages of medication are printed on containers in English and/or Afrikaans. It was hypothesised that farmers who can read Afrikaans or English and can make basic calculations (add, subtract and multiply) would be more able to use medication technologies than illiterate or poor arithmetic skilled farmers. The dummy variable is a one for farmers with the above-mentioned abilities and zero if otherwise. The variable "gender" will be included as a categorical variable if the number of women farmers are sufficient to do a statistical analysis. If the head of the farm is a woman, a one will be scored and a zero if otherwise.

Farming skills or experience is proxied by the number of years of farming experience with livestock. Farming efficiency is proxied with a weighted average weaning percentage of the different small ruminant herds kept by the same farmer (the weaning percentage of a larger herd carries a higher weight in the calculation). Weaning percentage is one of the most important efficiency parameters for the small ruminant farmer because it includes fertility, conception rate, lambing percentage and mortality rate (Greyling, 1998). It measures technical efficiency.

Management skills are proxied by the number of days that the farmer is planning ahead.

Giles and Stansfield (1990) refer to planning as an integral part of management. Most medication activities of the small ruminant farmer are actions that must be taken according to a management programme (prophylactic) made in advance, which include the treatment for internal and external parasites as well as vaccination against diseases. This programme is highly dependent on the seasonal variations of climatic conditions that play a determinant role in the epidemiology of different animal diseases over the year. This makes planning ahead a very important component of a successful small ruminant operation.

The **level of entrepreneurship** is measured by means of two questions under each heading. The results were added and weighed according to a scale to develop an entrepreneurial index which was used in the models as a variable. A set of statements included in the questionnaire to evaluate entrepreneurial skills were developed from literature on evaluation of entrepreneurial skills (Bird, 1989; Cromie & O'Donaghue, 1992; Maasdorp, 1992) with the assistance of Human (1997). These questions (Annexure A, Section B.8) were refined and tested in Qwaqwa in collaboration with Komako (1998). These statements tested leadership, need for goal achievement, creative skills, motivation to progress, need for autonomy and attitude towards risk.

- ❑ **Farm/herd size – Annual livestock income per livestock unit**

Herd size as well as total annual livestock income are scale variables. It is obvious that larger farms or farms with a higher income are more likely to adopt new technological inputs. This is trivial for this study. The difference in tenure between farms in Old (communal) and New Qwaqwa (commercial) makes it difficult to work with farm size or the area utilised by each farmer. The number of small ruminants can also not be linked to their feed intake to compute the grazing area used, due to the overgrazing problem in Old Qwaqwa. Total annual income per LSU (which includes own consumption) as a measurement of financial efficiency, will be used instead of total farm income. This will counter the problem of scale variables that tend to dominate other variables in a model. The total small ruminant (LSU) herd size will be used as variable to determine the effect of the fixed cost part of transaction costs in the adoption of livestock veterinary technologies.

❑ Mortality rate

Mortality rate is one of the parameters indicating technical efficiency in a livestock farming enterprise (Devendra & McLeroy, 1982) as it has a direct effect on the number of marketable animals. It is hypothesised that farmers experiencing higher mortality rates will also be the ones with a lower adoption rate of livestock veterinary technologies. On the other hand, higher mortality rates can motivate farmers more to adopt livestock veterinary technologies than those with lower mortality rates. No previous adoption study could be found that has considered this variable.

❑ Extension visits

Extension services form part of the institutional explanatory variables. Extension is perhaps one of the most important ways of transferring information to a farmer (Wheeler & Ortmann, 1990). This variable is measured by the number of extension visits that the farmer receives in a year at the farm or at the shearing shed.

