EVALUATING THE RETURNS TO RESEARCH ON A PROJECT LEVEL: COVER CROPS IN THE SOUTH AFRICAN WINE INDUSTRY

by

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature

Date..

OPSOMMING

Die doel van hierdie studie is om die opbrengs op navorsing oor dekgewasse in die Suid-Afrikaanse wynbedryf te bepaal. Hierbenewens het die studie dit ook ten doel om gepaste metodieke vir die evaluering van navorsingsprojekte daar te stel. In hierdie opsig maak hierdie studie 'n bydrae tot besluitneming oor die allokering van openbare fondse vir landbounavorsing op 'n ekonomies en sosiale optimale wyse.

Die Suid-Afrikaanse wynbedryf beleef tans 'n bloeifase, hoofsaaklik as gevolg van sterk internasionale vraag na sy produkte, maar sal op sy internasionale mededingendheid moet let indien die volle voordele hiervan benut kan word. Daarom is dit noodsaaklik dat die bedryf op tegnologiese gebied moet kan meeding, en dus dat navorsingsbesteding nie onoordeelkundig ingekort word nie. Inligting oor die opbrengs op navorsingsbesteding is dus noodsaaklik om die volgehoue betrokkenheid van die staat te kan regverdig, hetsy as finansier of as katalisator vir privaatsektor betrokkenheid.

In hierdie studie is die opbrengs op navorsing gemeet deur beide die bekende produksiefunksie benadering sowel as deur koste-voordeel ontleding. In die eerste geval is 'n opbrengskoers van 44% gemeet, en in die tweede geval is dit 37%. By die koste-voordeel ontleding is ook 'n verdere onderskeid gemaak tussen twee wynbou-streke om die invloed van meer besproeiing te bepaal.

Ten spyte van dataprobleme, veral wat betref die koste van navorsing, kan beweer word dat die inligting so verkry van nut sal wees vir besluitnemers by die toekenning van skaars navorsingsfondse, asook by bedinging om privaatsektor fondse.

ABSTRACT

The purpose of the study is to determine the rate of return to cover crop research in the wine industry. The method followed will prove an invaluable contribution toward the need to determine a suitable approach for evaluation studies. The importance behind such a study is the development of appropriate *ex ante* evaluation approaches, which will assist in the allocation of public research resources in both a social and economical manner.

The wine industry is currently enjoying healthy international demand, but will need to remain competitive to reap the full benefit of international exposure. The need therefore exists for a continuation of research at the institutional level, in order to maintain the progressive nature of research knowledge that was available in the past. The evaluation of *ex post* and *ex ante* research will assist in maintaining government funding for research and help with campaigning for private investment of research in the wine industry.

The use of two evaluation approaches was used for the analysis. Firstly, the production function approach achieved a rate of return of 44 percent, using weather and research expenditure as a means to explain the variations in wine grape yield. Secondly, a cost benefit approach was devised in order to make a direct comparison between the cost and benefits related to the cover crop research. The rate of return achieved for this mode of analysis is 37 percent, using trial plot data as a source of information on potential benefits. In addition to this the cost benefit approach was used to show the difference in rate of return that is achievable between two growing regions. The variable that exists between the two regions, is the higher rate of irrigation in one of the regions.

The high rate of return achieved for the investment, provides suitable motivation for the increase in state funding for research in the wine industry, and provides valuable information for the enticement of support by private investors. The two methods used in the study will both draw a certain amount of criticism, largely as a result of the lack of

available data. The empirical nature of the approaches is however simple and applicable down to the project level.

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INTRODUCTION

Agricultural research at the institutional level may have only started in the middle of the nineteenth century, but has been active at the private level for as long as man has endeavoured to produce agricultural products. One could go as far as to compare the link between agriculture and agricultural research, with that of the question of what came first, the chicken or egg. After all, the first cultivated vineyard could theoretically be classified as research, as the probability of success was uncertain. Every time a new area was placed under cultivation, a producer was taking the risk of not knowing whether the area would be appropriate, the rainfall sufficient, the soil type correct, the planting method accurate, or whatever other variable may have had an effect on the outcome of the harvest. Therefore, agricultural research whether conducted at the institutional or private level, has and continues to be exercised on a daily basis.

The above may pose the question of why invest public money in agricultural research, if it is being undertaken at the producers' expense on a daily basis? The answer is simply that with research being conducted on an institutional level control can be exercised to ensure that important research issues are not left to "chance". Research on a public level addresses issues, which are not always profitable, but important for the maintenance and sustainability of production resources. Public research will consider the needs of the industry and act according to an organised research program. The sole reliance on private research will result in the duplication of research hypotheses, as the extension of privately owned research knowledge would be limited. Furthermore, this research will be specific to the production set up of the producer undertaking the research, and therefore may render itself negligible for other producers.

The South African agricultural industry has historically identified with the importance of institutional research, and set-up the necessary statutory bodies to ensure that research continued in a progressive manner. The 16 research institutions country-wide not only ascribe to the importance of agricultural research, but also indicate the financial backing which agricultural research has enjoyed in the past. These institutions covering all agricultural disciplines, except sugar cane research, will however have to adapt to the reduction of state financial backing, a policy, which has accompanied the South African Government of National Unity. Furthermore, research projects will need to become more socially aware, so as to consider the current resource factor endowment in South Africa. The increase in the accountability and competition for public funding will therefore require that suitable methods of enticement exist for research proposals to be accepted and undertaken.

Theoretically, the importance of agricultural research is clear, the need however exists to provide the necessary proof that capital is not being expended in a haphazard manner. Funds, which are directed toward research by the state, will need to be accounted for and diverted in the direction which will ensure social, financial, environmental and economical returns. Similarly the attracting of potential private investment will require extensive *ex ante* evaluations to be conducted, indicating probable returns on investment. The lobbying for research proposals are however foreign to most research institutes, as funds were "freely" available in the past. The need has therefore arisen for probable means of determining *ex post* returns to research and developing *ex ante* evaluation techniques.

The case study is minimum tillage research conducted at the wine research institute in Stellenbosch. The minimum tillage research includes a wide range of production techniques and occupies a vast number of research projects. The focus of the study will therefore be broken down to include only those projects which have resulted in the use of cover crops, as one of the suitable means of minimum tillage. Townsend and Van Zyl (1998) conducted a similar study, which attempted to determine the rate of return to research conducted in the wine industry, at the institutional level. The rate of return achieved was 61 percent for research expenditure only and 45 percent for research and extension expenditure combined. This study will attempt to determine a probable means to evaluate the returns to research, and in so doing arriving at a rate of return for the investment. Unlike the study by Townsend and Van Zyl, the evaluation will be conducted on a project level. The importance of project level evaluations will increase as the need arises to distinguish one project proposal from another. This requirement for the development of thorough *ex ante* evaluation techniques will be facilitated by the approaches used in determining returns for *ex post* studies. Furthermore, this paper attempts to provide empirical evidence that will justify the investment of funds in research. The wine industry accounts for 14 percent of the value of the horticultural sector, and also generates a significant quantity of foreign exchange from exports. Research is therefore vital to maintain the current growth rates in the industry, and remain competitive with international competitors.

Evaluation techniques have in the past been categorised on the *ex post* and *ex ante* distinctions, but have also been moulded by the availability of data. Most studies in the past have been criticised not on the method of evaluation used, but as a result of the lack of sound historical data. It is therefore important that research institutions become aware of the requirements for research related data, so as to facilitate *ex post* and *ex ante* evaluation studies.

The proposed methods of evaluation for the purpose of this study are that of a production function approach, and cost benefit analysis. Both of these methods have been used extensively for macro level studies, but have a limited usage on project level evaluations. The production function method is predominantly used for *ex post* studies, whereas the cost benefit approach is an *ex ante* approach. The advantage of the latter method is that it is flexible in set-up, and can also be used as an *ex post* evaluation technique. The predicted lack of suitable data will require that these methods be modified to accommodate this shortage.

The importance of such a study is the useful information, which is generated for decision-makers, as the optimal allocation of scarce resources is sought. For higher level decision making *ex post* information on costs and benefits is of greater importance than *ex ante* information. The usefulness of *ex ante* evaluations becomes apparent at the lower levels of decision making. This study being *ex post* at the lower level of decision making will attempt to give some insight into the requirements for a successful *ex ante* evaluation.

The study therefore attempts to determine the rate of return of the investment into cover crop research in the wine industry. Through this, extensive research will have to be conducted on current evaluation approaches, and a suitable method of evaluation selected for the purpose of this project level analysis.

A brief description of the South African wine industry is given in Chapter One. This chapter endeavours to illustrate the strength of the industry, as well as show the improvement in market conditions, which the political climate in South Africa has brought about. The importance of research will therefore be imperative in order to remain competitive and reap the benefits of the international exposure. Chapter Two highlights the various methods of evaluations that have been used in the past, for both *ex ante* and *ex post* studies. The details of each specific method may differ from one study to the next depending on the availability of cost and benefit data. This Chapter attempts to explain the various approaches on a theoretical basis, and highlight the advantages and disadvantages of each approach.

Chapter Three explains the evolution of agricultural research in South Africa, and the present day structure of research institutions. The aim of the chapter is to firstly place the cover crop research in perspective, and secondly to describe the transition which cover crop research has undergone. A description of all related projects is given in this chapter. Chapter Four will attempt to compile all the relevant data for the study, and display the data in a useable format. Lastly, Chapter Five will analyse the data using the production function and cost benefit approaches. A description of both these approaches and the results achieved will be given in this chapter.

CHAPTER ONE

The South African wine industry

1.1. Introduction

The South African wine industry came into being soon after Jan van Riebeek founded the Cape Colony in 1652. The first wines produced were exceptionally astringent, and it was not until 1679 when Simon van der Stel established the legendary 750ha Constantia wine estate outside Cape Town, that the quantity and quality of the wine improved. The wine trade in South Africa was first bolstered by the Napoleonic Wars, which forced a major reduction in the wine trade between England and France. Britain thus turned to South Africa to fill the void left by the lack of French wine. These good fortunes were enjoyed until 1861 when the Gladstone government removed empire preferential tariffs, thus re-allowing the inflow of French wine from across the channel. In 1886 the misfortunes of the South African wine industry were to continue in the form of the Phylloxera disease which wiped out almost the entire industry. This setback was however to prove beneficial in the long run as farmers re-established their vineyards with high-yielding vines.

The new high yielding varieties were however to prove detrimental to the market in the short run as the sudden production of vast quantities of wine created an unmanageable oversupply. It was at this stage that the industry realised the need for a means of control within the industry, to prevent the excess of wine depressing its price. This therefore lead to the formation of the Cape Wine Growers Cooperative (KWV) in 1918. It was created to limit production and set minimum prices, in view of stabilising the wine industry (De Jongh, 1976). The KWV membership comprised of only wine and brandy farmers countrywide, and it was estimated that by the end of 1917 that 90 percent of the wine farmers in the Cape had signed the constitution of the KWV. The noticeable exclusions from the sign-ups were some Stellenbosch farmers and most of the Constantia farmers, who were of the impression that the attributes offered by the KWV were ineffective for farmers who produced a superior quality wine (Report, 1997).

The scheme proposed by the KWV to create stability was based on enforcing all members to sell all wine produce through the co-operatives. This would have the effect of improving the bargaining power of the farmers in the industry and creating a means whereby a minimum price could be set in the domestic market. Furthermore, it was proposed that the producers would deliver all excess wine to the co-op to be used at the discretion of the organization. The capital generated from a sale of the excess wine was either reinvested back into the co-op or paid out to the members on a pro rata basis. By 1923 the surplus had grown to 50 percent of production, and it was at this stage that the leaders of the industry realized that statutory powers of intervention were necessary to put an end to surplus production which plagued the industry. The KWV were finally given the right in 1957 to enforce a quota system whereby each farmer's production would be controlled. This had the bizarre effect of creating a shortage of wine during most of the 1960's and 1970's, amidst frequent adjustments made to the quotas. The excess, which again prevailed in the 1980's, was controlled by the KWV's decision to invest in the production of grape juice concentrate. This market was to prove so effective that farmers were at times achieving higher prices for grape juice concentrate than for distilled wines. The demand for grape produce was later increased as the markets for flavored wines and alcoholic fruit beverages were exploited. In addition to the diversification of products, the changing political environment in South Africa helped re-open export avenues and improve the exposure of South African wines through tourism (De Jongh, 1976).

1.2. A description of the South African wine industry

The South African wine industry, which is predominantly situated in the Cape, can be divided into eleven main regions, namely Constantia, Stellenbosch, Paarl, Worcester, Robertson, Olifantsriver, Orange River, Klein Karoo, Mossel Bay, Walker Bay and Elgin. The wine farms in these regions can effectively be reclassified into three main categories, which consist of firstly, the estate farms which are characterised by adequate capital and the production of sufficient high quality grapes to operate modern and fully equipped cellars for the production of wine. The second category of farmers are those that sell farm made cellar wine to wine merchants. Inclusive in this category are farmers who belong to the district cooperative and supply newly harvested grapes to the cooperative cellars, where it is made into table wine, sweet wine, rebate or distilled wine. This wine is later sold by the cooperatives to wine merchants and distillers. A smaller percentage of these wines are also sold on to retailers for domestic consumption under the cooperative name. The final category of farmers has their wine made by wine merchants, who purchase the produce at the grape stage. An important activity of the wine merchant is the purchasing and marketing of wine produced by cooperatives, including the KWV (Morgan, 1988).

Table 1.1:Geographic distribution of South African vines per KWV district for 1996.

KWV District	Number of vines	% of total vines	Area Hectares	% of total ha.
Orange River	26 233 397	8.4	14 080	13.3
Olifants River	25 851 604	8.2	8 479	8.0
Malmesbury	33 959 811	10.8	13 551	12.8
Klein Karoo	11 054 814	3.5	3 415	3.2
Paarl	58 026 134	18.5	19 064	18.1
Robertson	40 318 325	12.8	11 171	10.6
Stellenbosch	50 225 224	16.1	15 575	14.8
Worcester	68 130 458	21.7	20 274	19.2
Total	313 799 767	100.00	105 609	100.00

Source: KWV: SA Wine Industry Statistics, No 21. 1997.

During the 1980's the South African wine industry expanded production to almost 3,500 wines, which ranged from first-rate dry whites to deep flavoured, splendidly oaked, tannic reds; feathered sparkling wines; and port and sherry. In South Africa it is the climate, and especially the levels of annual rainfall, which is the primary factor in determining vineyard locale. Of the eight areas mentioned in Table 1.1 all but the Orange and Olifants River regions are situated in the Cape, where rainfall can vary from 30 too more than 300 inches per year. The climate is generally mild, with heavier rainfall in the coastal areas and irrigation required among some of the interior vineyard locales. The soil types vary from sandstone in the west, granitic in the east, shale in the valleys, to alluvial sandy loam in the river valleys (Robinson, 1994).

The white Chenin Blanc variety makes up nearly one-third of the wine produced in the country, and together with the Sultana and Colombar varieties, the tally of white wines is raised up to almost 50 percent of the total wine produced. It is estimated that only 15 percent of the wine produced is red and only one in every eight bottles of wine sold are red. The fact that the Chenin Blanc variety can be used to make almost any style of white wine has helped keep it a firm favourite amongst the producers. In addition to this the ratio of red to white varieties has remained true to the demand therefore, as only a small proportion of the population has traditionally consumed and been able to afford a good quality red wine. It has only recently become a fashion to consume good quality wine.

The consumer market for wine in the Cape has not supported the industry to the extent that would have been expected. The black and coloured majority in the Western and Northern Cape remain faithful to beer, with an annual consumption of more than 130 l which makes them one of the world's top five beer markets per capita. In the late fifties one of the largest producer firms launched a cheap white wine of high quality that increased the initial annual sales a thousandfold. The potential for the wine market was extended in 1963 with the amendment of the Liquor Act, allowing the sale of wine to the black population, and again in 1966 when grocery stores were given the right to sell wine (De Jongh, 1976). The increase in the exposure of wine to the general public had the effect of improving the demand thereof, and has created a current fashion for noble red wine. In spite of the above, South Africa is not a nation of wine drinkers, and owing to the hot climate beer is still a firm favourite, followed by brandy and other spirits. The South African climate is however not the only contributing factor toward the demand for beer, the increase in the demand for noble red wines, has allowed dealers to push up the price thereof, thus dragging the middle and lower-priced wines with it. This has resulted in the cheaper beer market once again making inroads into the wine consumer market.

The industry at present consists of 4 634 winegrowers, 4 394 of which are KWV members and 240 are non-KWV members. A concerning fact of the South African wine industry is that a clear division can be made between the quantity-producing majority and the quality-producing minority of the growers. It has been estimated that more than half of the annual harvest, amounting to approximately half a million tons, is destined for distillation or non-table wine products such as grape spirits and grape concentrates. With just over one percent of the world's vineyards, South Africa ranks 20th in the area planted under vines, but its annual output of 1 012 million litres makes it the world's seventh largest wine producer. This can widely be attributed to the fact that approximately 75 percent of all the vineyards in South Africa are irrigated, resulting in areas such as the Orange River producing almost nine times more per hectare than some French wine farms (De Jongh, 1976). In France the majority of the vineyards are not irrigated, as it is believed that a vineyard needs to experience hardship, so that it will be able to produce a good quality wine.

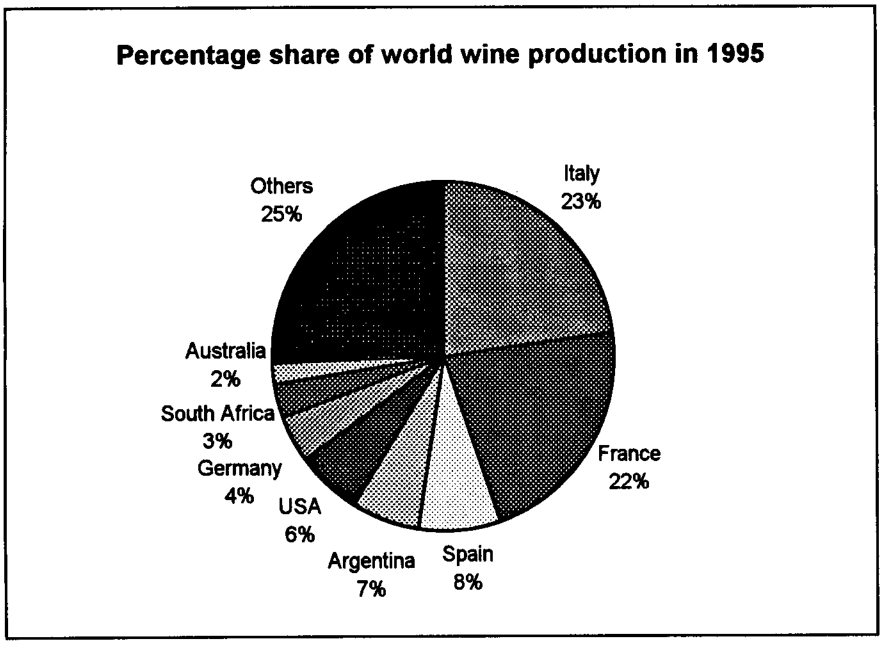

Fig 1.1: Percentage share of world wine production in 1995
Source: *SA Wine Industry Statistics No.21, KWV, 1997.*

The widespread wine production areas in South Africa allow for notable variations on the requirements for irrigation. This has a major impact on the output achieved from the vineyard, and also the effect with which the research will have on the productivity of the vine. The percentage of hectares under irrigation for the various production areas is shown below in Table 1.2.

Table 1.2: Irrigation patterns between production areas for 1996

Production area	Irrigated vineyards - ha	Percentage of production area	Dry land vineyards - ha	Percentage of production area
Orange River	12231.38	96	460.56	4
Olifants River	7114.35	90	794.30	10
Malmesbury	4063.64	33	8518.12	67
Little Karoo	3073.73	97	104.36	3
Paarl	11895.54	70	5029.45	30
Robertson	11017.49	99	107.65	1
Stellenbosch	7050.97	45	8447.55	55
Worcester	15468.18	98	343.49	2
Total	71915.18	75	23805.48	25

The South African wine industry has experienced an indifferent history of exports, with international demand being influenced by a number of factors outside of the control of the local industry. These factors include the competition from wines produced in both Spain and France, and the restriction on exports as a result of sanctions against South Africa during the apartheid years. However, since 1991 wine exports from South Africa have increased by almost three-fold, totalling 71 million litres in 1995. This amount was approximately 11 percent of the total harvest made into wine and nearly 30 percent of the total wine farming income. It is however disturbing when considering that during the same period the producers' incomes have increased by a mere 60 percent. This is illustrated in the Table 1.3 below. An obvious lack of income returning to the producer is evident and can partly be attributed to the fact that the state revenue received from the wine industry has increased three-fold in the same amount of time. This revenue is collected by the state in the form of customs and excise duties drawn on the full range of products that are taken from the vine.

Table 1.3: Comparison of producer and state revenue realised from the industry

Year	Wine Exports litre	Producer Income R	State Revenue R
1991	23 090 052	653 100 000	586 600 000
1992	21 995 782	707 800 000	654 500 000
1993	24 596 957	692 200 000	764 500 000
1994	50 691 808	866 400 000	1 085 000 000
1995	71 316 718	963 200 000	1 282 200 000
1996	99 900 000*	1 233 100 000	1 599 500 000

Source: The KWV SA Wine Industry Statistics, No 21. 1997
* Estimate

1.2.1. Pricing policy

Prior to 1992, wine grapes and wine products were sold and marketed through the KWV, which was legally empowered to determine quota limits, fix minimum prices and pre-determine production quotas. This system however handicapped the private wine producer in favour of the bulk grape grower. The scheme was applicable to all wine products produced and marketed in South Africa and therefore included regulations' governing imports and exports.