❑ Reasons for farming

Another variable that did not receive attention from researchers on technology adoption studies, is the reason why farmers are farming with small ruminants. Farmers were asked to rate different reasons for farming with small ruminants (from 4 as very important to 1 as not important) (Annexure A, section E.6) . The rates given by farmers for farming for normal purposes (commercial reasons) were analysed, as it is hypothesised that farmers who are more commercially orientated, will rate it important to very important and will have higher adoption rates than subsistence farmers who will rate it as not important. It is assumed that most farmers in developing countries have commercial objectives; however, in traditional African production systems it is often reported that the main objective for farming is social prestige and to invest in capital which is easily converted into money (Diomisio, 1985).

❑ Type of small ruminant farmer

It was decided to include the variable "type of farmer", because it was hypothesised that the kind of small ruminant farmer will have an influence on the adoption of medication technologies. Sheep are hypothesised to be more susceptible to diseases than goats. This variable is expressed as sheep LSU's (mutton and woolled) as percentage of total small ruminant LSU's in the herd.

❑ Kind (tenure) of farm (location of farming operation)

The location of the farm or farming activities in Old and New Qwaqwa is important for this study because of the different tenure systems in the two areas of Qwaqwa (Chapter 4). The variable is a one if the farmer is from Old Qwaqwa and a zero if the farmer is from New Qwaqwa.

❑ Attitude towards risk

The attitude towards risk in this study refers to the farmers' attitude towards profit flow (Annexure A, section D.7). A risk-seeking farmer is the one willing to spend money in adopting a new technology that will probably have higher incentives. A risk-averse farmer is not willing to risk current profits in a new technology that costs money, in the hope of higher incentives. To estimate the influence of attitude towards risk on technology adoption, two dummy variables are used by choosing one of the categories (risk-seeking) as a control (or base) category (Table 3.1).

Table 3.1: **RISK DUMMY VARIABLES**

Variables	Risk-seeking	Risk-neutral	Risk-averse
Risk d1	0	1	0
Risk d2	0	0	1

❑ Access to credit

The nature of livestock production systems are not as capital intensive as crop production systems, which makes the availability of credit to buy veterinary technologies as less important than crop technologies, especially in the case of medication technologies where the medication to be purchased is not so capital intensive. However, if the farmer wants to purchase registered or graded rams, access to credit can play a more important role. This variable is included as a categorical variable and it will be considered as one if credit is available and zero if otherwise. It is hypothesised that this variable, which is in general terms an important variable within livestock veterinary technologies, will not emerge as a significant predictor.

❑ Financial management

Financial management was included by the panel as variable. The level of financial management was used as measurement. Olivier (1998) found in unpublished field studies that the farmers adopting medication technologies tend to have better financial management skills. If a farmer keeps any cost and income records this variable was considered as a one and a zero if otherwise.

❑ Traditional medication or remedies used (herbs and plants)

If enough cases emerge from the surveyed data this variable will be used to determine whether the use of traditional medication encourages the adoption of livestock veterinary technologies or not. This variable will have a one if the farmer is using traditional medication and a zero if otherwise.

❑ Training sources on medication usage

The medication technology transfer programmes before 1994 were in the form of training (learning by doing) and demonstration programmes, which is an efficient method suggested by Nagy, Sanders and Ohm (1988) for technology transfer.

In order to limit the categorical explanatory variables (17 different sources were listed in the questionnaire – Annexure A, section F.2), some of the sources had to be classified and grouped in a logical way. The relative low number of cases in some of the categories of adoption makes this action necessary. The farmers were categorised in related groups according to the nature of the sources of training and information. If a group has a zero or low frequency (number of cases), it can be combined with the group that has the closest characteristics. This variable is divided into the following four main groups:

- ***Group 1:*** Self (no-one or do not know where to get training).
- ***Group 2:*** Media (books, television, extension publications and press).
- ***Group 3:*** Co-farmers (co-farmers and sheering association chairperson).
- ***Group 4:*** Extension sources (extension personnel from the Department of Agriculture, cooperative, bank, supplier of inputs, market agents, veterinary surgeon and livestock inspectors).

Group 1 is where the farmer relies on his/her own knowledge and has no access to any of the other three sources of training. Group 2 uses the media. All the sources listed can be linked to the media. Group 3 refers to people approached within the farming community, and group 4 refers to extension officers and people approached with recognised farming knowledge. The way in which this variable is set as dummy variable is presented in Table 3.2.

Table 3.2: **DUMMY VARIABLES FOR TECHNICAL AND FINANCIAL DECISIONS AND TRAINING SOURCES**

Variables*	Self	Media	Co-farmers	Extension officers
Tech d1, Fin d1 & Tr1	0	1	0	0
Tech d2, Fin d2 & Tr2	0	0	1	0
Tech d3, Fin d3 & Tr3	0	0	0	1

* Tech = Technical decisions.
Fin = Financial decisions.
Tr = Obtain training sources on medication usage.

❑ Information sources

Sources of information approached to make technical, financial, and marketing decisions and obtain training when it is needed, are classified in this section and grouped in the same way as described in the previous variable (training sources). When the number of cases in a specific group is too low for the analysis, the groups are combined (Table 3.3). The organising of the dummy variables in this section is given in Table 3.3.

Table 3.3: **DUMMY VARIABLES FOR TECHNICAL AND FINANCIAL DECISIONS**

Variables	Self and media	Co-farmers	Extension officers
Tech d2 & Fin d2	0	1	0
Tech d3 & Fin d3	0	0	1

Because of the low number of farmers using their own knowledge (self) and the media, these two groups were merged in one category (Table 3.3). This action is necessary when quasi-complete separation occurs.

❑ Mating seasons

The usage of mating seasons is an indication of the level of development of the farmers. Breeding technology transfer programmes were one of the main livestock developing programmes of the government before 1994. The use of breeding seasons requires at least basic infrastructure to keep the rams separated from the ewes for some time between breeding seasons. If a farmer adopts such an advanced technology, it is hypothesised that basic medication technologies such as internal and external parasite control would also have been adopted first. For these reasons this variable was selected by the panel of livestock experts to be included in the adoption models. The dummy variable takes the value one if any mating season is used and a zero if otherwise.

❑ Breeding technology

It is hypothesised that farmers using registered and grade rams will most likely adopt livestock veterinary technologies. Farmers will most probably take better care of these animals because of their higher value, and it is therefore hypothesised that they would more likely adopt veterinary technologies to prevent their animals from getting sick or die. The dummy variable takes the value one if registered or grade rams are used for breeding and a zero if otherwise.

❑ Infrastructure

The following types of infrastructures are tested individually for their contribution to livestock veterinary technology adoption:

- Telephone.
- Electricity.
- Roads.
- Transport.
- Local markets.
- National markets.
- International markets.

The dummy variables take the value one if the specific infrastructure is available and accessible to the farmer and a zero if otherwise.

❑ Institutions

In this study institutions were divided into two groups, which were used individually as variables:

- ***Group 1***: Government extension system, cooperative extension system and agricultural research.

- *Group 2:* Suppliers of inputs, that is **input suppliers** (businesses where farmers can buy feed and medication for livestock), **output markets** (institutions like the cooperative where wool and mohair and auction pen where livestock can be marketed) and **banking services**.

The dummy variables take the value one if the specific institution is available and accessible and a zero if otherwise.

3.3 THE SURVEY

3.3.1 The study area

The study was conducted in the area of Witsieshoek and the portion of the Harrismith district of Qwaqwa (Old Qwaqwa) and part of the Harrismith/Bethlehem district consolidation of the South African Development Trust (SADT) (New Qwaqwa). Qwaqwa is situated in the south-eastern corner of the Free State province, bordered by Kwa-Zulu/Natal and the Kingdom of Lesotho and situated between 28 and 30 degrees longitude and 28 and 30 degrees latitude (see the orientation map of Qwaqwa in Figure 1.1). It is situated between the Gauteng, Durban/Pinetown and Bloemfontein metropolitan areas.