In 1992, the KWV relinquished most of its powers, setting the stage for a freer production scene. The amended price system, which ensued, aimed to allow market forces to function freely, but at the same time keep in place basic stabilising mechanisms. It was at this time that the quota system was abolished. In general the deregulation aimed to allow the wine industry to operate on a free market free enterprise orientated system. Producers could plant what they wished where they wished, make their own wine or sell their grapes to any of the 69 cooperative wine cellars. This forced producers to become aware of the fundamentals which governed the industry, and farm in a manner which would result in the highest possible income. The incentive had therefore been created for the producer to produce a better quality product, and thus achieve higher prices therefore.

Over the past six years the deregulation of the market has had a visible impact on the industry, especially in terms of the prices and production thereof. The deregulation allowed producers to sell their produce in whatever avenue available to them, therefore creating the option for the producer to either sell the produce to the local co-op, or to any other willing buyer both locally or internationally. Therefore in conjunction with the increase in exports that the dropping of sanctions had on the industry, the increase in the options available to the producer have lead to an upward swing in the price of wine products. The growth in prices has been seen in all forms of wine produce, but as is evident from the Figure 1.2 below it was the trend in price for the good quality wine that increased at the most impressive rate.

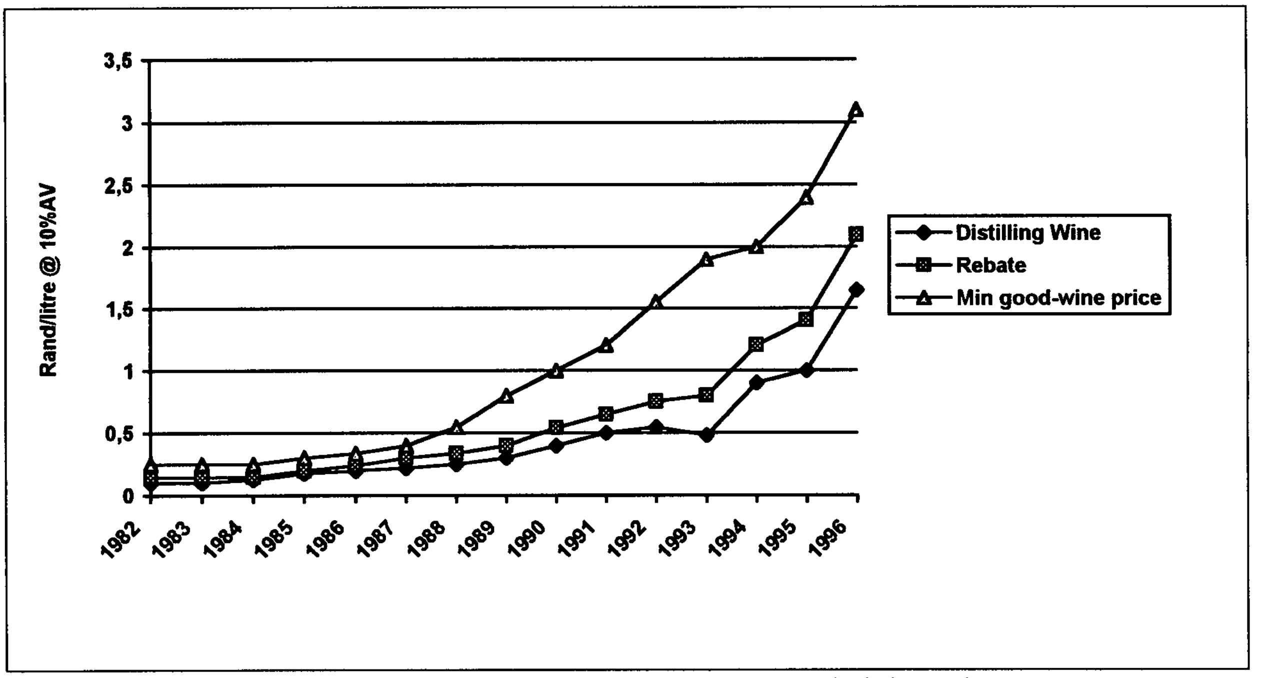

Figure 1.2: The price increase of good quality, rebate and distilling wine.

Source: Ewert (et al) (1998). State and market, labour and land - the South African wine industry in transition.

The improvement in the prices for good quality wine assisted in shifting the production towards better quality cultivars. In addition to this the relatively low set-up costs which characterised the industry, created a situation whereby the Internal Rate of Return (the highest rate of interest that can afford to be paid on borrowed capital) of the wine industry, was higher than those of similar industries which competed for the same resources. Table 1.4 illustrates the former and also shows the comparable set-up costs.

Table 1.4: Profitability of the wine industry *vis-à-vis* other industries

	Internal Rate of Return (IRR) (real) (%)	Establishment costs per ha excluding land (R)
Apples	16	57,418.00
Table Grapes	23	61,995.00
Pears	18	57,418.00
Wine	30	49,908.00

Source: Ewert (et al) (1998). State and market, labour and land - the South African wine industry in transition.

The favourable conditions of the deregulated market have lead to the expansion of the area planted under wine grapes at the expense of field and horticultural crops. It is projected that this situation will improve, and that as South African producers realise the potential of the export market, so too will the land allocation continue to favour the wine industry. The survey conducted by Ewert et al (1998) showed that only 30 percent of the total farm area is currently under intensive cultivation in the surveyed area, with wine grapes making up about half of this amount. Refer to Figure 1.3 in text.

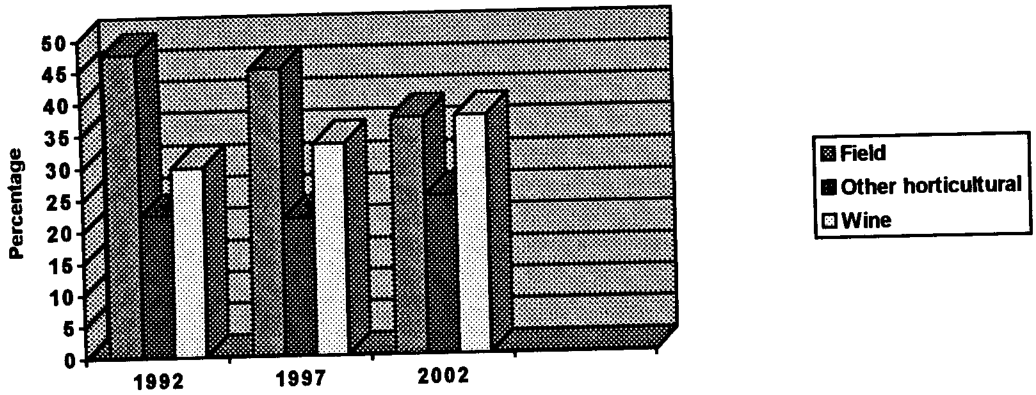

Figure 1.3: Land allocation on wine farms (%), 1992 - 2002

Source: Ewert (et al) (1998). State and market, labour and land - the South African wine industry in transition.

The increase of wine grape vineyards at the expense of other crops has also occurred at the expense of poor quality cultivars. Producers have realised the price benefit of growing a good quality cultivar and have moved toward replacing their old vineyards with better quality cultivars. Table 1.4 below illustrates this increase in surface area under better-quality cultivars since 1991, at the expense of poorer-quality cultivars.

Table 1.5: The change in the percentage of total surface area under grapes in South Africa occupied by certain grape cultivars.

Variety	1991	1992	1993	1994	1995	1996
Chenin Blanc	31.2	30.4	29.7	29.3	28.5	27.7
Cabernet Sauvignon	4.3	4.8	5.0	4.9	5.0	4.9
Sauvignon Blanc	3.7	3.8	4.0	4.2	4.5	4.7
Chardonnay	1.8	2.4	2.9	3.3	4.0	4.5
Pinotage	2.0	2.1	2.2	2.4	2.7	3.3
Merlot	1.2	1.4	1.6	1.7	1.8	1.9
Shiraz	0.8	0.8	0.9	0.9	1.0	1.1

Source: KWV: South African Wine industry Statistic, No 21, 1997

The two figures below make an interesting and important point that needs to be considered by producers when changing to better-quality cultivars. The fact of the matter is that the better-quality varieties generally do not produce as high a yield as the poorer-quality varieties.

The cooperatives therefore have a vital role to play in advising producers as to the best cultivar selection that will suit the specific soil type and area, so as to obtain the best production results. Many producers are currently sticking with the poorer-quality - high yielding varieties mainly because of the price of grape juice concentrate. In continuing with this practice the producer faces the danger of having limited options should the price for grape juice concentrate collapse.

The wine industry in South Africa has shown a brave and opportunistic face amidst the changing political environment in the country. It being one of the first regulated industries to see the advantages of changing to a deregulated market, thus setting the scene for other industries to follow. The industry has however failed to expand to its true potential into a greater market share for noble wines, partially as a result of the high ruling price for grape juice concentrate and distilling wine. The survey by Ewert et al (1998) concluded that the cooperatives have not adapted the ruling price for concentrates and distilled wines fast enough to create the catalyst needed for cultivar substitution. In addition to this it was concluded that the cooperatives needed to offer additional benefits to their members, so as to maintain current market share and survive in the changing environment.

1.2.2. Labour issues

The wine industry can be characterised as a labour-intensive industry, in the form of either permanent or temporary workers. In 1993 the industry accounted for 40 percent of the total number of permanently employed labourers in the Western Cape, and on a national scale the total number of workers amounted to 45 000 in 1997, a 7% increase since 1993. Since the deregulation of the market the aggregate employment levels have increased, the wage packages have improved, and the labour relations have become more formalised. The industry has however remained true to the traditional farm labour relations and prevented the move toward a more productive and modernised form of labour productivity.

The survey conducted by Ewert et al (1998) cited the fact that the Australian labour force are said to be twice as productive as that of the South African industry. The reason for this can partially be attributed to the cultural and social barriers, which characterise the South African labour force, and which have acted as a barrier to it becoming a modern and productive outfit. In addition to this the Australian labour force is paid considerably more than labour in South

Africa, a contributing factor to the present high mechanisation rate of the Australian industry. The trend toward mechanisation has begun in South Africa, with the survey showing that 84 percent of farmers will look to mechanise in the future. This can partially be attributed to the fact that new labour legislation has forced farmers to reconsider employee living conditions, wage rates and general employment contracts. The process of mechanisation has however been hampered by the low cost of labour and the high cost of mechanisation that is characteristic of South African agriculture.

The laws governing the South African wine industry may have changed in the new political era, but the actual living and social conditions of the workers have remained the same. Farmers have generally been hesitant to commit to permanent labour, due to the long-standing constraints that this implies. The farmers will have to identify with the need to become productive and lead labour into a situation where productivity and wage levels are directly related. The current problem is that the present low wage rates and the weakening exchange rate have created favourable market conditions and negated the need to ensue more productive means of production. The imposition of more statutory control may have the adverse effect of reducing the employment rate, as farmers substitute labour with machinery. Back in the 1980's the wine industry showed its concern for labour living and social standards with the formation of the Rural Foundation. The lack of state support has however seen the institution drastically cut down its involvement in the industry. It will therefore require that the individual farmers once again make a concerted effort to improve the living and social conditions of the farm workers.

1.3. Current developments

In January 1997 a committee was set-up to investigate the regulation of the wine and distillation industry. One of the major reasons for the investigation was to determine what the possible consequences would be, should the KWV be given the right to convert to a company. One of the issues surrounding the conversion was the utilisation of the assets, which the KWV had accumulated over the years as a cooperative. These assets which were accumulated under statutory controls were classified as the possession of the industry, and not the KWV. It would therefore be unjust for the KWV to accept ownership of these assets, in an industry that has become competitive.

The positive trend of the South African wine industry toward a more modern and competitive market, which has stemmed from the deregulation of the industry, has created a situation in which the existing controlling bodies are deemed non-viable for the current situation. The industry however does identify with the need for some sort of statutory control for issues that will not be in the interest of a private company. Of the more important issues the commission indicated are that statutory control will be needed to firstly control the surplus removal of produce; secondly, the need for research funding to be extracted from the industry; and thirdly, legislation should be in place which would aid the collection, processing and dissemination of information which will assist management decisions in the industry. The commission concluded that there existed a need to retain certain of the controls, which regulated the industry in the past. Their recommendations included the following points:

- That the Wine and Spirit Control Act, No 47 of 1970 be repealed by the date of conversion of the KWV to a company.
- That the Wine and Spirit Board be charged with the responsibility to administer the information function and that Winetech control the funding of the industry related research.
- That legislation allows for the importation of cheap imports during times of shortage.
- That the functions relating to the above be dealt with under the auspices of the Marketing of Agricultural Products Act.
- That a regulatory framework be in place that will assist in the utilisation of the assets accumulated in the course of exercising statutory powers.

1.4. Conclusion

The statutory control of the wine industry has allowed for the creation of many vital activities in the industry, and should be maintained to ensure the future of the industry. It is important that the private companies that result, realise the importance of a function such as research, and continue to maintain the existing research structures that are in place. In addition to this it will be the responsibility of the cooperatives to support the producers through the period of transition, so as to obtain the full benefit from the available resources. The privatisation of the industry will help to push the industry into a more productive and efficient industry, but will also place the responsibility for many of the vital functions mentioned above, in the hands of the industry.

The question of surplus production, primarily the reason for the formation of the KWV, cannot afford to be neglected in the new deregulated market. Currently the demand for good quality wines and the high ruling price for grape juice concentrate, have negated the need to consider precautionary action to prevent the rehash of surplus production. The cooperatives will therefore have to assist producers in this regard.

The industry will be encouraged by the current devaluation of the Rand exchange which has improved market conditions and increased exports, but at the same time should be aware of the evils which exists in a market which is left to develop at its own accord. It is therefore the responsibility of the industry to ensure that funds for research are available, that labour conditions are improved, that surplus production is prevented and that the international competitiveness of the industry is strengthened.

CHAPTER TWO

Research and development evaluation techniques

2.1. Introduction

Worldwide technological improvements in agriculture have proven to be an important determinant of productivity growth in the agricultural sector for most of the 20th century. The economic value of technological improvements can be identified by the extent to which it represents an improvement over existing production inputs, techniques and products. The explosion of international research institutes since the founding of the Mexican based International Rice Research Institute (IRRI) by the Rockefellar Foundation in 1959, has illustrated the confidence placed in agricultural research by the international community. The fact that these international institutions exist, along with subsequent local institutions, has created the need for a means of evaluation, not only as an organisational tool, but also as a means of efficiently allocating scarce financial resources.

Historically, economists have spent a considerable amount of time analysing “appropriate” methodologies for the effective evaluation of research and development (R&D) activities. Two main reasons for R&D evaluation have been highlighted: firstly, the benefits/returns which can be attributed to R&D will illustrate the importance of public expenditure on R&D and, secondly, the limited availability of capital has created the need for improved resource allocation within the R&D system.

2.2. R&D evaluation techniques

Alfred Marshall first considered the theoretical understanding of current R&D evaluation techniques over a century ago. It was his comprehension of the concept of consumer and producer surplus that has been used by economists worldwide to develop appropriate research investment analysis methodologies. Schultz (1953) and later Zvi Griliches (1958) were the first to endeavour to put this theory to practice in an attempt to measure the returns to the investment into agricultural research. The mechanics behind current evaluation techniques were later discussed at a meeting held in Minnesota by the Minnesota Agricultural Experiment Station of the University of Minnesota, in 1969. The main objectives of the meeting were to examine recent evidence on the returns to investment in domestic agricultural research systems, and to explore the relevance of social and economic factors for the organisation and management of domestic research systems (Arndt et al, 1977).

A second international conference was held at Airlie House, Virginia, in January 1975. The major issues considered were organised under six headings 1) the productivity of agricultural research, 2) the demand for research and technical change, 3) the generation and diffusion of agricultural technology, 4) the productivity and potential of the international research institutes, 5) the organisation and management of agricultural research and 6) the improvement of research decision making (Arndt and Ruttan, 1977). The Airlie Conference proved to be a major success in as far as the interaction that occurred between the agricultural and social scientists.

Having considered a former review by Schuh and Tollini (1979), Norton and Davis (1981) reviewed and compared the more common approaches that had been used to evaluate public agricultural research investments. The numerous methodologies illustrated are evidence of the need for evaluation techniques on different levels of research, and within different industries and institutions, all requiring specific methodology. The fact that methodologies are far from being "clear-cut" techniques, adds to the uncertain nature with which analysts appraise research methodologies, and allows for continual progress within the field.

Traditionally analysts have found common ground when differentiating between *ex post* evaluation and *ex ante* appraisal studies. The former referring to the evaluation of research that has been completed and the latter to research that must still be started. Evenson (1971) however, contests this common ground by differentiating evaluation studies according to what outcome is deemed necessary from the particular analysis. His first subdivision separates evaluation methods into those that use an average rate of return, those that use a marginal rate of return, and those that use alternative criteria as a focus of measurement. The common ground is once again reached when the specifics of evaluation techniques are considered. The review by Norton and Davis (1981) is used to illustrate the techniques currently in use (refer to Table 2.1).

Table 2.1: Evaluation techniques edited from the work of Norton and Davis (1981).

Ex post Evaluations	*Ex ante* Evaluations
Economic Surplus Approach	Scoring Models
Production Function Approach	*Ex ante* Benefit-Cost Approach
National Income Approach	Simulation Approach
Nutritional Impact Approach	Mathematical Programming Approach

Source: Adapted from Norton and Davies (1981).

In the section that follows each technique will be considered in more detail, along with the advantages and disadvantages surrounding these techniques. Furthermore, a brief mention will be made illustrating the use of these techniques in past studies.

2.2.1. *Ex post* evaluations

2.2.1.1. Economic surplus approach

This approach, also referred to as the Index Number Approach, is based on the summations of the gains and losses of producer and consumer surplus that can be associated with a technology-induced shift in the supply curve. The aggregate benefit as a result of the supply shift is compared with the costs and expenditures that are associated with research and development. Once discounted, the comparison between the benefits and costs is a direct reflection of the return on investment in R&D, also referred to as the internal rate of return (IRR). A graphical explanation of the trade-off between producer and consumer surplus is given below in Figure 2.1.

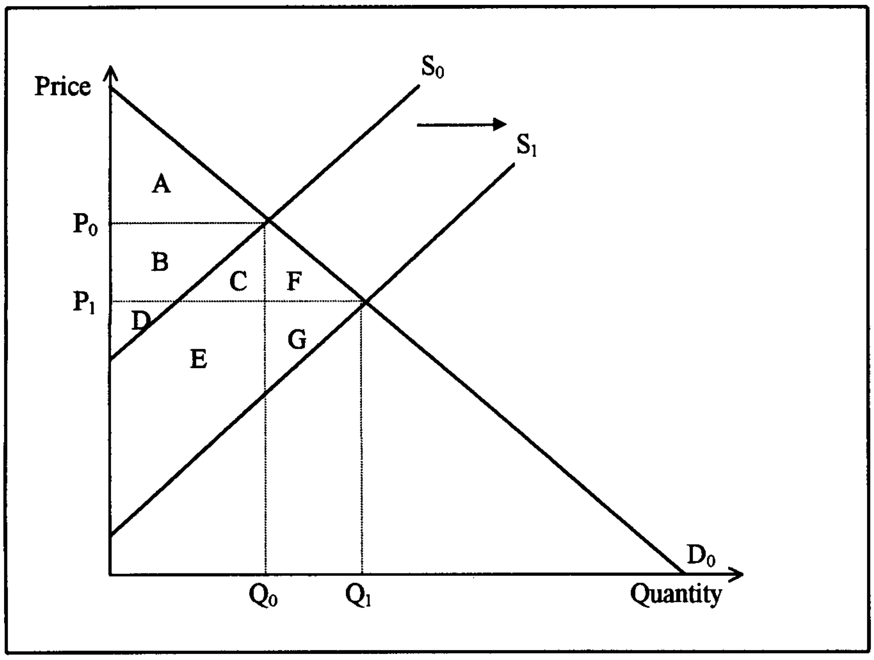

Figure 2.1: Economic surplus model

Consumer surplus, defined as the difference between the value a consumer places on a commodity and the amount a consumer is willing to pay for the same commodity, is illustrated by area A, assuming initial supply curve S_o. The producer surplus, defined as the difference between the amount received for a commodity and the total variable cost of producing the same commodity, is illustrated by area B+D, with supply curve S_0. It is assumed that technology will increase the output of a particular commodity, shifting the supply curve from S_o to S_1.

The shift in the supply curve ($S_0 \rightarrow S_1$) reduces the price ($P_0 \rightarrow P_1$) and increases the output ($Q_0 \rightarrow Q_1$). The consumer surplus is increased by areas B+C+F, and the change in producer surplus is (D+E+G)-(B+D). Therefore, consumers gain area B+C+F and producers lose area B, but gain area E+G. The overall gain to society is therefore C+E+F+G. Hertford and Schmitz (1976) used equation 1 to calculate this area:

$$K P_1 Q_1 \left(1+\frac{1}{2} \times \frac{K}{N+E}\right) \qquad (1)$$

Where: K is defined as the percentage increase in production attributable to research

P_1 is the price of the commodity after the supply shift

Q_1 is the final output

N and E are the price elasticities of demand and supply respectively.

Schultz (1953), who first applied the parallel shift used in the example above, was later followed by Griliches in 1958. They were the forerunners in R&D evaluations. The use of a parallel shift is however by no means the "presiding rule", as Peterson's (1967) poultry study assumed a proportional shift. Akino and Hayami (1975) who conducted a study estimating the social benefits in Japan from rice-breeding research, used a pivotal shift, and Lindner and Jarrett (1978) and Rose (1980) assumed four shifts. The nature of the shift of the supply curve is of such importance that Lindner and Jarrett (1978) argued that previous measures of gross annual research benefits may have produce biased results, simply because insufficient attention had been paid to the nature of supply curve shifts, in response to technological improvement.

The value of estimated returns will also vary according to what is assumed about the supply and demand elasticities of the product, and according to the K-value. The K-value has in the past been measured either as an output effect (horizontal shift in the supply curve) or as a cost effect (vertical shift in the supply curve). The demand and supply elasticities and the K-value will also have an influence on the distribution of benefits that will occur between producers and consumers. The results of a study conducted by Ayer and Schuh (1972), measuring the rates of return of cotton research in Brazil, show that producers realised the greatest share of the social gains from the research. Estimates for the study were based on a price elasticity of demand of -5.3 (elastic) and of supply of 0.944 (inelastic). The study by Hayami and Akino (1976), evaluating rice-breeding research in Japan, showed that the social returns from research were fully captured by consumers, and that producers were worse off. These results were derived using low price elasticities of both demand and supply. The distribution of costs and benefits among producers and consumers is, therefore, critically dependent on the assumed elasticities of supply and demand. Care should be taken in the choice of these magnitudes.

The concept of economic surplus was first attacked by Samuelson (1967), who dismissed the concept as being of "historical and doctrinal interest with a limited amount of appeal as a purely mathematical puzzle". Little (1960) continued in this line by describing economic surplus as a "totally useless theoretical toy". Hicks (1940) however, one of the avid believers in the concept of economic surplus, believed that the idea would help in the study of the detailed effects of deviations from the optimum, and offered a way of measuring the size of the deviation.

Hertford and Schmitz (1976) noted the controversy with which the concept of economic surplus has been considered, but continued to mention that most shortcomings of studies of returns to research arise not from the concept of economic surplus, but from overlooking or mistreating the methods used to estimate the returns to agricultural research. They were of the impression that research should be treated as a tradable good, that the problem of unemployment should be considered, that a distinction between intermediate and final goods should be made, and that the returns should account for the income distributional effects of research. The uncertainty with which economic surplus model results are considered goes as far back as Schultz's study in 1953, where he concluded that the economic surplus approach might produce results that are biased downwards, as not all beneficial research aims at increasing production. Peterson (1971) continues along this line by commenting that production levels would have almost certainly declined if research had not been conducted. There is therefore an indirect benefit of preventing a decline of production and potential market share loss.

The primary advantages of the economic surplus approach are 1) the flexibility of the surplus approach, 2) the fact that it provides a mechanism to analyse the distributional benefits between producer and consumer, 3) it can be applied to a closed or open economy, and 4) it is capable of handling the side effects of technological changes such as income distribution and environmental consequences (Anandajayaseram et al, 1996). The confidence with which Hicks (1940) considered the surplus approach is illustrated by the following quotation: "*...beyond all doubt it (consumer surplus) is still capable of much further development; if economists are to play their part in shaping the canons of economic policy fit for a new age, they will have to build on the foundations of consumer's surplus*".

2.2.1.2. The production function approach

The production function approach is a form of multiple regression or correlation analysis and is the most common econometric method used to estimate the economic benefits of R&D. The production function is based on the premise that the level of output associated with the production process is causally dependent on the amount of input(s) used in the process. The production function has traditionally been used as an *ex post* evaluation tool for a commodity or agricultural sector, which includes agricultural research and development as, inputs in the production process. The basic production function model is illustrated in equation (2) below:

$$Y_i = \alpha + \beta X_I + \varepsilon_I \qquad (2)$$

In the above equation (2) variable Y is expressed as a function of variable(s) X, illustrating the relationship between inputs and output. Y is referred to as the dependent variable, X the independent variable(s), α the y-intercept, β the coefficient of regression i.e. the slope of the regression line, and ε the error term. This approach estimates the contribution made by each input (such as research, extension, prices etc.) to the final output. The coefficients of the independent variables, if found statistically significant, are used to calculate the marginal productivity of these inputs. The major source of variation among production function studies is the way the lagged response of output to research inputs is specified in terms of length and pattern reflecting the impact of research expenditure on output.

It was Griliches (1964) who first used this approach to evaluate the returns to agricultural research in the United States between 1949 and 1959. In this study, Griliches used a single year's lagged expenditure and estimated the returns to be in the order of between 35 - 40 percent. Evenson (1967) used the same period, a concave distribution of benefits and a mean lagged expenditure of six to seven years, and measured a return of approximately 47 percent. However, problems of multicollinearity in time-series data for conventional production inputs, and the general lack of sufficient data, were highlighted by Norton and Davis (1981) as reasons for the use of productivity indexes rather than output as the dependent variable. This technique is referred to as multiple regression and may be written in the following form:

$$Y^* = \alpha + \beta_{y1}X_1 + \beta_{y2}X_2 \ldots\ldots\ldots + \beta_{yk}X_k + \varepsilon_1 \qquad (3)$$

Where the dependent variable Y^*, is a function of k independent variables, X_1, X_2..........X_k, and ε_1 is the error term. The coefficient β_{y1} represents the regression coefficient of Y on variable X_1. This expresses the change of Y with respect to a change in a particular variable when the rest of the variables are held constant (Anandajayaseram *et al*, 1996).

Once the research coefficient has been estimated a two-step procedure, illustrated by Anandajayaseram *et al* (1996), is used to determine the marginal rate of return to agricultural research. Step 1 involves calculating the value of the marginal product of research:

$$MVP_R = \beta_{RY} \quad \textit{times Average Product of Research}$$

$$= \beta_{RY} \times \frac{Y}{X_R}$$

Step 2 involves determining the discount rate (MRR) which equals the discounted flow of benefits with the discounted research costs:

$$r = (MVP)^{1/n} - 1$$

where r is the MRR, and n is equal to the mean lag of the distribution of benefits.

The problem associated with the production function approach is that extensive time series data is needed for the proper application of this technique. In addition to this, serious econometric problems often arise, as the variables move together over time, creating correlation between the variables involved. One of the major advantages of the production function approach is that it is capable of isolating the contribution made by a single variable in the production process.

2.2.1.3. The Impact approaches

Tweeten and Hines (1965) endeavoured to calculate the impact that agriculture had on national income, since 1910. The method used was based on calculating by how much the national income would have to be reduced, if the percentage of people on farms was the same as in 1910, and the resulting additional farmers had the income of today's farmers. The costs of public and private research, education and federal programs were estimated and a cost-benefit ratio calculated.

Pinstrup-Anderson *et al* (1976) conducted a second type of impact study. Their aim was to measure the impact of increased agricultural output on the level of nutrition, in different income groups, as a measure of the value of research. This method will require detailed knowledge of food demand and consumption levels, but may be beneficial for research focused primarily on improving nutritional levels.

2.2.1.4. Conclusion

In concluding the review on the *ex post* methods of research evaluation some relevant deductions can be made. First, while it is important that suitable time series data be available, past studies have shown that cost data is often unavailable. Schuh and Tollini (1979) have, for example, noted that "methodological developments have probably outrun the availability of data....". It is therefore of vital importance that data be collected in a manner that will benefit future research evaluation studies. Secondly, there is no hard and fast rule as to what method of evaluation should be used in any particular study. Donovan (1986) concludes that the economic surplus method would be more suitable for estimating the returns to R&D on an aggregated scale, while the production function approach will be preferred for estimating the value of specific technological advances. The consumer surplus approach will also be useful in illustrating the distributional effect of research between consumers and producers. Thirdly, neither the economic surplus or the production function approaches are complete methodologies, and results from studies using these approaches should be considered cautiously.

2.2.2. *Ex ante* appraisal

There is a growing interest in methods of appraising research programs or projects prior to their implementation. In the past, many agricultural research projects were conducted with little regard to the financial, social and economical impact that it would have. However, with limited resources available for research, choices among research activities will have to be made before they are implemented. The methods illustrated below are a means by which these choices can be made with the assistance of organised collective judgement.

2.2.2.1. Scoring models

The scoring model is an approach whereby research alternatives are ranked, based on a specific set of criteria. Evaluators, usually 'experts' in the field, are required to rank projects according to their likely contribution or chances of success in achieving specified goals (Schuh and Tollini, 1979). The criteria can be both quantitative and qualitative, so long as each is scored independently of each other. An overall score is then calculated for the effort by summing the product of criteria weights and scores over all criteria (Shumway, 1977).

An evaluation study conducted in Iowa, serves as an example of the contribution that these methods can make. The study originated in the need to guide research programs, promote consistency, and ensure balanced attention to the problems of the state. Much of the research was funded through federal contracts, which created fragmentation, reduced local communication among scientists, and resulted in the threat of lower total benefits for Iowa. The structure of the evaluation panels was decided on by the agricultural department heads and administrators, and included 19 panels representing the major areas of research in Iowa. Throughout the evaluation procedure, alternatives competed with each other across disciplines and panel areas on the basis of cost efficiency and contribution towards economic growth (Mahlsted, 1971).

The value of scoring models is dependent on the objectives that are put to the panel, the expertise which makes up the panel and the appropriate weighting structure that is used. The scoring model is labor intensive, costly and time-consuming. Like most *ex ante* appraisal methods, it is a subjective analysis, which is based primarily on past experience of those present in the selected panel. The importance however, of effective *ex ante* techniques should not be diminished by the potential flaws or subjectivity which exists in the outcome of such studies.

2.2.2.2. *Ex ante* Benefit-Cost Approach

The benefit-cost approach is based on an estimation of the potential benefits and costs, which can be attributable to a specific research project. A benefit-cost ratio is then determined, depicting the potential returns from the investment. Fishel (1971) used this approach in a model for collecting and processing the information required to evaluate research activities and to assist in resource allocation. The model, called Minnesota Agricultural Research Resources Allocations Information (MARRAIS), involves four major steps, illustrated BY Figure 2.2 below:

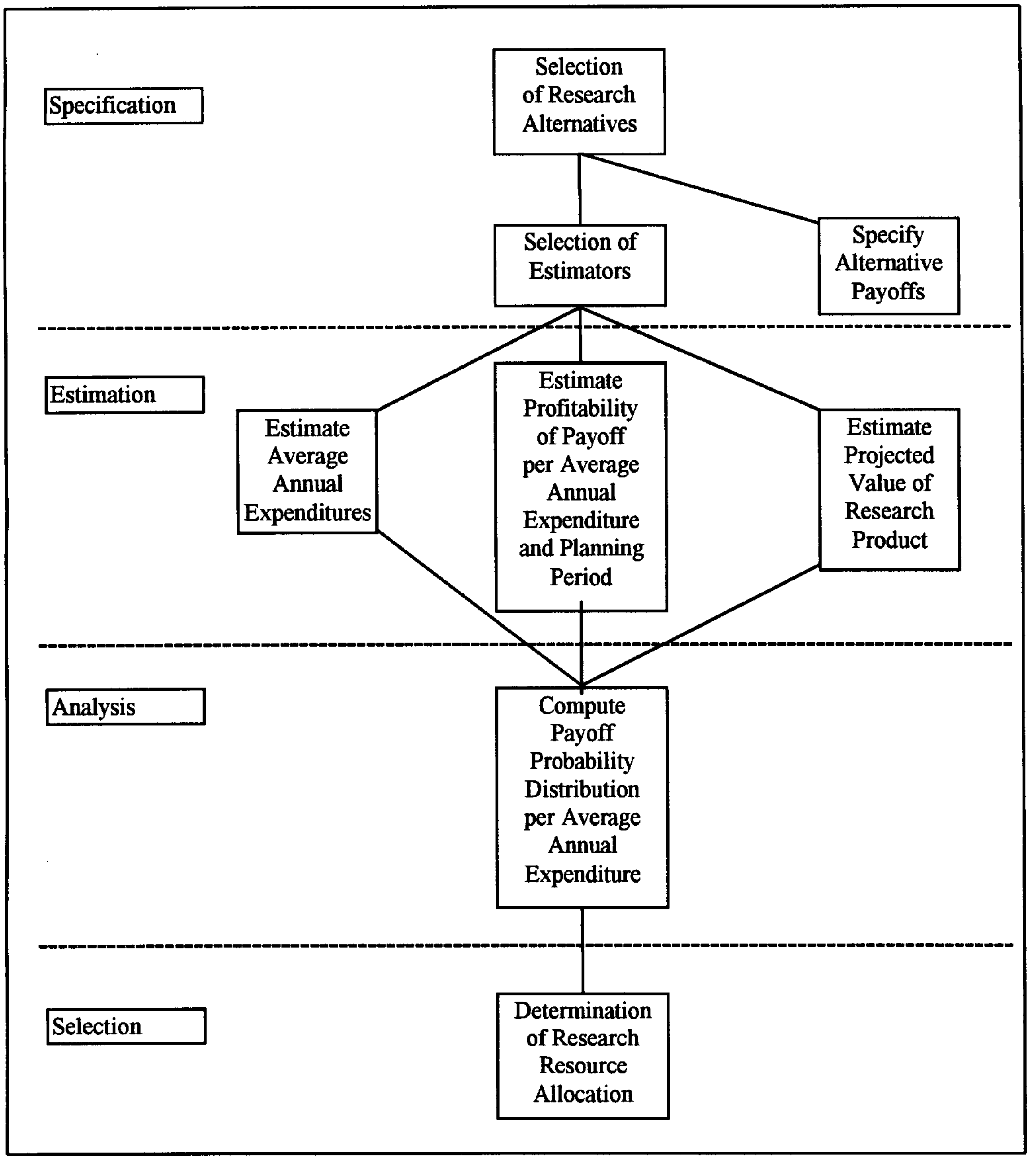

Figure 2.2: Modular form of cost-benefit estimation model

Ulbricht (1977) comes out strongly against the use of the cost-benefit model as a means of *ex ante* evaluations. Firstly, he is of the impression that the technical data which are subjected to economic analysis are imprecise and riddled with uncertainties; secondly, a lack of uniformity exists in the manner in which costs and benefits are estimated, making comparisons between studies difficult; and thirdly, the presentation of the results of cost-benefit analyses, especially in the way benefits were related only to R&D expenditure, is considered to be unacceptable and could lead to misleadingly high benefit-cost ratios. Ulbricht goes on to suggest that the alternative should be an informed judgement by a panel, prioritising between commodities and research areas, within one commodity or research area, and between individual projects.

2.2.2.3. The Simulation approach

Atkinson and Bobis (1969), using a simulation model attempted to measure the maximum expected profit through the optimal allocation of a fixed five-year research budget among projects and over time. Their model helps to distribute funds over the stipulated years, measures costs and benefits in economic units, and uses a simulation procedure to obtain solutions. In addition, the model permits direct consideration of multiple funding options and the effects of uncertain parameters.

Pinstrup-Andersen and Franklin (1977) made use of a simulation model to assist in predicting the relative contributions and costs of alternative research activities in order to establish research priorities and allocate available resources. Their procedure was to:

- define goals;
- predict expected changes in product supply, input demand, and domestic farm consumption;
- identify relevant research problems;
- identify alternative technologies to solve problems;
- estimate the research and adoption costs, time requirements for research and adoption, and adoption probabilities;
- estimate the impact on farm consumption, product supply and prices, and input demand and prices;
- estimate the contribution made to social goals;
- identify alternative technologies expected to solve a specific problem.

Simulation models are more effective and more frequently used in the private sector than in agriculture, the reason being that a better understanding of the industrial research process is generally in place (Norton and Davis, 1981). The disadvantage of simulation models is that they require limited, but costly primary data, and are also a relatively slow method of evaluation. The advantage of the simulation model is that it can be expanded to include noneconomic variables, and can be modified to incorporate different decision variables, and functions of analysis.

2.2.2.4. The Mathematical Programming approach

Mathematical Programming models differ from more general simulation models in that they provide a more powerful and sophisticated technique for setting priorities. Such models rely on the mathematical optimisation of a multiple goal objective function, subject to resource constraints. A mathematical model developed by Russell (1975), called the Resource Allocation System for Agricultural Research (RASAR), was used to assist in selecting between agricultural research programs in the United Kingdom.

The RASAR was based on the attainment of three dimensions, namely consumption, security, and equity, of a specified goal. Russel (1975) identified nine aspects of the three dimensions and devised a rating system to assist in selection between research programmes. The model provided information on 1) the set of projects in the research programme, 2) financing for each project, 3) the marginal utility derived from investing in extra units of resources for the programme and each project, and 4) the sensitivity of project selection to varying weights on goals.

The advantage of the mathematical model is that it selects an "optimal" portfolio, taking into account the various evaluation criteria and constraints imposed in the programming problem, rather than simply ranking research areas. The problem with the method however is that it is not particularly useful for evaluating too diverse a set of R&D projects. If the constraints faced in executing the projects are not well defined, then nonsensical solutions can result (Anandajayaseram et al, 1996).

2.2.2.5. Conclusion

Ex ante project evaluation methods are readily addressed within economic theory, but are in practice hampered by the technical demands that need to be met before they can be rendered operational. Most assessment techniques require an understanding of the probability of achieving the objectives set, the time period over which the costs and benefits will extend and the manner in which the benefit flow will occur. In many cases it is difficult to predict what the outcome of a research project will be, or whether the project even has the potential to generate a measurable return. Many of the past evaluation models have been based on the assumption that the diffusion of knowledge from research occurs in a linear manner. This assumption has been challenged, as it is believed that research knowledge in one field may have a beneficial effect on another field. Despite these problems, in addition to the subjective nature of *ex ante* evaluations, these methods help to define the objectives of research projects, prioritise between projects and allocate funds efficiently among scarce resources.

2.2.3. The choice of a method

It is important to remember that no one method is superior in all situations and that in many cases it is common practice to use more than one approach in combination. Norton and Davis (1981) attempted to categorise certain types of studies with evaluation techniques. The economic surplus and *ex ante* cost-benefit approaches are useful in situations where the effect between consumer and producer surplus is of importance. The production function approach is best for determining the relative productivity and income share of input categories at the aggregate level of evaluation. The production function approach has the added advantage of being able to statistically incorporate time lags into the model. All three of the above mentioned evaluation approaches are most widely used as quantitative evaluation tools. The simulation and mathematical programming approaches have greater use at the project level, but are labelled as relativity expensive approaches. It is important to realise that the methods available for evaluating the impact of R&D must frequently be adapted and combined to meet the specifics of any particular research activity.

It is of vital importance for future research evaluation that research institutes and those involved with research, are made aware of the data requirements for effective use of evaluation techniques in agricultural research. The reliability of past evaluation studies is predominantly questioned as a result of the lack of dependable time series data, and not as a result of methodological shortcomings.

CHAPTER THREE

The history of agricultural research

3.1. Introduction

Agricultural research was practically non-existent up until the middle of the nineteenth century. During this pre-agricultural research era it was estimated that approximately 90 percent of the world population were engaged in some or other form of agriculture on a subsistence level. This was however soon to change with the invention of the diesel engine and later the tractor. In conjunction with this the advent of agricultural research allowed for traditional forms of agriculture to be continually replaced with more modern and productive forms, and thus together created the means by which one man could produce the same output as 20 men. This had the effect of reducing the percentage of people dependent on subsistence agriculture, as goods and services could now be traded between farmers and non-farmers. Men and women were therefore able to exploit other activities, lending a hand to the creation of society, as we know it today.

J.B. Boussingault of Bechelbronn in Alsace, France, was the first man to start an agricultural research station in 1834. He conducted field experiments in an attempt to determine the effect of the use of manure and rotational cropping systems. He also established a chemical laboratory on his farm in which he analysed soil and crop products. In 1843 a second research station, the Rothamsted Agricultural Research Station was established near London. This station, the oldest in the world today, dealt mostly with fertilisers for crops, including both mineral fertilisers and barnyard manure (Salmon and Hanson, 1964).

The aim of this chapter is to illustrate how minimum tillage research ties into the research conducted in South Africa. A brief illustration of the evolution of research on an institutional level is given, as well as a description of the present research structure in South Africa. Research within the wine industry will be considered, highlighting the structure and activities of the major wine research institute in South Africa. Finally a description of surface cover research will be given, along with trial plot results achieved, and the benefits associated with this management practice. The literature for the following section was edited from Roseboom, *et al* (1995) and Corbett, *et al* (1994).

3.2. Agricultural research in South Africa

3.2.1. History

Agricultural research in South Africa dates back to before the Union of South Africa in 1910, but only really began to take shape once the Government established the Department of Agriculture (DOA) in 1911. At its inception the DOA consisted of 18 different divisions, and in 1913, the administration of agricultural education, including the agricultural colleges, was transferred to the DOA. The faculties of Agriculture at the University of Stellenbosch (1920), Pretoria (1940) and Natal (1948) were later also transferred. General restructuring of the DOA continued throughout the 1920's and 1940's, up until World War II, during which time things were put on hold.

The first post-war restructuring took place in 1952/53, when the technical services (responsible for most of the DOA's research) were re-organised into three main branches: 10 national divisions (an additional one was added in 1960), three special institutes (a fourth added in 1956), and six agro-ecological entities (increased to seven in 1961).

The DOA was then split in 1958 into two separate government departments, namely the Department of Agricultural Technical Services (DATS) and the Department of Agricultural Economics and Marketing (DAEM). The DATS was to be involved in the technical aspects of research, and the DAEM was responsible for developing agricultural research policy and administrative services. In 1962 the DATS was split further into the Directorate of Agricultural Research (DAR) and the Directorate of Agricultural Field Services (DAFS). The two Directorates were comprised of the following sub-divisions (refer to Figure 3.1).