The Qwaqwa area was chosen for this study because its agricultural activities are mainly on livestock production, and perhaps one of the most active in agricultural technology diffusion programmes up to 1994. The discontinuation of these programmes was due to a population explosion, intense urbanisation and expansion of informal settlements, which forced the farmers away from the service centres to the mountainous areas with low nutritional grazing. This has resulted in a complex situation regarding the conditions for adoption and usage of new livestock veterinary technologies essential for profitable livestock production.

3.3.2 Source of information

Descriptive, theoretical and analytical data and the experience of informed veterinary surgeons are methods and techniques used in this study. Time series data on the population growth, farming area available (hectare) and animal population (small stock units), were attained from the Central Statistical Services (South Africa, Republic, 1991) and surveys done in Qwaqwa by the Development Bank of Southern Africa (DBSA, Sec.2, 1985), the South African Development Trust Corporation Limited (SADTC, 1988), Urban-Econ (1992) and Vrey and Smith (1980) (see Chapter 4).

The collection of farm level information to obtain data and to determine variables (predictors) contributing to the adoption of livestock veterinary technologies was based on the adoption-diffusion theory and previous empirical work. The literature on diffusion (transfer) and adoption of agricultural technologies suggest that the farmer's adoption behaviour is explained by farmer and household characteristics (Wheeler & Ortmann, 1990), its perceptions regarding agricultural technology (Feder *et al.*, 1985) and institutions and the available infrastructure (Hayami & Ruttan, 1985). Taking these aspects into consideration, a questionnaire was developed and farmers interviewed to obtain the relevant information. Only farm level cross sectional data was used in the modelling of the five groups of livestock veterinary technology adoption (veterinary surgeon services and four medication groups).

3.3.3 The development of the questionnaire

A questionnaire (Annexure A) was developed to obtain relevant information on farmer and household characteristics, management, productive parameters, usage of livestock technology, availability and accessibility of institutions and infrastructure. Examples of other questionnaires (Nichola, 1994; Van Schalkwyk, 1997; Venter & Madolo, 1997) and significant variables contributing to technology adoption from other studies in developing agriculture and technology adoption, were used as guidelines.

Discussions with veterinarians and extension officers formerly involved in technology diffusion programmes in Qwaqwa, livestock experts, business economists, computer experts, bio-statisticians and business psychologists from the University of the Orange Free State were also involved in the development of the questionnaire in order to obtain realistic information for statistical data processing. The questionnaire was pre-tested on six black farm managers in the Bloemfontein area as well as five small ruminant farmers and four extension officers from Qwaqwa, before being used in the survey.

3.3.4 Determination of the farmer population and sampling

Information on the farmer population in New Qwaqwa was obtained from Sentraal Oos Corporate Limited (SOK) where accurate and up to date information was available. From a total of 94 farmers, 78 are small ruminant farmers. No official information on the small ruminant farmer population of Old Qwaqwa is available. After a three-day visit to the area and the collaboration of local extension officers and chair persons of the sheering association from Old Qwaqwa, a list of 178 farmers was compiled from information gathered at sheering sheds (sheering data) and individual farmers visited and found while driving through the mountains.

A proportional stratified sample of 45 small ruminant farmers from a population of 78 in New Qwaqwa and 65 small ruminant farmers from a population of 178 in Old Qwaqwa, were selected.

3.3.5 Data collection

Interviews were conducted by means of a questionnaire with 99 small ruminant farmers in Qwaqwa (63 in Old Qwaqwa and 36 in New Qwaqwa), during the first two weeks of January 1998. Approximately half of the New Qwaqwa farmers were interviewed during a meeting organised by the extension officers from the SOK and the rest of the farmers were visited individually on their farms. The majority of the farmers in Old Qwaqwa were interviewed at sheering sheds, schools and extension officer ward offices and only a few visited individually at their farms. The interviews with farmers who are not fluent in English or Afrikaans was done with the help of translators in order to preserve the accuracy of the information.

3.4 DATA PROCESSING

The SAS (1990) statistical package will be used for data processing in order to define farmer characteristics, possible predictors and to identify the predictors of the defined dependent variables in the different adoption models considered.

In order to prevent the inclusion of two or more highly correlated explanatory variables in the same function that may lead to bias results, the explanatory variables were tested to identify possible correlations between them. The continuous variables were tested using the Spearman Correlation Test and the categorical variables by means of the Kappa Coefficient Test-chance corrected measure of agreement. None of the variables showed correlations either amongst the continuous variables or the categorical variables.

3.4.1 Determination of adoption predictors – modelling

The purpose of this section is to present the methodology used to identify possible predictors to be included in the different models of adoption, the modelling process and the determination of the significant predictors contributing to the adoption of the different livestock veterinary technologies studied (veterinary surgeon services and medication).

3.3.1.1 Determination of possible predictors

The explanatory variables selected from the literature and by the panel of livestock experts were tested for significant differences (to identify possible predictors to be included into the models) between the different adoption groups/categories considered, using one of the following four statistical tests (depending on their type and distribution) described by Siegel (1956):

- The **t-test** will be used to determine significant differences between two continuous explanatory variables with a normal distribution.
- The **Mann-Whitney U-test** will be used to determine significant differences between two continuous explanatory variables with skew distribution.

- The **Chi-square test** will be used in the analysis of categorical explanatory variables with larger frequencies (observations).
- The **Fisher exact probability test** will be used in the analysis of categorical explanatory variables with small frequencies (observations) or where data have low expected scores or counts (values) and to determine significant differences between two categorical explanatory variables.

The age of the farmers is the only variable that had a normal distribution, and therefore the mean will be used as a summary statistic. All the other variables had skew distributions, which make it necessary to use the median in these cases since it is a more representative criterion in a data set where the distribution is skew (Steyn, Smit & Du Toit, 1994).

The explanatory variables of adoption of veterinary surgeon services were divided into two sections, namely continuous and categorical explanatory variables. Two tests were used to determine the differences between the groups for each of the 13 continuous explanatory variables, namely the t-test in the case of normally distributed variables and the Mann-Whitney test for the variables with skew distributions. To determine the difference between the groups for each of the 10 categorical explanatory variables, the Chi-square or Fisher's exact tests were used.

Variables tested, which presented p-values of $\leq 0{,}15$ between the different adoption categories or groups, were selected as possible predictors and included in the modelling analysis.

3.4.1.2 Determination of significant predictors

The identified possible predictors for each adoption model will be included in the most adequate discrete choice model. The logit and the multinomial logit models are used in this study to determine the predictors contributing to the different adoption categories of livestock veterinary technologies.

These models were selected due to the fact that the dependent variables (adoption categories) considered in this study were measured in a qualitative way as categorical variables (values 0, 1 and/or 2), and not quantitatively, as percentage of adoption (continuous variables). For this reason, the tobit and the double hurdle models, which are more suited to quantitative data, could not be used. Discriminant analysis was also not used in this study mainly due to the fact that it handles linear functions and the technology adoption curve tends to be a sigmoid curve, which is better handled by the logit, the probit and the multinomial logit models. The discrete choice models used in this study are presented and discussed in full in Annexure B. In the same annexure, the mathematical functions (logit models) used to estimate dependent variables with two dummy categories are given in Equations B.6 and B.7, and those used to estimate dependent variables with three dummy categories (multinomial logit models) are given in equations B.8 and B.9. In these models, stepwise regression analysis will be used to identify the predictors contributing significantly ($p \leq 0.15$) to the adoption of livestock veterinary technologies. The outcome of the surveyed data will determine the number of dummy categories to be accounted for in the four medication groups. This will help to decide whether logit models or multinomial logit models will be used.

For the above-mentioned reasons, logit models will be fitted to determine the predictors contributing to the adoption of veterinary surgeon services, as two definitions (conventional and adapted) are under discussion, each with two adoption categories.