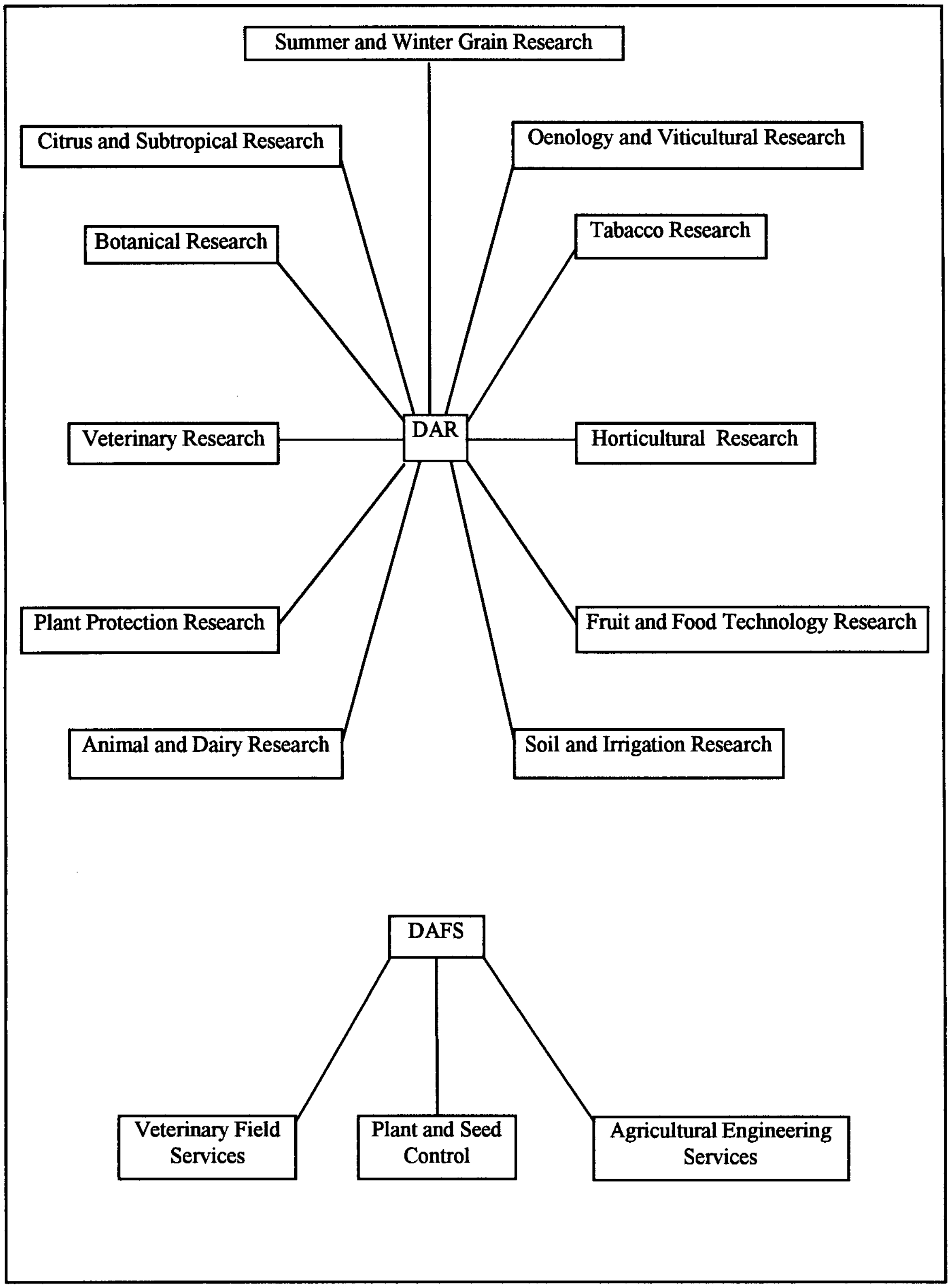

Figure 3.1: Subdivisions of the DAR and DAFS.

The Agricultural Credit Act of 1966 resulted in the establishment of the Department of Agricultural Credit and Lands (DACL), which was to control all credit allocations and government owned land. In 1980 the DAEM, DACL, and DATS amalgamated into the

Department of Agriculture and Fisheries (DAF), which was later renamed as the Department of Agriculture and Water Supply (DAWS) in August 1982.

In 1984, with the introduction of the Tricameral Constitutional dispensation, the administrative agencies responsible for agriculture were divided into various "own" affairs and "general" affairs departments. DAWS was subsequently split into a "whites own affairs" department (the Department of Agricultural Development {DAD}) and a "general affairs" department (the Department of Agriculture {DA}). DAD took over all research activity formerly under DAWS, including the 11 research institutes, the seven regional organisations, and all eight directorates.

In April of 1992 most of the agricultural research activities under DAD, were transferred to the Agricultural Research Council (ARC). At present the council is the principle agricultural research entity in the country, comprising of 16 institutions deployed throughout the country, and with the exception of sugarcane, supporting all the major agricultural commodities in South Africa. Many of the research activities at the regional level were consolidated into seven Agricultural Development Institutes (ADI), and are responsible for research, training and other services. Examples of these institutes are Elsenburg, Cedara, Dohne etc. A diagrammatic illustration of the changes that occurred is given in Figure 3.2 below:

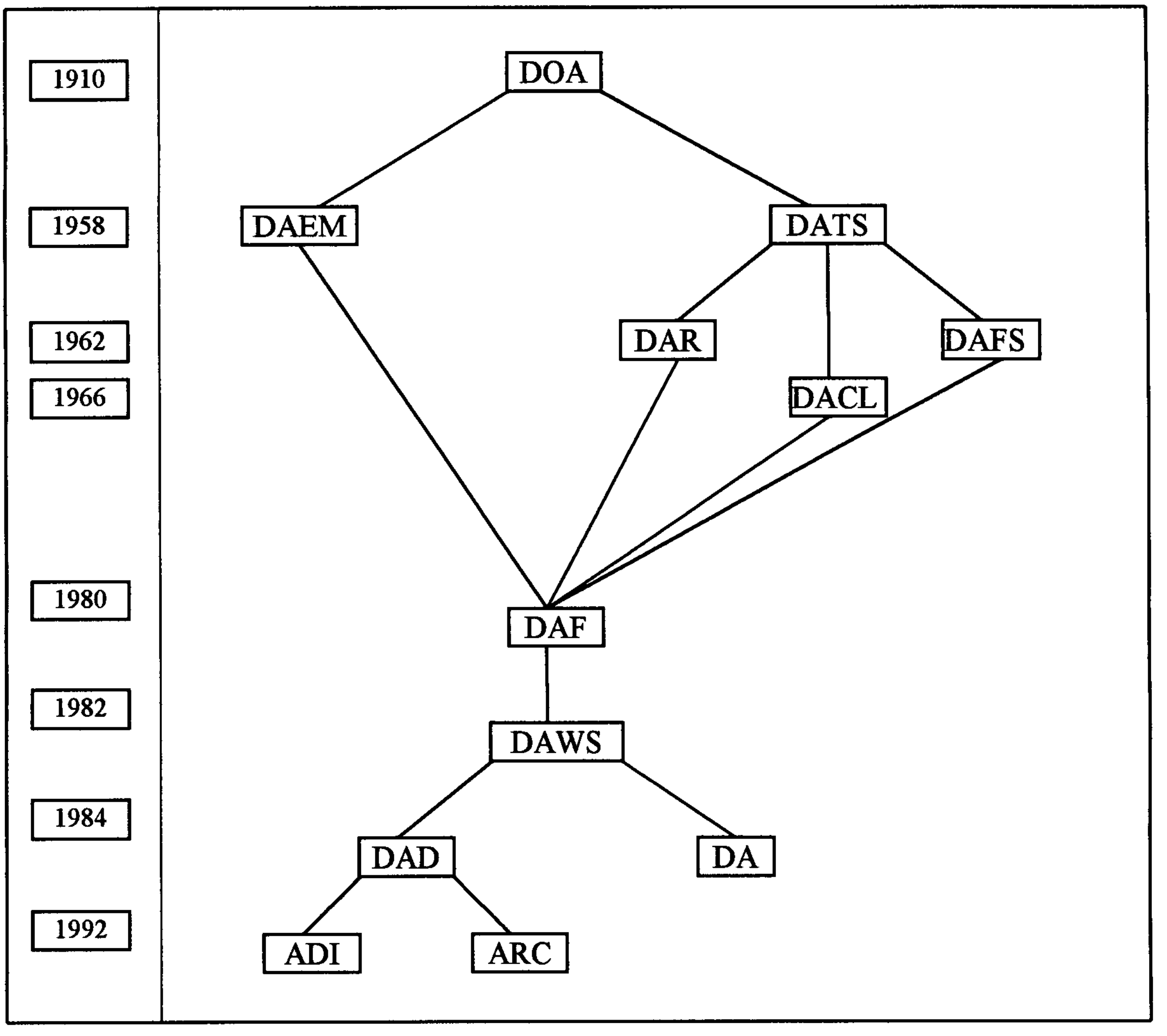

Figure 3.2: Changes in research structure since 1910 in South Africa

3.2.2. Present research structure in South Africa

The South African agricultural research structure comprises of a number of controlling bodies. These include the government-funded institutions, the semi-public institutions, and the academic and private sector institutions. The supervisory agents that fall under these categories are illustrated in Table 3.1 below.

Table 3.1: Present structure of agricultural research in South Africa

Institutional Category	Supervisory Agent	Executing Agent
Government	Department of Agriculture	12 Institutions *
	Department of Environmental Affairs	National Institute Sea Fisheries Research Institute
Semi-public	Council of Scientific and Industrial Research	1 Institution
	Agricultural Research Council	12 Research Institutions*
Academic	University of Stellenbosch	Faculty of Agriculture Faculty of Forestry
	University of Pretoria	Faculty of Agricultural Sciences Faculty of Veterinary Sciences
	University of Natal	Faculty of Agriculture
	University of the North	Faculty of Agriculture
	University of the Orange Free State	Faculty of Agriculture
	Medical University of South Africa	Faculty of Veterinary Science
	University of Fort Hare	Faculty of Agriculture & Agricultural and Rural Development Institute
	University of Bophuthatswana	School of Agriculture
	University of Zululand	School of Agriculture
	University of Venda	School of Agriculture
Private Sector	Sugar Cane Growers Association	
	Outspan Citrus Center	
	The Fertilizer Society of South Africa	
	Unifruco Research Services Ltd.	

* Refer to Appendix for details.

The ARC, a result of Act 86 in 1990, took control of the research institutes from the Department of Agriculture in 1992, leaving the extension work as a function of the Department. The Council was created as an autonomous body, reporting directly to the Minister of Agriculture. The institutes previously under the control of the Department, conducted predominantly "white orientated research". The mandate given to the ARC is to service the entire population, including black subsistence farmers and emerging farmers. The Act permits the ARC to sell services, to manufacture and sell equipment and to produce, process and sell products.

The procedure for the disbursement of government funds across all national research activities was recently agreed upon at the meeting of the Ministers Committee on Science and Technology. The procedure is based on the assessment of a panel of experts, who average the performance of the Science Councils in seven areas considered critical for the optimal contribution of science and technology to national goals. These categories include (Marasas *et al*, 1997):

- Contribution to the RDP and Growth and Development strategy;
- Contribution to wealth and well-being;
- Optimal use of natural resources;
- Optimal use of human resources;
- Research and service capacity development;
- Partnerships with industry; and
- Knowledge generation.

The total allocated to the 13 relevant institutions for 1997/98 amounted to R1, 043,529,000, of which R291, 946,000 (28 percent) was allocated to the ARC. This allocation represents a 1.34-percent reduction from the 1996/97 allocation.

Within the agricultural research sector it is estimated that the ARC receives approximately 50 percent of the total expenditure on agricultural research in South Africa, in the form of government grants. This amount is distributed via the central administration of the ARC to the regional research institutes, and is usually disbursed according to the gross value of agricultural production of a particular year, i.e. the 1993/94 funds were distributed according to the 1990/91 production figures (40 percent to animal research and the remaining 60 percent on crop research). Apart from the government grant the ARC also receives income in the form of research contracted out, interest on investments, donations, and product sales. Since 1992 efforts have begun to diminish the share of government funds received by ARC institutes. The reported share of Government funding dropped from 90.5% in 1992, to 83,9% in 1993, and to 82.6% in 1994. This drop can partially be attributed to research contracts conducted with private clients. The distribution of agricultural research expenditure among institutions is illustrated in table 3.2 below.

Table 3.2: Research expenditures, 1992

Institutional Category		Percentages
Government		17.6
DOA – ADIs	14.8	
– Directorates	2.8	
Other Government [a]		13.0
Semi-public		60.1
ARC Institutions	54.2	
Other	5.9	
Universities		9.3

[a] Includes the Department of Sea Fisheries, the Department of Forestry and CSIR, and the National Botanical Institute expenditures.

The ARC employs approximately 4,160 persons, of which 672 are professional researchers. Despite cuts in Government support, the ARC institutes have managed to maintain a salary to operational costs ratio of approximately 70/30. The number of full-time equivalent (FTE) researchers employed within the ARC far outstrip any other research body in South Africa. As far as qualifications are concerned, a significant share of researchers at the ADI's, ARC research institutes, and the universities hold postgraduate degrees. In 1992, 14 percent of the researchers at the ADI's held a PhD compared with 26 and 50 percent at the ARC and universities, respectively. This reflects the fact that ADI's focus more on applied and development research, while universities do more basic research.

Table 3.3: Spread of researchers across research bodies (1993).

Research Body	Number of Researchers (FTEs)
Agricultural Research Council	672
Department of Agriculture	304
Department of Environmental Affairs	121
Council of Scientific and Industrial Research	139
South African Sugar Association	33
Universities	134

The ARC comprises of 16 research institutions covering research in animal production and animal diseases, crop production, breeding and protection, including horticultural crops, soil and water resource management and biotechnology. The challenges that face the ARC are in line with the changing economic, political and social environment in South Africa. The ARC will need to support resource-poor food security farming, along with emerging and established commercial farming. Furthermore, the competition for available funds will force research proposals into a position where adequate social and economic returns and environmental sustainability will have to be met.

For the purpose of this study, research conducted in the grapevine industry will be considered further in the following section. As a result of the fact that the Research Institute for Fruit, Vine and Wine conduct the majority of grapevine research in South Africa, it has been assumed that the expenditure on research collected at Nietvoorbij will act as a suitable representation of the research expense on an industry level.

3.2.3. Research in the wine industry

By the beginning of the nineteenth century winemaking and vine growing had already become a sophisticated practical art, considering that wine making dates back many centuries. It was however not until the seminal work by Louis Pasteur in the second half of the ninetieth century that the occupation transcended into a science worthy of academic study. Subsequently in 1880 both the University of California and the Institute d'Oenology at

Bordeaux University began teaching and researching Viticulture and Oenology (De Jongh, 1976).

Wine research in South Africa dates back to the 1890's, but only in the form of individual farmers conducting private research, especially after the Phylloxera devastation in the 1886. In 1912 the University of Stellenbosch offered the first institutional form of study into winemaking and vine growing. The first substantial government involvement in research came in the form of the establishment of what is today the leading research institute for viticulture and Oenology in South Africa, the Nietvoorbij Centre for Vine and Wine Research.

This institute, formerly known as the Viticultural and Oenology Research Institute, was established on the 27 March 1955. For the first five years of existence the institute conducted research on a number of sites in the area surrounding Stellenbosch, and it was not until 1960 that the Department of Technical Services purchased the farm Nietvoorbij. The farm, on which the head office was built, is situated a short distance outside Stellenbosch. In 1992, under the control of the ARC, the institute was renamed the Nietvoorbij Institute for Viticulture and Oenology. Further developments in 1997 have seen the amalgamation of the Viticultural and Oenology institute with the Institute for Fruit Technology. Together these institutes are referred to as the ARC-Fruit, Vine and Wine Research Institute, comprising of the two institutions namely, the Nietvoorbij Centre for Vine and Wine Research and the Infruitec Centre for Fruit Research.

The institute consists of five divisions (see Figure 3.3 below), each of which is run as an individual entity. The institute has approximately 31 scientific staff, 35 technicians, about 55 support staff, five farm managers for the five experimental farms and 90 labourers. The research program followed by the institute is industry driven, and reviewed on a yearly basis. Since 1992 Nietvoorbij has generated funds through the sale of research contracts to the private sector and other government institutions. The state has however remained the main source of funds, contributing approximately 70 percent of the total budget. The budget in 1993 amounted to approximately R16 million of which 61 percent was spent on salaries.

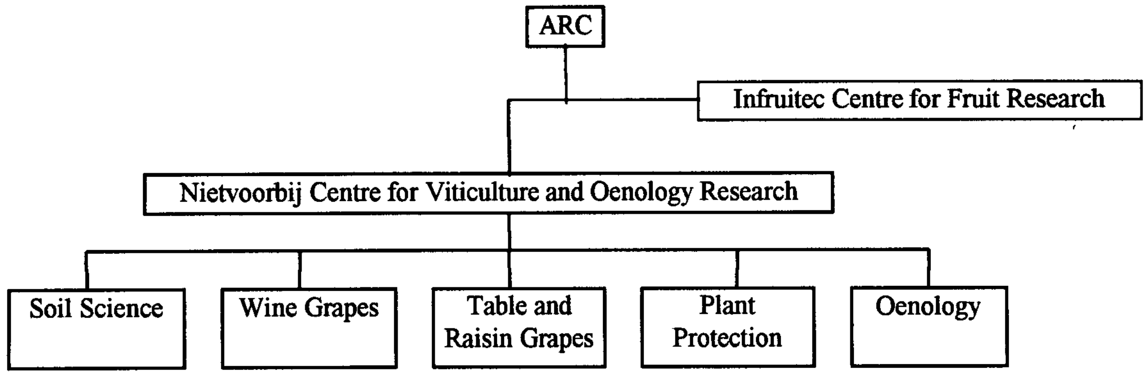

Figure 3.3: Organisational structure of ARC-Nietvoorbij

Research work at Nietvoorbij covers all aspects of wine production from the preparation of the soil for effective vine growth, to the production of different wines, raisins and table grapes. Much attention is also given to rootstock varieties, grafting methods, rooting techniques, etc. The institute also plays an important role in developing viable farming techniques for subsistence and emerging farmers.

Besides the farm Nietvoorbij, four other research farms exist. Firstly, a 56ha research farm is situated 5 km outside Robertson. The farm has been used for research concerning water consumption, and is also regularly visited by producers for information regarding cultivars and trellis systems. Secondly, the Lutzville research farm is situated 13 km from Lutzville and 20 km from the coast. This farm comprises of 129ha, of which 66ha are natural grassland, 19ha are under vineyards, and 10ha are under other crops. Thirdly, the Hex Valley experimental farm 3 km outside De Doorns, consists of 11ha of which 8ha are under table grapes. Lastly, the Bellevue experimental farm is situated on the slopes of Paarl Mountain, and consists of 5ha of table grapes only. At present 2ha are being used for development and evaluation of new hybrids, and 0.5ha on seedless varieties. All research conducted on these farms is controlled by Nietvoorbij management.

In 1996 a controlling body, called Winetech, was established to co-ordinate the focus of research in the wine industry in South Africa. This body is representative of the KWV, the cooperative industry, wine estate producers, large dealers in the wine industry and research development within the Department of Trade and Industry. The aim of Winetech is to keep research focused on the needs of the industry, preventing unnecessary and overlapping research projects. Winetech will also ensure that the necessary scientific research and technical staff are continually being trained. Furthermore, Winetech will assist resource-poor and emerging farmers, in developing and maintaining productivity. Winetech is structured as described by Figure 3.4.

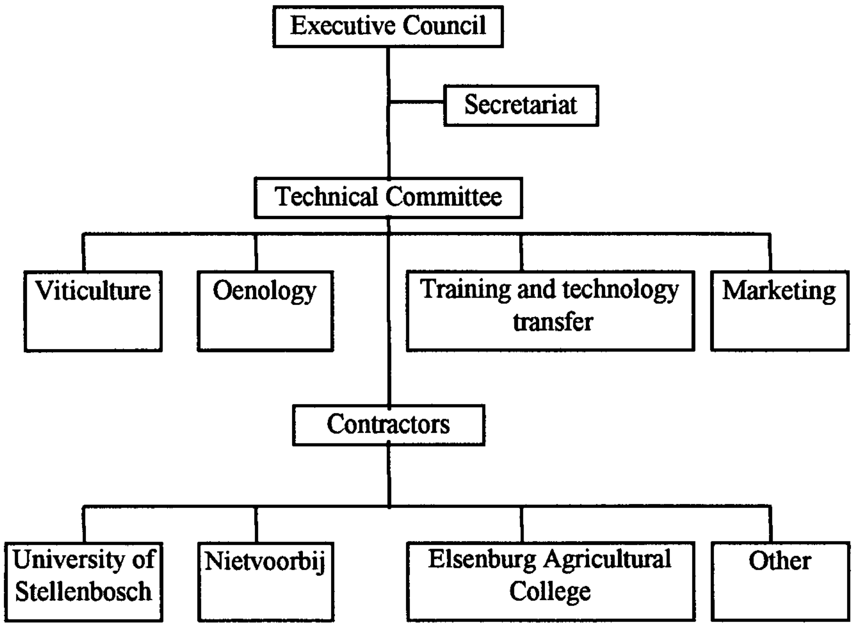

Figure 3.4: Organizational structure of Winetech

Source: Wynboer: September 1996.

The research conducted in both the wine and grape industries has contributed a great deal to the current success enjoyed in both industries. The extent of this contribution in the form of a numerical return to research investment, has challenged many analysts in the estimation of such a value. Townsend and van Zyl (1997) conducted a study to evaluate and assess the impact of research and technological development in the grapevine industry in order to determine the rate of return to research investment. The results of the study showed a return of more than 60 percent for R&D alone, and more than 40 percent for R&D and extension combined. These favourable results provide valuable motivation for increased research investment in the wine industry.

Table 3.4: Productivity within the wine industry.

Year	Total number of Vines	Hectares under Vines	Total Wine Crop (Gross tons)	% Good Wine
1981	280 290 797	91 562.2	864 195	0.47
1982	283 100 485	92 607.9	991 483	0.50
1983	283 833 047	92 923.6	1 022 712	0.47
1984	283 078 225	92 519.9	1 005 053	0.49
1985	282 100 908	92 142.3	931 034	0.51
1986	284 240 322	92 837.4	825 687	0.59
1987	287 972 793	93 899.4	969 241	0.55
1988	286 422 072	93 381.4	1 015 181	0.50
1989	286 387 192	93 281.0	1 072 775	0.47
1990	282 691 864	92 038.0	1 061 257	0.48
1991	282 789 227	91 942.0	1 073 750	0.49
1992	284 184 119	92 393.0	1 111 046	0.51
1993	287 124 028	93 247.0	1 023 509	0.51
1994	288 079 601	93 680.0	1 020 337	0.55
1995	288 341 320	93 889.0	1 063 915	0.62
1996	292 474 272	95 721.0	1 148 114	0.67

It is evident from the above Table 3.4 that productivity within the wine industry has improved over the years. Since 1981 the total wine crop in South Africa has increased by approximately 283 919 tons, whilst the total acreage has increased by 4 158.8 hectares. On a ton per hectare basis, the average harvest has increased from 9.44 tons/ha in 1981, to 11.99 tons/ha in 1996. This 2.55 ton/ha increase in tonnage should however be considered with caution, as it would be foolish to assume that a vineyard which produced 9.44 tons/ha in 1981, produced 11.99 tons/ha in 1996. This increase in output can be attributed to three factors that occurred as a result of research.

Firstly, research has played an important part in reducing the "non-productive" period of a young vine. In the past it could take a vine from 5-6 years to reach full production and at present a farmer is capable of a full production harvest as early as the fourth year after planting. This has been achieved by, for example, extensive research into suitable rootstock varieties, effective soil preparation before planting techniques and virus free planting material. Secondly, over the last few years farmers have been cultivating vineyards in the higher yielding areas. The benefit of these areas (Robertson, Worcester and Orange River) is that the production per hectare can be as much as double that which is harvested in the Western Cape regions. And thirdly, better management and labour skills, improved machinery, more effective fertilisers, farmer education etc. are all factors which have had an effect on the output per hectare of the vineyard. In addition to the increase in output, it is evident from the table above that this increase has not occurred at the expense of wine quality. Wine quality has in fact increased over the years.

Analysts have traditionally attempted to explain the change in productivity by inputs such as R&D expenditure, extension, education, and weather (Thirtle and Bottomley, 1989; Knutson and Tweeten, 1979; Lu *et al*, 1978). In other words, what percentage of the increase in output and improvement in quality can be attributed to the inputs mentioned above. Traditionally one of the methods used to measure the degree, to which specific inputs contribute toward increased productivity, has been by use of the production function approach. This is the case for a study recently completed by Townsend and van Zyl (1997), concerning the wine industry.

The research conducted at Nietvoorbij comprises of many different disciplines that are achieved through a number of projects. One of the earlier and more successful research projects undertaken at Nietvoorbij was an attempt at determining the most viable tillage practice available for soil maintenance and conservation. The selection of a "successful" research concept for such a study has in the past often come under fire. Griliches (1958), in a study conducted by himself, questioned the sense behind calculating the rate of return on a successful "oil well". However, in the case of his Hybrid corn study, the first tillage practice trial in 1972 was not a total success, but merely a starting point to those projects that followed. The cost estimate used in this study is therefore comprised of all the projects in which minimum tillage research has been undertaken, up to and including the present projects. The following section draws attention to the minimum tillage research projects that have been undertaken under the ARC, and identifies the relevant results obtained therefrom. For the remainder of this chapter only research conducted on wine vineyards will be considered.

3.2.4. Minimum tillage research

Traditionally farmers have been fixed to the belief that a well-adjusted tillage practice is considered to be the foundation of any successful form of agriculture. In addition to this many farmers have administered tillage practices mainly out of mere tradition. The problem however, is that it was generally not known that frequent tillage may cause damage to soil rather than improving it as a medium for root growth. With this in mind research attempted to illustrate the benefits associated with minimum tillage and alternative tillage practices, on vine performance and vineyard sustainability.

The use of minimum tillage practices was primarily aimed at limiting the damage caused by tractor implements on the structure of the soil between the vines. The advantages of reducing this damage and the soil compaction that occurred would be to help improve root penetration and water infiltration in the vineyard. The problem however was that weed control had traditionally been performed with the use of tractor implements. This therefore created the need for research to consider alternative forms of weed control in conjunction with minimum tillage practices.

One of the proposed minimum tillage tools was to cover the surface of the soil, between the vine rows, with straw mulch of some kind. The anticipated advantages of surface mulch were firstly the fact that it would help prevent the formation of a crust which usually forms after rainfall, thereby resulting in a reduction in water runoff, which is common with conventional clean tillage practices. The reduction in water loss would reduce soil erosion, thereby adding to the sustainability of the vineyard. Secondly, a surface cover would assist in maintaining a degree of control over the growth of weeds, thus eliminating the need for excessive weed control practices. And thirdly, a surface cover would be beneficial in conserving moisture in the vineyard soil.

The first South African research in the field of surface cover management under the Department of Agriculture dates back to a study conducted by Van Huyssteen in 1970. The aim of the study was to determine the effect of selected minimum and conventional tillage practices in vineyard cultivation on vine performance. The effect of six cultivation treatments on soil physical parameters and response of wine grapes were evaluated in the experiment. The trial was conducted on the Nietvoorbij experimental farm under dry-land conditions, using a Chenin Blanc vineyard planted in 1968. The six different treatments were:

B_1 - Shallow trench furrow

B_2 - Deep trench furrows

B_3 - Straw mulch

B_4 - Chemical weed control

B_5 - Clean cultivation

B_6 - Permanent sward.

The results of the study showed that the use of a straw mulch provided an increase in production over the control (B_5), of 3.14 t/ha, which was approximately 2 t/ha more than that of chemical weed control, the next best result. Furthermore, the vine shoots of the straw mulch treatment maintained the fastest growth rate during all the growth phases, the moisture conserving capabilities of the straw mulch treatment proved superior, and the quality of the must exceeded that of all other treatments. A foreseeable problem however with the use of a straw mulch as a surface cover, proved to be the cost associated with buying in the mulch. This, along with the certain results from the trial are illustrated in the Table 3.5 below:

Table 3.5: A cost/benefit assessment of different cultivation treatments

Treatments	Average Yield [a] (t/ha)	Average Income (R/ha)[b]	Average Cost [c] (R/ha)	Average Net Gain (R/ha)	Gain or Loss vs. Control (R/ha)
B_5 (Control)	7.038	879.79	24.67	855.12	–
B_1	6.493	811.63	25.89	785.74	– 69.38
B_2	7.746	968.25	28.66	939.59	+ 84.47
B_3	10.180	1272.50	438.95	833.55	– 21.57
B_4	8.175	1021.88	53.14	968.74	+ 113.62
B_6	2.152	269.00	38.47	230.53	– 624.59

[a] The average yield is taken over 6 seasons.
[b] The calculation is based on a minimum price of R125/t for good Chenin Blanc grapes.
[C] The average cost is calculated over seven seasons.
Source: Van Huyssteen and Weber (1980)

The table above illustrates the potential increase in output and income that could result from the use of straw mulch as a surface cover. Furthermore the net loss as a result of the excessive costs associated with bringing in straw mulch is shown, and was labelled as the draw back in the adoption rate of surface covers as an effective production tool. In some cases however farmers have the advantage of having straw mulch readily available on the farm, and would therefore be excluded from those farmers having to incur the excessive cost normally associated with the buying in of straw mulch. Besides the increase in output, the table neglects to show the advantages relating to improved quality, to the reduction in herbicide costs and to the increase in the sustainability of the vineyard. Furthermore the project provided valuable insight into the potential of surface covers and acted as an important starting point for future projects.

A second study was conducted in the Olifants River irrigation region. The aim of the trial was to assess the effect of a permanent cover crop and root pruning by means of deep ripping of a flood irrigated, ungrafted existing Colombar vineyard. Saayman and Van Huyssteen (1983) started the trial in 1973. Three different treatments were used for the study:

T1: Permanent cover crop: Two varieties of winter growing clover were sown. These were however both suppressed by an invading grass, which was later left to act as the cover crop for the remainder of the trial.

T2: Permanent cover crop plus deep cultivation: Same as T1 except for the fact that during early autumn, deep cultivation was done with a two-tined ripper in every second inter-row.

T3: Clean cultivation: Each winter pruning were ploughed under in alternative rows. Natural weeds were allowed to grow during winter and were disked into the soil just before budding.

The results of the study showed that the clean cultivation treatment out-performed the other treatments in both aspects of shoot mass and yield, for all but the first of the nine seasons under review. As far as the infiltration rates were concerned, the permanent cover crop plus deep cultivation treatment produced the best result. The infiltration rate for 50 mm of water was 15.5 min. for T2, compared to 18.5 min. and 35.7 min. for T1 and T3, respectively.

The trial showed that in the absence of compaction problems, the differences in vine performance could predominantly be ascribed to excessive root pruning and to the effect of weed competition for nitrogen and moisture. The researchers concluded that the inter-row pruning was too severe and tended to enhance the negative competitive effect that the weeds placed the vine under. It was therefore concluded that clean cultivation practices remain the more practical form of weed control provided that no compaction problem should arise (Saayman & Van Huyssteen, 1983).

In an attempt to explain the different results from the above two trials, an obvious starting point would be to consider the set-up differences. Firstly, the former trial at Nietvoorbij was conducted under dry-land conditions, compared to the irrigated conditions of the Olifants River project. Considering that one of the benefits of using a surface cover is the water retention capability thereof, the application of such a technique under an irrigated vineyard would show a reduced degree of influence on the performance of the vine. Under dry-land conditions however the cover crop would have a greater degree of impact due to the limited availability of water. Secondly, the use of a straw mulch in the Nietvoorbij trial reduces the competition factor that the growing weeds in the latter trial place the vine under. This is of vital importance especially in critical times such as before budding, and thus highlights the need for optimal growing conditions.

The long-term effect of tillage systems on vine performance was studied in a trial conducted by Van Zyl and Van Huyssteen (unpublished data), starting in 1977. The trial was conducted on an existing Colombar vineyard in Oudtshoorn, under flood-irrigated conditions. The following variations in treatments were used in the trial:

T1 - Continuous clean tillage during summer
T2 - Vetch cover crop
T3 - Wimmera cover crop without additional nitrogen
T4 - Wimmera cover crop with 25.0 kg/ha of nitrogen in addition to the normal fertilization program.

The trial attempted to show that within deep fertile sandy loam soil, with structurally unstable topsoil, vine performance might be effected by clean cultivation practices in the long run. This trial served as an important follow-up to the irrigated trial referred to above. The results showed that even though no short-term benefits resulted from the use of a cover crop under irrigated conditions, long-run negative effects are evident as a result of clean tillage practices. This is illustrated in the trial plot yields shown below:

Table 3.6: Long-term effects of tillage practices on performance of an irrigated Colombar vineyard.

Season	Grape Yield (kg/vine)			
	T1	T2	T3	T4
1982	12.66	11.08	11.37	11.83
1983	11.35	9.30	10.82	11.40
1984	14.33	12.44	14.04	14.80
1985	11.12	12.09	13.67	14.21
1986	11.77	12.56	13.62	13.80
Mean	12.25	11.50	12.70	13.21

Source: Van Huyssteen (1986)

The negative influence of the clean tillage practice can partially be illustrated by the way the yields taper off in the later years, whilst the other treatments show an improvement in output. In comparing the two irrigated trials above, it can be reasoned that the use of a temporary grown cover crop is more effective than that of a permanent cover crop, when compared with a clean tillage practice. Furthermore, the long-run effects of clean tillage are only evident in the latter trial, thereby illustrating the sustainability factor, which the use of a cover crop adds to the vineyard.

The cost advantage of using a cover crop was also considered in this trial. Unlike the case of the straw mulch trial, the use of a temporarily grown grain crop, proved more cost effective in comparison with the conventional weed control and tillage practices. These results are illustrated in the table below:

Table 3.7: Tillage cost advantage associated with the use of cover crops.

Tillage costs (R/ha/yr.)		
Cover Crop	Herbicide under the vines & clean tillage in row	Hoeing of strip under the vines & clean tillage in row
55.00	112.00	140.00

A fourth project was started in 1978 on a farm in the Vredendal district in an attempt to determine the effect that a layer of sand as a topsoil would have on water infiltration, and the performance of wine grapes on a heavy textured silt soil. The project was conducted in the Olifants River valley under irrigation. Four cultivation treatments were compared in the trial:

T1) Sand cover of 75 mm thickness on the surface, and chemical control of summer weeds. No cover crop.

T2) Sand as in 1), but the sand was incorporated into the surface soil by disking. Rye was used as a cover crop.

T3) The legume Vetch was used as a cover crop and chemical control administered in early spring.

T4) Wimmera used as cover crop, with chemical control in early spring.

Table 3.8: Average harvest (kg per allotment)

Season	Treatments			
	T1	T2	T3	T4
1979/80	155.73	167.56	142.17	162.63
1980/81	151.46	150.33	123.33	147.38
1981/82	164.32	173.23	159.08	164.78
1982/83	215.15	230.08	212.95	240.53
Average	171.67	180.30	159.38	178.83

Source: Van Huyssteen (Unpublished data)

The following general conclusions were drawn from the project. Firstly, the use of a surface cover proved effective in reducing crusting and the slumping of unstable silty topsoil found in the area. Secondly, water infiltration rates were improved by a surface cover, improving the availability of water. And thirdly, the use of a surface cover managed to control the summer weeds until the end of April. The project however failed to show any real statistical differences in vine performance, but was valuable with regard to the control of cover crops in the vineyard.

In 1979 a fifth cover crop related project was initiated on the Robertson experimental farm. The trial, conducted on a 12-year-old Chenin Blanc vineyard, was aimed at determining the effect that root pruning through periodical deep cultivation and the biological stabilisation of the newly created soil structure, would have on the performance of the vine. Two cover crops, Wimmera ryegrass and Vetch, were used as the stabilising element for the soil. The treatments varied from the "no pruning" control, according to pruning which occurred at different stages of vine growth within the season. Each plot was subdivided into three sub-plots. Two were Wimmera plots - one with chemical weed control and the other mechanical clean cultivation was practised. The remaining sub-divided plot under Vetch was sprayed with herbicides. Overhead sprinklers were used to apply blanket irrigation.

The project ran into unforeseen difficulty as poor vine growth and continuous dying of experimental vines made it difficult to draw sound conclusions. Furthermore the cover crops struggled to establish themselves as the large trellising systems provided extensive shade in autumn.

Based on previous research trials Fourie and Van Huyssteen (1987) compared practical hints and costs of the three different methods of weed control. Firstly, mechanical weed control was deemed effective in that weeds were immediately eliminated and that it proved acceptable on sandy soils, where pre-emergence control with a chemical agent hold a safety risk. The disadvantages of the method are the damage that the pressure and smearing action of the implements cause to the soil structure. Furthermore the weed control is only temporary, and compaction may result from tractor movements.

Secondly, chemical weed control proved advantageous in so much that it kept the vineyard free of weeds without disturbing the soil surface too much. The disadvantage is however the lower water infiltration rates and increased soil erosion that are associated with clean tillage practices. Thirdly, biological weed control is beneficial in that the use of a cover crop may result in improved soil structure, higher moisture levels, improved water infiltration and reduced soil erosion. The above methods are however seldom applied independently and are in most cases combined in a single weed control program. The cost comparisons of the alternative weed control techniques are highlighted below:

Table 3.9: Cost comparison for the control of weeds.

Total expense (R/ha/season)		
Chemical weed control	Mechanical weed control	Biological weed control
122.07	120.74	172.96

Source: Fourie and Van Huyssteen (1987).

A project concerned with water infiltration was initiated in 1987 with the aim of determining the most effective medium for improving water infiltration rates. The trial included six treatments (B1-B6), replicated four times in a randomised block design on Avalon sandy loam soil with a slope of 6.7%. The following treatments were used:

B1 = Control - no amendments

B2 = Straw mulch (7.5 tons/ha)

B3 = Cover crop (Triticale)

B4 = Phosphogypsum (5 tons/ha)

B5 = Polyacrylamide (5kg/ha)

B6 = Phosphogypsum (8.5 tons/ha)

The straw mulch of 3.3 tons/acre was consistently the best treatment and resulted in only 4% runoff of the total rainfall figure, while runoff from the control amounted to 29%. Erosion also proved to be significantly lower than that of the control and phosphogypsum treatments. High runoff occurred from the cover crop treatment while the seedlings were still too small to cover the soil completely. The cover crop treatment however proved comparable to the straw mulch treatment once the seedlings had grown completely. It was therefore concluded that covering the soil with either a straw mulch or cover crop proved to be the most effective way to prevent runoff and erosion from vineyard soils, with the cover crop being the more economical alternative. Furthermore the cover crop has the added advantage of being able to effectively prohibit the growth of weeds during the summer months, thereby eliminating the need for pre-emergent herbicides (Louw and Bennie, 1991).

An advised cover crop management technique had effectively been developed by the early 1980's and has basically remained the same since. This procedure is a minimum tillage practice based on reducing the crusting that results from rainfall, improving water infiltration, vine output and quality, reducing the related input costs and improving the sustainability of the vineyard through reduced soil erosion and the improved maintenance of soil structure. This procedure is administered along the following guidelines:

> A cover crop of barley, oats or rye should be sown directly after harvest, in each row or alternative row. For at least four years after the switch from clean tillage, a top-dressing of 30kg N/ha should be applied at the two-leaf stage of the cover crop. The cover crop should then be sprayed with an appropriate herbicide directly after bud burst, reducing the competition for nutrients and water. Thereafter the cover crop should be cut or simply rolled flat. It is most important to keep the mulch on the soil surface to obtain the best results in terms of water conservation, weed control, water infiltration, lower soil temperature and better soil structure (Van Huyssteen, 1986).

In the early 1990's surface cover research was once again undertaken with the aim of being area and cover crop variety specific. In 1990 a project was attempted with the aim of evaluating the different grasses and broadleaf species which would serve as suitable cover crops in the Lutzville, Robertson and Nietvoorbij regions. The results showed that in all three regions the use of a grain maintained a sizeable increase in yield, maintained quality and reduced water loss, and also proved to be relatively inexpensive. Furthermore the trial showed that in all three regions the planting time of the cover crop had a visible impact on the quality and quantity of the dry-material production. The project was terminated in the 1994/95 year.

In 1989 a project was initiated with the aim of investigating the means by which a high infiltration rate on vineyard soils could be maintained. The use of a surface cover as a means of improving infiltration rates was considered only in the 1993/94 year. The results of which showed that the use of enough straw on the soil surface decreased soil crusting, ensured higher infiltration rates and reduced soil erosion. This project has yet to be completed, and thus no final conclusions have been made regarding the maintenance of high infiltration rates.

A further three projects were started in 1992 with the aim of evaluating different cover crop varieties and cover crop management practices on the basis of soil physical and chemical qualities, water consumption and performance of the vines. These projects differed with regard to the areas where the study was to be conducted, namely: the Breede River Valley, Lutzville and Coastal regions. One of the two stages of the Breede River Valley study was terminated two years after commencement as the industry failed to contribute financially towards the execution of the trial. The final results from the remaining trials are not yet available as the projects are still in the final stages.

3.3. Conclusion

It should be obvious from the details concerning the before mentioned projects, that minimum tillage practices are an important means of achieving sustainable growth in South African vineyards. The use of a cover crop not only extends the life span of the vineyard, but also improves and maintains the structure and nutrient balance of the soil. Furthermore, the trial plot data showed an improvement in water infiltration, moisture content and grape harvest per vine. The reduction in water runoff limits soil erosion, thereby improving the sustainability of the vineyard.

Within the new era of farming, the environmentally friendly advantages associated with the use of a cover crop as an effective weed control tool, makes such a technique that much more appealing. Cover crop management preserves the quality of the soil and leads to a slow build-up of organic material in the soil, thereby increasing the fertility and structural stability thereof. In addition to this, the reduction of herbicide use will help facilitate integrated pest management (IPM) and help to secure a place for South African grapevine products in international markets.

The challenge ahead for researchers lies in the fact that producers are currently struggling to obtain sufficient dry material with cover crops over the long term. This is essential, as research has shown that a lower tons/ha yield of dry material will not have the same effect as a high dry material yield. Furthermore, as rainfall patterns differ from region to region, guidelines applicable to specific cover crop success in particular grapevine regions is of vital importance.

The importance of technology as has been discovered above is invaluable for the growth of the wine industry. The evidence however is visible that government spending in agricultural research is diminishing, thus creating the need for the private sector to intervene. The obvious shortcoming of private investment in research is the ability that the investor will have in controlling the use of the technology. The use of patents may curb the exploitation of new technologies, but will have difficulty in preventing the free-rider problem.

The move toward private investment in research will have the danger of neglecting maintenance research. Research is often conducted to maintain sustainability, prevent soil erosion or develop environmentally friendly production techniques. The economic return of such research will therefore be low, and will thus present a problem in attracting potential investors. An industry representative body such as Winetech will have to ensure that funds are available for the continuation of such research programs.

The current restrictions, which have been placed on research funding, have forced the ARC to reassess the historical research focus and become more financially aware. The recent amalgamation of Nietvoorbij and Infruitec is but one example of the means by which the ARC has endeavoured to alleviate the financial strains which the extensive research staff and facilities have created in the past. Furthermore, the proposal of research projects will need to be accompanied by extensive cost and benefit analyses, adhering to the social and environmental needs of the industry. Proposed research projects will therefore have to be screened not only on a financial basis, but also based on the need to contribute toward social benefits, thus attempting to undo the skewed focus of research in the apartheid era.

CHAPTER FOUR

Identifying and compiling project costs and benefits

4.1. Introduction

Back in 1958 when Griliches first attempted to measure the returns to agricultural research, the success with which his results were considered set the scene for the initiation of similar studies, and may also have started a long and frustrating path for those analysts who were to follow. Even though research evaluation methodology has been modified and adapted to suit specific situations, the availability of relevant cost and return data for evaluation has remained as scarce as was the case in 1958. The methodology used by Griliches was based on a simple cost benefit analysis; the costs and benefits were collected and taken forward to 1955, where a rate of return of approximately 700 percent was calculated. The methodologically sound technique used by Griliches is however in sharp contrast with the vague nature of the data used for the study. Firstly the private and public cost data were estimated on the basis of a mail survey, of which only twenty replies were of any use to the study. Secondly the social returns were estimated by determining the value of the resulting increase in corn production, plus a price change adjustment. It is however not so much the methods of estimation which are questionable but more likely the source from where it came. Research institutions have historically not emphasised the need for cost data collection and potential social returns from research projects, and thus may prove to be an unreliable source of information.

This general lack agricultural research information, specifically for the purpose of measuring returns to agricultural research, has proven to be a major stumbling block in any attempt to use such information as an effective tool for policy and management decision-making. The majority of studies conducted in this regard have traditionally made use of information on a macro scale, measuring the returns to public funded agricultural research on either a national, industry or institutional level (Kahlon *et al*, 1977; Dalrymple, 1977). Furthermore, the use of cost and benefit data on a macro scale, determined through alternative means, has not been limited to a specific type of analysis, but has effectively been used in both *ex ante* appraisals (Araji, 1978) and *ex post* evaluations (Peterson, 1971). The use of cost and benefit data collected on the micro level, for the use of project appraisals or evaluations, has however historically not enjoyed as high a priority as those on the macro level. Recently however studies have been initiated in South Africa with the aim of measuring the socioeconomic impact of research programs conducted in South Africa (Marasas, *et al*, 1997; Niederwieser, *et al*, 1997). These studies both make use of specific research projects and attempt to identify the economic, institutional, sociocultural and environmental impacts that result.

The lack of extensive work conducted on the micro or project level in South Africa can partially be attributed to the way in which agriculture, and thus agricultural research, was controlled during the apartheid era. During this time there had been a long history of state support for the white commercial farmers in South Africa, not excluding the support through improved farming techniques that resulted out of government funded research. Therefore the abundance of government funds and the disregard for undertaking research that benefited the entire society, eliminated the need to distinguish between research projects and thus reduced the need for the collection or prediction of costs and benefits on a project level. The lack of project level information regarding proposed costs and benefits thus created a problem with the accuracy of studies, which were conducted on the micro level.

The distribution of funds within agricultural research institutions in South Africa has traditionally been limited to the allotment of available funds between research departments. Very little emphasis had been placed on maintaining a socially accepted diversity of research projects. The changing political environment in South Africa has however brought along with it a shift in the demands placed on agricultural research as a whole, and also raised a question as to the amount of government support that these institutions have traditionally enjoyed. Therefore, with the predicted cut in state support and the inevitable move toward socially acceptable research programs, the emphasis has slowly been shifted to the implementation of research projects which are both socially beneficial as well as cost effective. This has therefore increased the need to prioritise research projects according to accepted criteria, and allow for the selection of only those projects which "make the grade". Furthermore, the lack of state funds resulting in the need for private investment, has created the situation whereby researchers are forced to compile thorough research proposals, thereby illustrating and identifying the costs and benefits that are intended to transpire from the completion of a proposed project.

The importance of accurate cost and benefit data collection cannot be overemphasised, as these are both crucial elements in determining the financial and economic viability of a particular research project. Historically studies have placed a limited importance on the process of determining the costs and benefits, and concentrated on the method used to estimate the data. It was Hertford and Schmitz (1976) who were of the impression that it was not the methodology that posed a problem in achieving legitimate estimates, but more likely the data that was fed into the methodological options. This chapter considers the alternative cost and benefit attributes that are theoretically associated with agricultural research projects, and goes further to highlight those attributes which are relevant for this particular *ex post* study. In addition to this an attempt is made to compile the data in a suitable manner so as to conduct a suitable evaluation thereof.

4.2. Cost of minimum tillage research projects

4.2.1. Operational Costs

Gittinger (1982) has described the costs of a research project as anything that may reduce the objectives defined in the project analysis. The problem with this definition however, is that the objectives of the project may differ between participants, and will therefore result in discrepancies when attempting to account for the various objectives of every participant. He goes further to mention that in the economic context, a cost is illustrated as anything that reduces the national income, since the final objective should be to increase the sum of all final goods and services. Gittinger (1982) identifies a number of agricultural research costs based on the premise that these items will reduce the net benefit of the project outcome. For the purpose of this study the costs highlighted by Gittinger were used as a guideline in assessing the relevant costs for the minimum tillage research projects (MTRP).

The MTRP involving surface cover techniques, amount to 11 research projects, of which the first was started in 1969 and the last in 1992. Three of the 11 projects are still currently being conducted. It was decided at the onset of this study that the cost data would be extracted from the historical project files that existed at the Fruit, Vine and Wine Research Institute. On collection of these files, it was established that the files for five of the projects that were all started prior to 1981 were without any predicted or recorded cost data. Furthermore, the cost data for projects that existed between 1981 and 1992 lacked uniformity between the years that the project was running and between the projects themselves. The project files showed an improvement with regards to the thoroughness and uniformity of the available cost data after 1992, at which time the ARC had taken over the control of the research institutions in South Africa.

The lack of cost data therefore required that an alternative means of cost estimation be used. Different methods were however needed as the missing data occurred at varying degrees. Firstly, there were projects with no costs data in the project files; secondly, project files were found with only some of the necessary data; and thirdly, some project files used different means to estimate the cost values. It was therefore necessary to devise an alternative solution for the various degrees to which cost data were missing.

In order to estimate the costs of the five projects, which were running prior to 1981, the relevant researchers were approached and asked to estimate the cost of the project using one of three approaches. The first approach required that the researcher recall the time spent on the project and attempt to estimate the inputs that were used in the start-up and running of the project. These included the cost of the manpower used, the running costs, the implements and equipment, the overheads and the size of the land on which the project was conducted. Furthermore, the details regarding the research project were also requested, along with an indication of the years that were regarded as "high activity" years, in comparison to those years that were of "low activity". The comparison was needed, as a project will seldom run at its full capacity with regard to manpower and running costs over its full lifetime.

The second approach required that the researcher estimate what the cost of conducting a similar research project would be in 1996/97 prices. The consumer price index (1990=base year) was then used to deflate the values so as to represent the costing for the applicable years. The researchers were also required to estimate which years would be high activity years. In some cases the researchers supplied only an estimated yearly cost of the project, indicating which years would be "high activity". The values for the "low activity" years were calculated at 50 or 75 percent of the "high activity" years, depending on the project.

The third approach required that the researcher use the costing from another project which is similar in make-up and time-span. Some of the projects which were conducted from the late 1980's, and especially those conducted after 1992, had thorough cost records which were used to establish a possible cost similarity with the project in question. Adjustments were made and the costs deflated to account for the applicable years.

The second problem encountered with the collection of the data occurred as a result of the lack of a uniform collection technique, which existed between the running years of a particular project and between the different projects. This therefore posed a problem in arriving at reliable cost data, and it was therefore necessary to adapt the means of collection to suit the applicable years. Prior to 1981 very little useful data were found in the project files, and the means mentioned above were used to source the data. Thereafter, between 1982 and 1987 cost data were generally found in the project files as a budgeted value, broken down into salaries, running expenses and capital costs. The overhead costs were omitted from the cost prediction. In the years from 1988 to 1990, the costs were displayed in the project files as a single value, and referred to as a "facet" cost. These values were budgeted values and excluded overhead costs. For years 1991 and 1992, cost data were obtained from records that were collected under the soil management department, and represented budget values. The cost data for years 1993 and 1994 were obtained from the same source, but were fine-tuned by multiplying the budgeted values with the percentage of the budget that was spent for the entire soil management department. Finally, the data for years 1995 and 1996, were obtained from the "budget control sheets" which were collected by the department, and represented actual values spent on the particular projects. Furthermore, there were certain costs that were omitted from this costing and therefore the values had to be adjusted. An illustration of the data collected from the sources mentioned above is given in Table 4.1 below, excluding the years prior to 1988. The data represents the costs for a minimum tillage project aimed at determining the means by which high infiltration rates could be maintained in the vineyard. The table below is an indication of the cost data that had been collected, before any adjustments had been made. A similar table was drawn up for the other projects under review in this study.

Table 4.1: An example of the available information from the initial retrieval
Aim : An investigation into the maintenance of high infiltration rates on vineyard soils

Project 2462/30/3/9 - WW2/3					
Year	Salaries	Overheads	Running	Capital	Total
1988/89	21,925.00		1,200.00	2,000.00	21,125.00
1989/90					61,522.00
1990/91					77,661.00
1991/92	35,214.00	30,037.00	12,633.00		91,909.00
1992/93	27,490.00	23,449.00	28,400.00		79,339.00
1993/94	33,181.00	34,038.00	29,297.00		96,517.00
1994/95	31,618.00	35,486.00	33,873.00		100,977.00
1995/96	17,273.00	15,373.00	23,038.00		55,684.00
1996/97	23,186.00	22,251.00	12,967.00	2,950.00	61,354.00
Totals	189,887.00	180,805.00	141,408.00	18,975.00	670,258.00

Once all the possible cost data had been extracted from the project files and through other available means, many gaps and discrepancies still existed in the data. It was therefore decided in collaboration with the researchers, that the following methods would be used to fine-tune the cost data illustrated above. Firstly, it was decided that the missing overhead values would be calculated at 95 percent of the salary value. This is currently the method used by the soil management department to estimate overhead costs. The problem however existed that many of the years did not have a salaries value recorded separately from the other costs, and so it required that a salaries value first be determined. It was decided that the salaries should be extrapolated to account for the missing years, unless the applicable researcher indicated that extra manpower had been needed during those years. Once the salaries had been determined, the overheads were estimated at 95 percent of the value.

Secondly, an attempt was made to adjust the budgeted values in order to show a closer representation of the actual expenditures. Therefore, for the years 1993 and 1994 records were retrieved from the department in which the percentage of the department's budget spent had been calculated. The budgeted values were then adjusted according to these percentages. Thirdly, it had been established that the running cost values for the years 1995 and 1996 did not include the water & electricity and license fee costs. The values therefore had to be accounted for. The changes mentioned above resulted in the revised costs indicated in Table 4.2 below.

Table 4.2: Information after data has been adjusted.

Aim : An investigation into the maintenance of high infiltration rates on vineyard soils

Project 2462/30/3/9 – WW2/3						
Year	**Salaries**	**Overheads**	**Running**	**Capital**	**Total**	
1988/89	21,925.00	20,171.00	1,200.00	2,000.00	45,296.00	BPF
1989/90	26,354.66	25,036.93			86,558.93	F
1990/91	30,784.33	29,245.11			106,906.11	F
1991/92	35,214.00	30,037.00	12,633.00	14,025.00	91,909.00	B
1992/93	27,490.00	23,449.00	28,400.00		79,339.00	B
1993/94	29,753.40	30,521.88	26,270.62		86,545.90	BA
1994/95	30,454.46	28,931.73	5,851.99		65,238.18	BA
1995/96	18,627.90	17,696.51	5,467.10		41,791.51	BCS
1996/97	20,817.59	19,776.71	5,304.00		45,898.30	BCS
Totals	241,421.34	224,865.87	85,126.71	16,025.00	649,482.93	

Notes

Researcher: P.J.E.Louw.
F - Depicts the predicted yearly costs documented as Facet costs.
BCS - Depicts actual values taken from the Budget Control Sheet.
B - Depicts budgeted values taken from Department Budget data.
BPF - Depicts budgeted values taken from the project file.
BA - Depicts a budgeted amount which has been adjusted according to the percentage of the budget spent by the department.

The change in yearly values that occurred as a result of the adjustments having been made, is an indication of the unreliability with which cost data should be considered. Furthermore, the opportunity cost of the land has not been taken into account in these cost values. Gittinger (1982) identifies land as input into the research project and therefore looks to estimate a value therefore, as would be the case for any other input. He notes however that a problem may arise in valuing land because of the very special kind of market conditions that exist when land is transferred from one owner to another.

4.2.2. Other Costs

In the economic sense Gittinger (1982) identifies the opportunity cost of land as the net value of production foregone, when the use of the land is changed from its without-project use to its with-project use. Two simple methods of valuation are identified, these methods are however situation specific and need to be adapted to suit the problem at hand. Firstly, in a situation where production methods are altered, but the management control remains the same, the opportunity cost of the land is the market value of the incremental benefit that occurs as a result of the research. A second situation will result from land being purchased or rented for the purpose of conducting research. The fact that agricultural land is seldom sold may pose a problem in using this method, as very often the considerations of investment security and prestige may push its price above what its contribution toward agricultural production may be worth. An alternative is to use the rental value of the land, which may be entered into the financial statements as an annual cost attributable to the project. In a situation where neither the purchase price nor the rental value of the land act as a good estimate, a direct estimate of the productive capability of the land may be used. From a theoretical point of view the land rental value can be calculated using the following formula (Barlow, 1978):

$$V = [a/(1+r)] + [a/(1+r)^2] + [a/(1+r)^3] + \ldots\ldots + [a/(1+r)^n] \qquad (1)$$

this formula can be reduced to the following:

$$V = a/r \qquad (2)$$

$$a = V.r \qquad (3)$$

where V = the value of the land property

a = the expected average annual land rent

r = the capitalisation rate

The question of the opportunity cost of land becomes interesting when considering the situation relevant for the minimum tillage research projects. Let us assume that the ARC or the controlling body owns the land used for the relevant research projects at the time of commencement of the project. In this case the opportunity cost of the land could be estimated by determining the market value of production on a privately owned farm in the area. In the majority of accounting practices this value would be represented as a depreciation value and be recorded as an overhead value. The problem however arises when estimating the value of the opportunity cost of land that can be attributed to a specific research project, which is being conducted on an existing vineyard. It would be incorrect to assume that the opportunity cost of the land would be the productive value of the land, because the vineyard would produce a crop for the purpose of sale, and thus could not be considered as total income foregone. The opportunity cost of the land would therefore be the income foregone had the project not been conducted, and would be valued as the incremental benefit that occurs as a result of the research. A discrepancy might result from the fact that traditionally research institutions have not primarily been focused on the sale of produce, and may therefore be "under-achievers" in this field. This would therefore create the situation whereby an opportunity cost may arise as a result of the lack-lustre approach with which sales might be considered. In this case the opportunity cost would be the value of the extra income realised by a privately owned farm.

In 1996 it was estimated that the 105 609 hectares of land under wine grapes produced a wine crop valued at approximately R1 233.1 million. This therefore places the per hectare return to the farmer at approximately R11 676. In addition to this the revenue that the state received from the wine industry amounted to R1 599.5 million, and would also have to be included in a return per hectare value for the wine industry. Therefore, in total the revenue generated by the industry amounted to R26 821 per hectare. In the case of the land under research it is estimated that of the 386 ha available to the research institute for research only 109 ha are at present under cultivation. In the 1996/97 year it was estimated that product sales amounted to R1 469 092, resulting in a value of R13 478 per ha in sales. The total sales figure obtained from the institute does however include all sales at the institute, and not only those sales as a result of wine produce. Therefore the opportunity cost of land that can be attributed to the MTRP, will amount to the difference between the per hectare returns value for the 109ha, and the percentage of the remaining 277ha not under cultivation which can be attributed to the MTRP.

For the purpose of this study it has however been decided that the opportunity cost of the land would not be included in the total cost value. The reasoning is firstly as a result of the lack of accurate sales figure for wine produce at the research institute dating back to 1969, and secondly the split between working and non-working hectares at the institute is only available for 1996.

The adoption of a specific research activity can also result in a cost, which should be included in the total cost of the research. For example the use of a new hybrid seed variety may result in a higher input cost, which may be justified through improved output. In such a case the cost of the research would have to include an adoption cost, as the producer moves away from the cheaper seed variety and uses a more expensive variety. The situation is a little different for the cover crop research, as the proposed method proves to be cheaper than the alternative clean tillage method. Therefore adoption cost would have to be classified as a benefit, as a result of the reduction in input costs which the research has resulted in. This is highlighted in the following section.

In addition to the costs mentioned above, an allowance must also be made for the overhead and administration costs accruing to the ARC head office since its inception in 1992. The minimum tillage research projects must therefore reflect a certain percentage of these costs. This contribution is estimated by firstly establishing the ratio of the MTRP costs to the total expenditure of the ARC. This ratio is then applied to the overall budget of the ARC head office. The costs relating to the cover crop research will also have to include a contribution toward the overhead costs associated with the ARC Headquarters. This cost can be calculated using the following equation:

$$\text{ARC Overhead Cost} = \frac{\begin{matrix} Annual.Budget.of \\ Cover.Crop.\mathrm{Re}search \end{matrix}}{\begin{matrix} Global.Budget \\ of.ARC \end{matrix}} \times Total.Cost.of.ARC.Head.office$$

Gittinger (1982) identifies four other costs that are deemed applicable for the purposes of estimating the value of the cost data. Firstly, contingency allowances is the provision made in advance for possible adverse changes in physical conditions or prices that would add to the initial cost estimates. This cost, primarily included in *ex ante* cost estimates, is excluded from the cost value because of the *ex post* means of data collection. Contingency allowances may however be deemed relevant for the cost data that has been retrieved as a budget value. In order to account for this researchers were consulted in the likelihood that major changes were necessary for the continuation of a specific project. Such a case resulted from the need to install an irrigation system which, to the researchers knowledge, had not been budgeted for. The cost of the system was estimated and included in the project costs. The allowances for change in prices that may have affected budgeted data, were not taken into account on the pretence that this amount would be accounted for by the fact that researchers traditionally over-budgeted so as the cover any minor unexpected costs.

Second and thirdly, Gittinger (1982) considers taxes and the payment of interest for debt services as a cost in a financial analysis. In economic analysis, however, they are considered as transfer payments and are omitted from cost data. Lastly, the costs incurred as a result of prior work done, leading up to the relevant projects, are considered to be the "sunk costs" of the project, and deemed necessary for the complete estimation of the cost data. In the situation of the 11 relevant minimum tillage projects which have theoretically followed on from one to the other, the "sunk cost" would have to be taken on the work done prior to the commencement of the first relevant project in 1969. It was decided that as a result of the lack of cost data for these early projects, that an attempt at estimating such a value would prove to be futile.

Furthermore, Gittinger (1982) highlights the need to incorporate the secondary and intangible costs and benefits that may be associated with a project investment. Secondary costs and benefits are considered as the value added that arises outside the project but occurs as a result of the project investment. These may include considerations such as income distribution, number of jobs created, regional development etc. The costs and benefits are usually valued as either an opportunity cost or at the value of the consumer's willingness to pay for the item. The secondary costs and benefits are combined when added to the primary costs so as not to constitute a double counting. For the purpose of this study a quantitative valuation of these costs and benefits were not attempted, a mention will however be made of the applicable research induced benefits and costs in the following chapter.

4.3. Benefits of minimum tillage research projects

The benefits of agricultural research can be estimated by comparing the advantages that the new technology brings over the level set by the old technology. Puterbaugh (1971) recognises the need to make the distinction between commensurable, incommensurable and intangible research benefits. Commensurable benefits, identified as tangible benefits by Gittinger (1982), are those benefits which can be valued by the amount of rands saved due to a cost saving technology, or the rands gained as a result of technology aimed at improving the output or quality of the product. Incommensurable benefits are those consequences that can be valued in quantitative terms but can not be added to the commensurables above. The distinction between the two before mentioned benefits comes in the inability to assign a definite cost-saving or output-improving value to the related benefits. Estimates of the reduction of stream pollution or the improved sustainability of a piece of land are examples of incommensurable benefits. Intangible benefits are those consequences, which are not a direct result of research investment, and lack any formal means of evaluation.

For the purpose of measuring the returns to the MTRP using a cost benefit methodology, it was decided that the best estimate would be achieved by using available trial plot data. The lack of project level data once again proved to be a hazard in attaining the necessary data, and it was therefore decided that relevant results would be selected, from the available information, to show a realistic outcome of research investment. Referring to the chapter before, it can be concluded that the 11 relevant MTRP have achieved a proven minimum tillage technique, which show a number of beneficial consequences. Once again the benefits identified by Gittinger (1982) are used as a guideline to establish the relevant benefits from the investment in the MTRP.

It is important to remember that the idea behind the minimum tillage research programme was primarily to eliminate the excessive use of tractor implements, thereby reducing the damage caused to the soil structure. The desired result from achieving the above goal was to improve the soil structure, without effecting the quality or quantity of the product harvested from the vine. The point to consider is therefore the fact that the "commercial" benefits, that are identified below, are an indirect consequence of that which was initially set out to be achieved.

To explain the above consider the following: it was established that the excessive use of tractor implements in the vineyard had a detrimental effect on the structure of the vineyard soil, and would thus have a negative effect on production levels. The inter-row tillage was however deemed necessary for the elimination of weeds, the prevention of crust formation (reducing water runoff, improving water retention and maintaining soil moisture), and assisting in the reduction of soil erosion. Therefore, a suitable cost efficient technique was sought to substitute the use of tractor implements, whilst achieving similar production levels. Different minimum tillage techniques were therefore experimented with and the desired results were achieved through the use of a cover crop, carried out using the approach mentioned in the chapter before. The use of cover crop thus managed to achieve the initial aim of successfully substituting the use of tractor implements, and had the additional benefit of improving the productivity of the vineyard.

4.3.1. Increased production

The majority of research programs aim to increase the existing production of a particular crop, whether it is through improved tillage practices, a reduction in weed competition, the development of a disease resistant cultivar etc. The increase in production, in the cases where production is marketed through commercial channels, can be valued by determining the market price of the product. In the case of the MTRP the distinction has to be made between the research conducted under dry-land conditions, and that which was conducted under irrigated conditions. For the purposes of this study a comparison is made only between the results achieved from the traditional clean tillage and cover crop practices.

Table 4.3: Yield difference taken from trial plot data.

Season	Grape vine yield (tons/ha)			
	Irrigated Conditions		Dry-land Conditions	
	Clean Tillage	Cover Crop	Clean Tillage	Cover Crop
Year 1	31.14	27.97	4.11	7.64
Year 2	27.92	26.62	4.74	8.07
Year 3	35.25	34.54	6.01	9.93
Year 4	27.36	33.63	7.72	9.53
Year 5	28.95	33.51	10.29	12.29
Year 6			9.38	13.63
Year 7			19.28	25.13
Mean	30.14	31.27	8.79	12.32

Notes: The difference in the yield volumes between the irrigated and dry-land trials can be attributed to the fact that in the case of the former trial, an existing vineyard was used, in comparison to the new vineyard used in the case of the latter trial.

The trial plot data clearly illustrates the benefits that can be attributed to the use of a cover crop in the vineyard. For reasons mentioned in the previous chapter the increase in output under dry-land conditions (3.53 t/ha) will be greater than that realised under irrigated conditions (1.13 t/ha). The trial conducted under irrigation was aimed at determining the long term effects of alternative tillage practices. It was concluded from the trial that the vine performance reflects the negative effect of clean tillage only after about eight years. This lag will therefore have to be considered when estimating the benefits attributable to the research investment. In contrast with the above, the dry-land conditions showed favourable results from the outset of the trial.

The value attributed to the increase in production will therefore be dependent on the break down between irrigated and non-irrigated vineyards. The lack of such information within the industry limited the available data to the year of 1996. For the purpose of this study it was therefore assumed that the percentage break down would be the same as the value depicted below, for all applicable years.

Table 4.4: The breakdown between irrigated and non-irrigated vineyards.

Region	Area under wine vineyards/hectare				
	Irrigated	% of total	Non-irrigated	% of total	Total
Orange River	12 231.38	96.4	460.56	3.6	12 691.94
Olifants River	7 114.35	90.0	794.30	10.0	7 908.65
Malmesbury	4 063.64	32.2	8 518.12	67.8	12 581.76
Klein Karoo	3 073.73	96.7	104.36	3.3	3 178.09
Paarl	11 895.54	70.3	5 029.45	29.7	16 924.99
Robertson	11 017.49	99.0	107.65	1.0	11 125.14
Stellenbosch	7 050.97	45.5	8 447.55	54.5	15 498.52
Worcester	15 468.18	97.8	343.49	2.2	15 811.67
Total	71 915.28	75.1	23 805.48	24.9	95 720.76

In order to estimate the market value of the increase in production a breakdown of the quality of wine produced and the market price for the applicable years had to be determined. This data was readily available from the yearly "SA Wine Industry Statistic" that is produced by the KWV.

Table 4.5: Quantity and price of different quality wines.

Year	Percentage of Total Wine			Price (R/Litre)		
	Good Wine	Distilled Wine	Brandy Wine*	Good Wine	Distilled Wine	Brandy Wine*
1976	46.3	53.7		0.20	0.10	
1977	45.4	54.6		0.22	0.13	
1978	48.6	51.4		0.23	0.11	
1979	44.2	55.8		0.26	0.12	
1980	45.1	54.9		0.29	0.14	
1981	46.6	53.4		0.32	0.13	
1982	49.6	50.4		0.38	0.17	
1983	46.6	53.6		0.42	0.14	
1984	49.0	51.0		0.44	0.16	
1985	50.3	49.7		0.49	0.19	
1986	59.3	40.8		0.55	0.33	
1987	54.8	45.2		0.66	0.33	
1988	50.0	50.0		0.76	0.31	
1989	45.2	54.7		0.87	0.31	
1990	47.7	52.3		1.00	0.41	
1991	48.2	44.2	7.6	1.03	0.42	0.74
1992	51.1	45.0	3.9	1.18	0.40	0.85
1993	51.4	46.0	2.6	1.28	0.31	0.92
1994	55.2	38.0	6.8	1.28	0.56	0.92
1995	62.0	30.0	8.0	1.39	0.59	1.00
1996	67.0	21.0	12.0	1.10	1.04	1.04

***Since 1991 quality wine for brandy has not been included with distilling wine**

The most important determinant in valuing the returns to society as a result of research, must be the adoption rate of the technology. The rate at which new technology will be adopted will vary according to a number of factors that include

i) the net benefit that the producer can expect from the technology;
ii) the probability that the producer will actually receive the benefit;
iii) the degree of risk associated with the new technology;
iv) the management level required by the new technology;
v) the efficiency of extension services; and
vi) the infrastructure that determines access to markets.

In applying the above points to the cover crop technique, it can be assumed that the adoption rate for this technology would be high for the following reasons. Firstly, the benefit from the technology can be illustrated from the trial plot data above, secondly, the producer will receive the majority of the benefit through increased production, and thirdly, the risk and management levels required for implementation of the technology are low. The estimation of an adoption rate for the purpose of this study has however proved to be a difficult task due to the limited time and resources available. It was therefore decided that relevant questions would be included in a questionnaire set-up for farmers, by the Department of Sociology at the University of Stellenbosch. The results are indicated in Chapter Five.

4.3.2. Quality improvements

Voon and Edwards (1992) view quality improvements as "an increase in the amount of a valued characteristic in each unit of a homogeneous product". In a study conducted by the former, an attempt was made at determining the research payoff from quality improvement in a case focused on the protein content in Australian wheat. The model used in this study is based on the improvement in quality shifting the supply and demand curves upwards. The results show that the benefit from a one-percent point increase in wheat protein, will result in a net benefit of A$ 29 million per annum, of which 98 percent accrues to the producer. Studies concerning the returns to quality improvement research have however enjoyed little attention, and are thus a relatively unknown subject.

For the purpose of this study, the possibility of using a complex model as the one used above is restricted. The reason being that in the case of the minimum tillage research conducted, the research seldom continued to measure the quality improvements of the wine produced from the crop realised. Results obtained from the 11 trials undertaken, show favourable results with regards to quality, based simply on the fact that the quality of the grape maintained the standard set before the project was undertaken. Within the industry there is however no fixed way in which quality is determined from the grape which is harvested. Therefore for the purpose of this study it has been assumed that the quality has remained fixed after application of the technology.

4.3.3. Reduction in costs

Traditionally agricultural research has placed a great amount of emphasis on reducing the cost of agricultural inputs, and improving related farming techniques so as to increase productivity. A classic example of this is the invention of the tractor, which had the resultant effect of improving the productivity of agriculture, but at the same time reducing the need for labour requirements. This reduction in labour costs resulted in a benefit for the farmer, but also acted as a cost to society as employment levels in the agricultural industry decreased.

For the purpose of this study the relevant costs involved in the growing of wine grapes were identified and compared. The cover crop technique developed through the MTRP, results in a cost difference for the soil tillage and weed control practices. These differences are highlighted in the tables below.

Table 4.6: Comparison of tillage costs

Tillage Costs (R/ha/yr.)		
Cover Crop Treatment	Clean Tillage with chemical weed control under vines	Clean Tillage with manual weed control under vines
55	112	140

The lower cost value for the cover crop treatment can be attributed to the reduced number of tractor trips that are needed in the vineyard.

Table 4.7: Comparison of weed control costs

Weed Control Costs (R/ha/yr.)		
Cover crop	Chemical	Mechanical
172.96	120.74	127.07

The weed control cost for the cover crop treatment will be higher because of the costs involved in buying in the seed for the crop, the establishment cost of the crop, and the cost of the chemical which is needed to kill the crop so as to form the mulch. However on combining the two effected costs, it is evident that the cover crop treatment (R227.96) is cheaper than the chemical treatment (R232.74), which is cheaper than the mechanical treatment (267.07). Therefore the use of a cover crop will reduce the costs by R4.78 /ha/year in comparison to chemical control and R39.11/ha/year in comparison to the mechanical weed control practice. Additional chemical weed control applications are not needed when using the cover crop technique because the crop will out-compete any weeds that should attempt to penetrate the soil. Furthermore an incommensurable benefit will arise from the fact that a cover crop will be more environmentally friendly, as a result of the reduced amount of chemical agents that are used for weed control practices.

In addition to the benefits that have been mentioned above, the use of a cover crop will also have other incommensurable benefits that need to be considered. In the presence of the cover crop, research has shown that water runoff will be reduced, thereby having the effect of reducing the amount of nutrients lost from the soil and limiting the amount of soil erosion which occurs. It can be assumed that the reduced nutrient loss value will be accounted for by the increase in productivity of the vine, along with the reduced soil erosion to a certain degree. However, it can also be assumed that the reduced soil erosion will result in the improvement of the sustainability of the vineyard. Should the vineyard therefore have a prolonged life span, the benefit could be calculated by determining the value of output for each year of the extended life of the vineyard.

4.4. Conclusion

The literature above is indicative of the data with which economic analysts have had to work with in the past. The diverse source or lack thereof, of project related data stems from the lack of accountability with which research projects were approached in the past. The mere fact that funds could be spent on a project that produced an empty folder for historical storing purposes is evidence enough to believe that projects were conducted in a haphazard manner. The diminishing of research funds has however seen a change in the historical situation, and it is evident that since the inception of the ARC, that the importance of data collection has been identified.

The collection of historical data is of vital importance not only for the evaluation of research projects, but more importantly to be used as a benchmark for the costing of future projects. With the movement toward private investment, the formulation of accurate *ex ante* evaluations will be the driving force behind ensuring suitable financial support.

Since the first study conducted by Griliches in 1958, numerous other studies have attempted to measure the returns to agricultural research. These studies have generally maintained methodological similarity in the sense that they have all been conducted using either a cost benefit or production function approach. Uniqueness within each study does however exist as a result of the limited cost and benefit data, which has traditionally characterised the research industry. As a result of the lack of detailed data analysts have had to conjure up new ideas to arrive at data which is suitable for analysis. These different methods have often been the source of criticism for many of the previous studies, which have been conducted. It must however be remembered that there are no set rules as to the type of data that is required for the purpose of such a study, and that with each new idea a more formalised means of evaluation is developed.

Care should however be taken when estimating the returns to research based on the potential that is determined through trial plot data. Dalrymple (1977) highlights this problem in a study conducted on the impact of research on wheat and rice production. He notes that the yield potential of high yielding varieties (HYV's) determined on experimental stations is often several time higher than that obtained in practice. He attributes this difference firstly to the fact that many factors outside the control of the research station - such as biological and economic constraints - may interfere with the optimal use of new technology, and secondly, to the fact that the experiments seldom reflect the entire agroecological nature of the targeted country, thereby not considering the biological limited areas. Furthermore, non-experiment achieved yields are not as high as expected because the majority of the farmers do not follow the recommended practices that are ascribed by the researchers. Therefore, because no alternative form of benefit data is available, it is necessary to consider the benefits with a certain amount of caution.

CHAPTER FIVE

Analysis of data

5.1. Introduction

Agricultural research originates from the aim to improve or sustain an existing agricultural technique or practice. The theory of "cause and effect" will therefore indicate that should an existing technique be altered, a resultant effect will occur. In other words the implementation of new farming practices will have an effect on the associated industry, whether it be social, financial, economical, or environmental. The aim of this chapter is to place a numerical value to the "effect" that the cover crop research has had on the industry. The cover crop study, at the project level, is a continuation of the study conducted by Townsend and Van Zyl (1997), where the returns to research on the institutional level were evaluated.

Using the data collected in Chapter Four, the impact of the cover crop research will be determined using two methods. The first is a commonly used approach for *ex post* studies, the production function approach. As mentioned before, this approach makes use of a linear regression model, using the inputs of agricultural research as explanatory variables used to explain the shifts in the production function over time. The second approach is less analytical and makes use of trial plot data as a measure of the increase in output and the reduction in the cost of inputs. The method is based on a simple cost benefit analysis. Norton and Davis (1981) refer to the cost benefit approach as an ex *ante* evaluation technique, based on potential benefits and costs that can be attributed to a specific research project. In the case of this analysis the research cost and benefit data is *ex post* and therefore requires an alternative cost benefit technique.

5.2. The basic production function approach

The basic production function technique used in this analysis dates back at least to the early 1920's work of Cobb and Douglas who fitted a production function to data based on the US manufacturing industry. By including agricultural R&D expenditures, extension expenditures and education as explanatory variables, Griliches (1963, 1964) was able to explain shifts in agricultural output over time.

The inclusion of the logarithms of R&D and extensions (T) to the basic Cobb Douglas production function gives the following equation:

$$LQ = L_{\alpha 0} + {}_{\alpha 1}LX_1 + {}_{\alpha 2}LX_2 + \ldots {}_{\alpha n}LX_n + {}_{\alpha t}LT \quad (1)$$

The preferred functional form is linear in logarithms, so that the coefficients can represent the elastities.

The analysis follows the structure of the simple production function model of Cobb Douglas to assess the returns to research expenditure. In line with other production function models of the Cobb Douglas production function, this analysis uses yield as the dependent variable. The plot of the wine grape yields in Figure 5.1 shows no substantial increase in yield over the period 1987-1997. Thus implying that technological effects on wine grapes have at best been minimal.

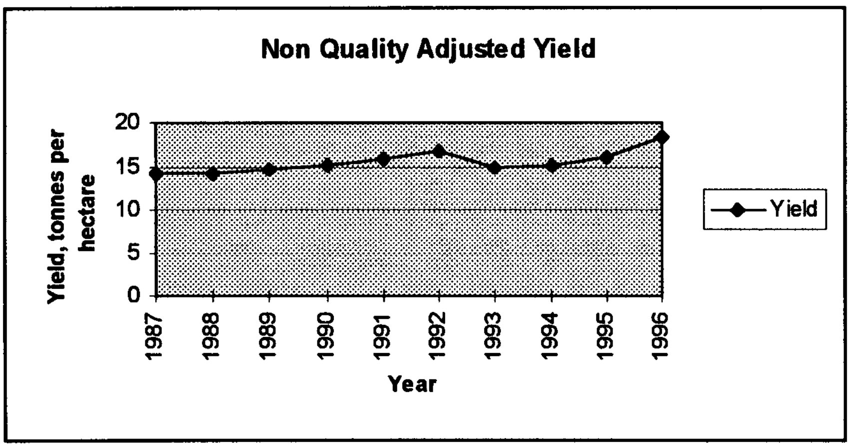

Fig 5.1: Yield index excluding a quality component.
Source: Townsend and van Zyl (1997).

However, in line with most crops, research is also focused on increasing the quality of the product as opposed to concentrating solely on the yield. In order to capture this improvement, the yield series is quality adjusted. A quality-adjusted yield index was created by taking into account the increasing proportion of good wine produced, in comparison to the total wine grape crop. In other words, the value of good wine is divided by the total value of wine. Thus an increase in the ratio of good wine to total wine reflects higher quality. This index is then normalised to one in 1987, and multiplied by the yield to derive a quality adjusted yield index. The resulting quality adjusted series is shown in Figure 5.2. The series increases at a much faster rate than the unadjusted yield.

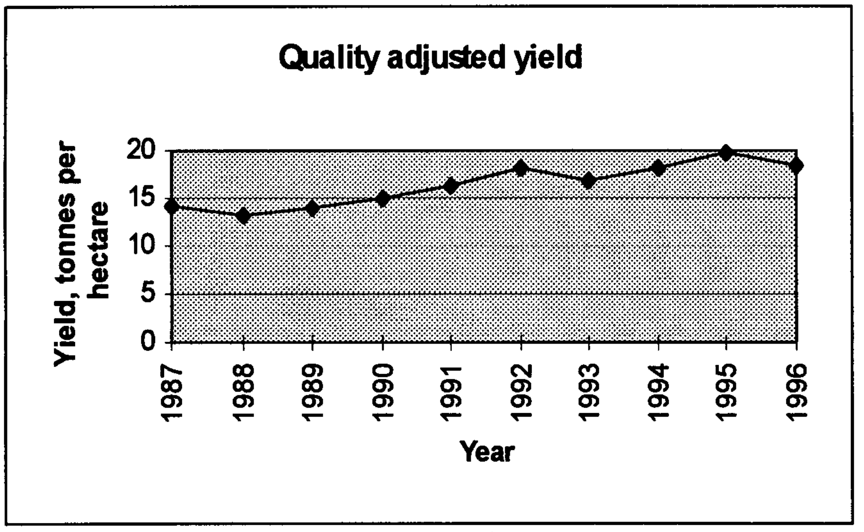

Fig 5.2: Yield index including a quality component.
Source: Townsend and van Zyl (1997).

This study, using the production function approach, attempts to quantify the effect of past research expenditures on cover crop management on quality adjusted yield. In the model variations in yield is explained using weather and research expenditures. Inputs such as fertiliser may be expected to effect yield, but due to degrees of freedom problems, all conventional inputs are however excluded from this analysis.

5.2.1. Data and lag structures

The data used in this section is mainly from the Abstract of Agricultural Statistics (Republic of South Africa, 1996), but was supplemented by unpublished information from the Department of Agriculture and the Weather Bureau, KWV and the ARC's Research Institute for Fruit, Vine and Wine (Nietvoorbij). Both KWV and the Nietvoorbij institute are responsible for the bulk of the R&D and extension within the wine and grape industry. However, most of the research on wine grapes is conducted at the Nietvoorbij institute, while extension is conducted by the KWV. R&D expenditures include cover crop management expenditures, which will be targeted in this analysis.

There is usually a lag between R&D expenditures and productivity growth. Because lagged values of R&D are likely to be highly correlated, and use up to many degrees of freedom in the econometric estimation, a distributed lag structure is assumed. This is normally an inverted V or a second degree Almon polynomial lag, which is an inverted U-shape. The underlying reasoning is that the average R&D expenditure has little immediate effect. On average, the peak effect on productivity is about 4 to 8 years after expenditure, and then the effect declines until it reaches zero after some 8 to 16 years, when technology generated is superseded and becomes obsolete (Khatri *et al.*,1995).

5.2.2. Modelling the lag structure of R&D expenditures

To avoid the collinearity problem of the unrestricted lag model, a common approach is to use an Almon Polynomial lag (Evenson, 1967; Knutson and Tweeton, 1979; Doyle and Ridout, 1985; Thirtle and Bottomley, 1989). The polynomial form is popular due to its empirical simplicity, providing a smooth and feasible form. However, the specification may require restrictions. As a result these models may lead to biased estimates of the effects of research spending (Hallam, 1990). Thus, the less restrictive forms such as the beta and gamma distributions were also tried to avoid such biased estimates.

The appropriate lag structure used in the analysis is given by the equation below:

$$LnYield_t = Ln_{\alpha o} + Ln_{\alpha 1}WEATHER + \sum_{i=1}^{n} \beta_i LnRD_{t-1} + u_t \qquad \textbf{(2)}$$

Where yield is in tons per hectare of wine grapes, RD is the research expenditure of Nietvoorbij and Weather is the weather index. While the rate of returns calculation in this paper is made on the basis of estimating equations that do not include conventional inputs (Akgungor et al., 1996), Alston et al (1995), argue that the conventional inputs should normally be included. Exclusion could bias the R&D elasticity upwards and inflate the ROR.

Estimation of the lag coefficients of R&D expenditures using an unrestricted form with many lag terms gives positive and negative coefficients because of collinearity problems, but providing that the OLS assumptions are satisfied, the sum of the unrestricted lag coefficients should be an unbiased estimate of the total elasticity. The polynomial form used for the supply function is popular due to its empirical simplicity. The advantage of the polynomial form in this situation is that it saves the degrees of freedom. For a second-degree polynomial, irrespective of the number of lags of R&D included, only three degrees of freedom are used.

The polynomial lag model was estimated with no restrictions, near end, far end and both end points restricted to equal zero. These restrictions were applied to second, third and fourth order polynomials for a range of lag lengths, using the Akaike and Schwarz as the model selection criteria. For the quality adjusted yield equation, these criteria indicated the second-degree polynomial lag with both end point restrictions preferred, and a lag of eight years. In the case of cover crop management expenditures, a small proportion of total R&D expenditures, the lag preferred was a lag of six years. The lag of eight years is a relatively short period for agricultural research, and illustrates the degree to which the minimum tillage practise has effect on the production of the vine.

5.2.3. Estimation and results

To determine the returns to cover crop management research expenditures two separate methods were applied. Using the production function approach two models were estimated using ordinary least squares (OLS) to determine the impact on yield of cover crop management expenditures. In the first model, yield is explained using two sets of R&D expenditures. The first R&D series is the total institute R&D expenditures exclusive of cover crop management expenditures, and the second is the total cover crop management expenditures. The following equation is estimated using OLS.

$$\ln Y = \ln \alpha_0 + \alpha_1 \ln(RD_{total} - RD_{cc}) + \alpha_2 \ln RD_{cc} + \alpha_3 W + u_t \quad (3)$$

Where RD_{total} is total institute R&D expenditures, RD_{cc} is cover crop management expenditures and W is the weather index. The coefficients on the cover crop management expenditures, which are the elasticities, are used to calculate a rate of return on cover crop management expenditures. Both research expenditures were significant in explaining variations in yield over time. The sum of coefficients for the lagged R&D expenditures on cover crop management is 0.0002 as opposed to the sum of coefficients from total R&D expenditures exclusive of cover crop expenditures which is 1.5. This reflects the small proportion of research expenditures devoted to cover crop management, about 2 percent of total research expenditures in 1996. The results are reported in Table 5.1.

Table 5.1: Results: Method One

Dependent Variable: Yield Adjusted R-Squared: 0.96 DW: 2.2 F-statistic: 77				
Var.	**Constant**	**Weather**	**Rdtot-cc**	**RDcc**
Coeff.	-20.99	1.32	1.54	0.00022
t-stat	-12.49	5.04	13.22	6.419

The second model estimates three separate equations. First, yield is explained using the total institutes R&D expenditures including expenditures on cover crop management and the weather. Equation (4) is estimated using ordinary least squares and R&D expenditures are modelled using a second-degree polynomial with an eight-year lag. Then in a second equation, yield is explained using total R&D expenditures exclusive of expenditures on cover crop management and the weather. Equation (5) is estimated using ordinary least squares and R&D expenditures are modelled using a second-degree polynomial with an eight-year lag. The difference in the residuals from equation (4) and (5) is thought to capture the effect of cover crop management expenditures on yield. This difference in residuals is then explained in equation (6) using cover crop management expenditures and weather. The coefficients on cover crop management expenditures from equation (6) are then used to calculate a rate of return on cover crop management expenditures.

$$\ln Y = \ln \alpha_0 + \alpha_1 RD_{total} + \alpha_2 W + u_t \qquad (4)$$

$$\ln Y = \alpha_0 + \alpha_1 (RD_{total} - RD_{cc}) + \alpha_2 + u_t \qquad (5)$$

$$\mathrm{Re}\,sid = \alpha_0 + \alpha_1 W + RD\mathbf{cc} \qquad (6)$$

Where RD_{total} is total institute R&D expenditures, RD_{cc} is cover crop management expenditures and W is the weather index. The weather index has been obtained from the KWV and is based on rainfall and temperature conditions. The coefficients on the cover crop management expenditures, which are the elasticities, are used to calculate a rate of return on cover crop management expenditures. Both research expenditures were significant in explaining variations in yield over time. A 1 percent increase in total research expenditures resulted in a 1.785 percent increase in Yield while a 1 percent increase in total research expenditures exclusive of cover crop management expenditures resulted in a 1.5 percent increase in Yield. The coefficient achieved for RD_{TOT-CC} of 1.54 is outside the rational region and therefore casts a certain doubt over the result achieved. On the other hand the result achieved for RD_{cc} occurs between this region. The sum of coefficients for the lagged R&D expenditures on cover crop management is 0.00022. This once again reflects the small proportion of research expenditures devoted to cover crop management, about 2 percent of total research expenditures in 1996. The results are reported in Table 5.2.

Table 5.2: Results: Method Two

Dependent Variable: Yield **Adjusted R-Squared: 0.77** **DW: 1.4** **F-statistic:** 16				
Var.	**Constant**	**Weather**	**Rdtot**	**RDcc**
Coeff.	-18.27	0.29	1.78	
t-stat	-4.71	0.66	5.50	
Dependent Variable: Yield **Adjusted R-Squared: 0.74** **DW: 1.51** **F-statistic:** 14				
Var.	**Constant**	**Weather**	**Rdtot-cc**	**RDcc**
Coeff.	-14.84	0.1	1.55	
t-stat	-4.14	0.22	5.13	
Dependent Variable: Residual **Adjusted R-Squared:** 0.18 **DW:** 0.78 **F-statistic:** 2				
Var.	**Constant**	**Weather**	**Rdtot-cc**	**RDcc**
Coeff.	-0.52	0.1		0.0002
t-stat	-1.64	1.6		1.99

5.2.4. Calculating the rate or return

Thus, the lag structure in the polynomial model identifies the effects of changes in R&D expenditures on wine grapes and can be used to calculate rate of return. The elasticities then have to be converted to a value of marginal products. Each lag coefficient, B_i is the output elasticity of R&D for that year:

$$\beta_i = \frac{\partial \ln YIELD}{\partial RD_{t-1}} \cdot \frac{RD_{t-1}}{YIELD} \qquad (7)$$

Thus, the marginal physical product of R&E is the elasticity multiplied by the average physical product.

$$MPP_{t-i} = \frac{\partial YIELD_t}{\partial RD_t} = \beta_i \frac{YIELD_t}{RD_{t-i}} \quad \textbf{(8)}$$

Replacing $YIELD/RD_{t-i}$ by its geometric mean, and changing from continuous to discrete approximations gives the marginal physical product

$$\frac{\Delta YIELD_t}{\Delta RD_{t-i}} = \beta_i \frac{\overline{YIELD}}{\overline{RD_{t-i}}} \quad \textbf{(9)}$$

Then, multiplying by the average price converts to output value terms. Thus, the value marginal product of R&E in period *t-i* can then be written as

$$VMP_{t-1} = \frac{\Delta VALUE_t}{\Delta RD_{t-1}} = B_t \frac{\overline{YIELD}}{\overline{RD_{t-1}}} \cdot \frac{\Delta VALUE_t}{\Delta YIELD} \quad (10)$$

where $YIELD/RD_{t-i}$ is an average and $\Delta VALUE_t / \Delta YIELD_t$ is the average of the last five years minus the average of the first five years, for both variables. Thus, these are constants, but b_i varies over the lag period, giving a series of marginal returns resulting from a unit change in R&E expenditure. The value of output, $\Delta VALUE_t / \Delta YIELD_t$ is the geometric mean calculated using the value of output. Similarly, $YIELD/RD_{t-1}$ is a constant-price geometric average. The marginal internal rate of return (MIRR) is calculated from equation (7),

$$\sum_{i=1}^{n} \frac{VMP_{t-i}}{(1+r)^i} - 1 = 0 \quad (11)$$

where n is the lag length, by solving for r.

The MIRR calculated using the PDL lag structure is 44 percent using the preferred method. The coefficients used to estimate the rate or return to cover crop management research expenditures were those from the second method of determining the effect of research expenditures on cover crop management. This involved explaining residuals using cover crop management expenditures. Note that at the crop level there are no net output measures, such as net farm income. The value used is the gross value of output, without the value of inputs being netted out. This can be done if there is gross and net margin information that is representative of the whole country and consistent over the period. Net returns, calculated in this way would be lower, but still prove to be substantial.

5.3. Cost benefit approach

The production function approach used above takes into account the total cost of research in the wine industry, the relevant minimum tillage research costs and the weather as a function of the industry yield. The cost of the research therefore acts as a proxy for the contribution that minimum tillage research has made toward yield. There is however no reference made to the actual results achieved from the minimum tillage projects. The emphasis is thus placed on the cost of the research, and not the potential thereof, thus negating a realistic evaluation of the research conducted. Considering that the minimum tillage research makes up only two percent of the total wine industry research costs, the use of industry yield data allows for the focus of the study to be lost. The production function approach attempts to assess the value of a micro-level study using macro-level data. The cost benefit approach however allows for the trial plot data to be considered, giving a more virtual approach to the analysis. In addition to this, the approach will only consider the returns for Chenin Blanc vineyards, based on the fact that all 11 projects were conducted on Chenin Blanc or Colombar vineyards. The production of Colombar and Chenin Blanc are similar and therefore considered as a homogenous product for the purpose of this study.

The economic surplus approach referred to in Chapter Two, makes use of the net summation of producer and consumer surplus that is induced by a technology shift in the supply curve. Based on this it was decided to use a cost benefit approach that resulted in a summation of the costs and benefits of each year for a specified time period. The net benefit/loss for each year is then discounted and an internal rate of return for the entire period is determined. The cost data are collected by the means stipulated in Chapter Three and the source of the benefit data is taken from the trial plot data.

The benefit data will be retrieved from two specific cover crop projects, highlighting the varied response of cover crops exposed to irrigated and dry land conditions. The cost data will include all 11 of the research projects relevant for the cover crop research, based on the fact that all the projects whether successful or not, are interrelated and have some relevance on the present-day cover crop research practices.

The use of trial plot data has the potential to draw a certain amount of criticism due to the controlled nature of research. These projects under review were however conducted in areas that are representatives of the wine growing regions, and therefore subjected to similar environmental forces. Furthermore, the use of trial plot data negates the need to consider weather as having an influence on the yield, as the realised increase in output is a direct comparison between the clean tillage and cover crop minimum tillage practices. These comparisons are taken from results of the same projects, thus being subjected to the same environmental factors. The quantitative benefits of the research are represented by the increase in output which is retrieved from the trial plot data, and averaged to arrive at a value which indicates the increase in output that can be attributable to the variant in the trial. Furthermore, the benefit data will also account for the cost savings that result from the use of the new technology. The trial plot results show other benefits in the form of improvements in the quality of the produce, the reduction in soil erosion, and the improvement in water infiltration. These benefits will not be quantified in this approach because of the indirect contribution that they will make to the increase in the output factor. The exclusion of these benefits may result in the underestimation of the benefits of the technology.

5.3.1. The cost of cover crop research

5.3.1.1 Research costs

As was pointed out in Chapter Three, cover crop research comprises of a number of different individual projects dating back to 1969. The "sunk costs" prior to this date are deemed inaccessible due to the lack of available information, and therefore limit the cost data to the years between 1969 and 1996. As is evident from Appendix 3 the costs of the research have steadily increased as the number of projects running concurrently have increased and inflation has had an effect on the cost thereof.

The costs related to the research include the salaries and benefits of the researchers and applicable support staff, depreciation, set-up costs, overheads and administration, and the running costs of each project. Furthermore, an attempt was made where possible to account for any unexpected costs that may have occurred. The methods used for collection of these values have been identified in Chapter Three. The overhead cost attributable to the ARC Headquarters and the extension costs relevant for the distribution of the research information is deemed negligible and excluded from the study.

5.3.1.2. Resultant benefits

The benefits that have resulted from the research conducted on cover crops have been highlighted in Chapter Three. For the purpose of the cost benefit analysis only two of these benefits will be used to determine the internal rate of return, namely the increase in yield and the cost saving on inputs which is evident from the trial plot data. The improvement in the quality of wine will be taken into account by the break down of the total annual wine into the two categories of resultant produce, namely good and distilled wine. The quality-associated benefits take the form of higher achievable prices for better quality wines. Table 1.5 illustrates how production has shifted away from the poorer quality wines and moved toward the production of noble wines. The improvement in the sustainability of the vineyard will partially be taken into account by the increase in yield that is evident, for a prolonged period of time, thus contributing to an increase in the average yield achieved from the trial plot. The extended life span of the vineyard will however not be considered in this method of analysis, which may again result in the underestimation of the benefit data. Furthermore, it has been assumed that the additional visible benefits such as the improvement in nutrient retention, the reduction in soil erosion and water runoff and the reduction in soil compaction can be accounted for by the increase in yield and the improved percentage of good quality wine.

The cost saving benefit will result from the fewer number of tractor trips and reduced herbicide usage. The cost of the seed for the cover crop is out-weighed by the extra number of tractor trips that are needed for soil tillage and weed control. The use of cover crops will also have an environmental benefit in the reduced herbicide use that is associated with this technology.

The resultant benefits will thus be calculated using the increase in production yield, the reduction in input costs, the adoption rate of the technology, the allotment between dry-land

and irrigated vineyards, the break-down of wine produce into the different quality categories and the industry price of the produce. A thorough description will be given at a later stage.

5.3.2. Adoption rate of technology

The Department of Sociology at the University of Stellenbosch conducted a survey with the aim of determining the extent to which the changes in the agricultural set-up have influenced the farming methods of farmers in the Western Cape. A number of relevant questions for cover crop research were included in the survey, so as to attempt to establish what the adoption rate of cover crop technology has been. The questions asked sought to establish if the farmer used the relevant technology, and if so, for how long. Three farming districts in the Western Cape were surveyed, namely Wellington, Robertson and the Olifantsrivier. A summarised table of the results is given below.

Table 5.3: Adoption rate of cover crop technology

District	Mean Usage	Yes	No	Total
Wellington	14 yrs	15	13	28
Robertson	15 yrs	10	19	29
Olifantsrivier	19 yrs	26	21	47
Total	**16 yrs**	**51**	**53**	**104**

The findings of the survey concluded that approximately 49 percent of the producers questioned had used the cover crop technique at one time or another. Table 5.3 indicates that on average, cover crop techniques have been used since 1982, which could prove significant considering that the first publication resulting from the initial cover crop project was published in 1980. This is however only an average and in the case of an adoption, will prove to be useless. Therefore, for the purpose of the cost benefit approach an adoption per year will be used, starting from the date of the first publication in 1980. As will be shown later the cover crop technique had been used for many years prior to this date, but could not be attributed to the findings of the relevant research.

The results from the survey showed that some of the producers had first used the technique almost 50 years ago. The actual percentage adoption of producers per year for all cultivars and for Chenin Blanc vineyards is indicated in Figure 5.3 below. The first minimum tillage project in South Africa was started in 1970 and ran for approximately eight years. Preliminary results of the trial would have been available at an earlier stage than 1980 and could have been extended to the producers through farmer days and verbal communications. Thus it is not unrealistic to assume that producers who adopted the technology prior to 1980 would not have done so as a result of the research conducted. The years prior to 1980 have however not been included in the cost benefit analysis, so as to maintain a fixed starting point. Producers who used the techniques prior to 1970 may have acquired the knowledge through international spill over effects, and are also not included in the analysis.

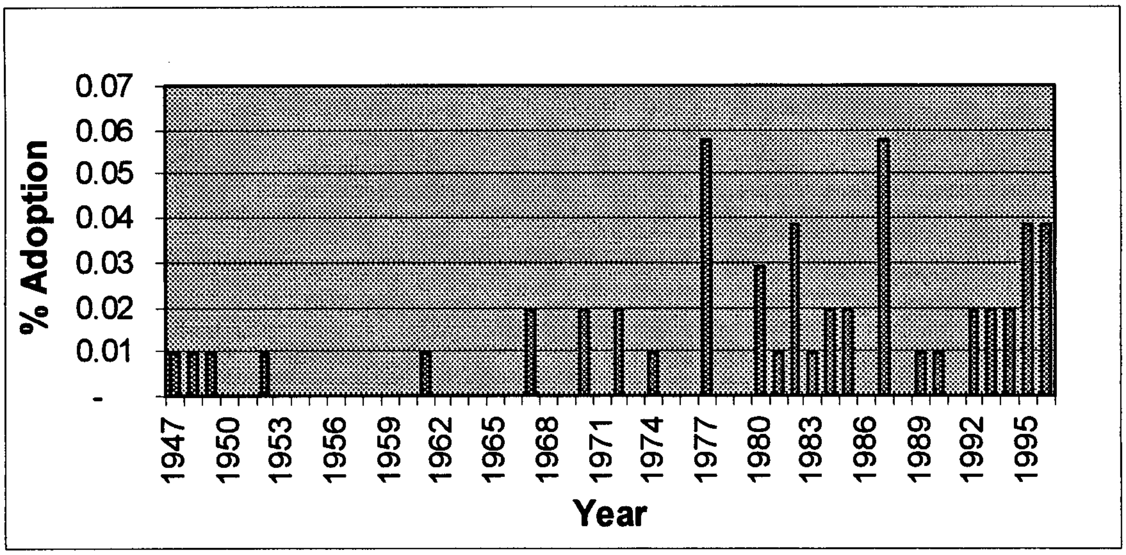

Figure 5.3. Adoption of cover crop practices per year

The six-percent adoption in 1977 is an extremely high adoption to be attributed to international spillover, and could be as a result of the research conducted. It is however prior to the publication of the first article regarding the technology generated from the research, and therefore not included.

The survey was conducted amongst a random sample of producers within the three farming districts, and is deemed representative of the industry. The fact that producers generally have a range of cultivars on their farms negates the need to adapt the adoption rate to account only for Chenin Blanc vineyards.

For the purpose of the cost benefit analysis an adoption rate is therefore needed from 1980, the adoption prior to this year will be excluded from the analysis for the reasons mentioned above. Therefore for each year after 1980 an accumulated adoption will be used in determining the returns to investment. This is indicated in Figure 5.4.

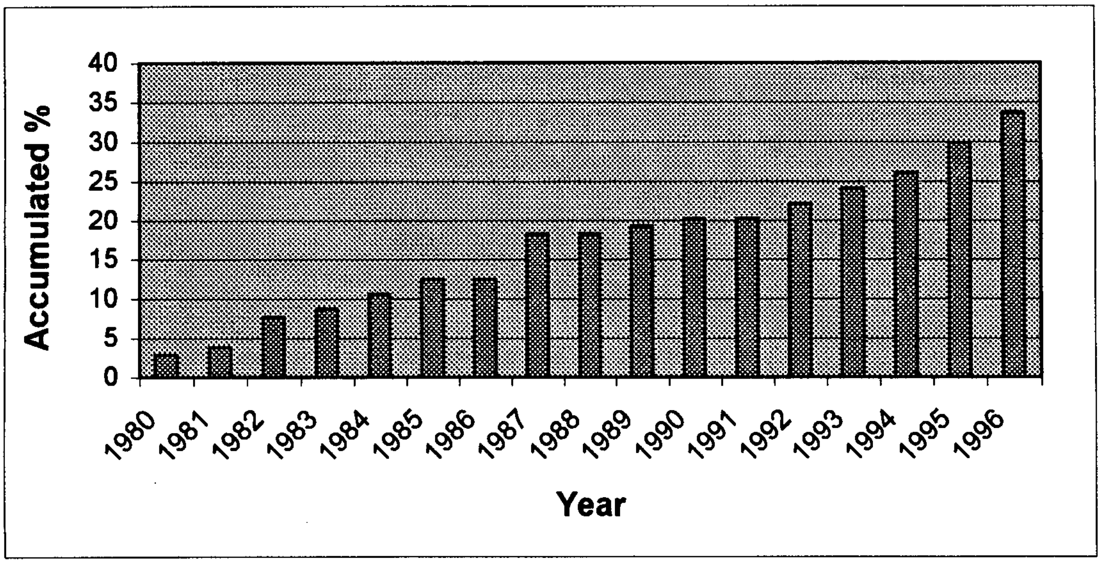

Figure 5.4. Accumulated adoption of cover crop practices

Figure 5.4 highlights the fact that approximately 33 percent of the producers have adopted the technology since 1980. The producers who adopted the technology prior to this year amount to approximately 16 percent, which could be as a result of international research spillover, private research and the interaction between the researcher and farmer on a personal level.

5.3.3. Discount rate

The cost and benefit data retrieved needs to be adjusted to account for an appropriate discount rate. This will ensure that the cost and benefit values compared are considered in the same time frame. The discount rate can be calculated using the following formula (Johnston, et al, 1992):

$$r = [(1 + n) / (1 + \text{inflation rate})] - 1$$

where r = real discount rate

n = nominal discount rate

The nominal discount rate can be established by referring to the bank rate used by banks, which was 16 percent on average for the 1996/97-book year. The estimated inflation rate for the same period is 8.5 percent. The resultant discount rate is 7 percent.

5.3.4. The approach

The cost benefit approach is broken down into two sections. Firstly, the analysis is conducted using industry related Chenin Blanc and cost data. Secondly, the analysis is conducted using the relevant data for two specific growing regions, namely Stellenbosch and Robertson. The reasons for the distinction between the regions is that the former area is predominantly a dry land region and the latter an irrigated region.

5.2.4.1. Total South African Chenin Blanc production

The cost benefit approach for this particular study will be split into two initial components, namely the cost component and benefit component. The cost component comprises of the collection of the relevant costs for each year, resulting in a time series of costs dating back to 1969, removing the effect of inflation and including the discount rate to account for the time value of money factor. This would result in a cost per year and a total cost in 1996 monetary terms. The cost benefit flow of the approach is tabled in Appendix 7.

The benefit component poses a different problem in that the results retrieved from the trial plot need to be processed into monetary terms, so as to be comparable with the cost component. It was therefore decided to start the calculation using a known entity, namely the total output (in tons) of Chenin Blanc grapes. This information was retrieved from the KWV statistical yearbook.

The varied response of the cover crop treatment with regards to irrigated and dry land vineyards created the need to split the tonnage into the two components. This was achieved by firstly determining the breakdown between irrigated (71%) and dry land (29%) Chenin Blanc vineyards in South Africa. Together with the per/ha breakdown it was determined that irrigated vineyards produce on average three times as much output as dry land vineyards, thus arriving at a breakdown percentage between irrigated and dry land vineyards of 21/24 and 3/24 respectively. The ratio of 24:8 for irrigated versus dry land production is liable to come under a certain amount of criticism, due to the varied production, which is achieved from the widespread production areas in South Africa. The difficulty arises as a result of the fact that in the Stellenbosch area for instance, the irrigated tonnage may reach 11 tons/ha, whereas the dry land tonnage only 6 tons/ha. In the Upington area however the irrigated tonnage may reach levels as high as 45 tons/ha. The dry land tonnage is however unknown because production does not occur without irrigation in that area. On average therefore specialists have indicated a ratio of between 22-26:6-10, thus arriving at an average of ratio of 24:8. This ratio is however a subjective assumption, and should be considered in that light. An attempt will be made at a later stage to split the production areas into separate cost benefit analyses.

The trial plot data retrieved from the two respective projects showed that the presence of a cover crop increased the output per hectare under irrigated conditions by 5 percent and 20 percent under dry land conditions. It was necessary at this stage to assume an adoption of 100 percent, allowing for the full increase in production to be removed from the output volumes. The methodology behind this strategy is based on the "with" and "without" technology means of project evaluation. The difference between the "with" technology and "without" technology would therefore be the increase in production, which could be attributed to the use of cover crops (assuming 100 percent adoption).

Taking into account that an annual adoption rate has been determined, the increase in production achieved could then be adjusted to consider the accumulated adoption per year. The adoption per year must however include a time lag factor for both the irrigated and dry land components of the analysis. The time lag used in the production function analysis is six years, based on a second-degree polynomial lag with both end point restrictions. For the purpose of the cost benefit approach, the trial plot data were utilised for an appropriate lag time for both the irrigated and dry land projects. In the case of the dry land conditions the results showed that the increase in production occurred in the first year of production. This can effectively be attributed to the improved water retention capabilities of the soil and the reduction in weed competition for available nutrients. The other beneficial factors mentioned above (sustainability, soil erosion, soil structure) are all factors which will have an effect in the longer term.

In the case of the irrigated trial the effects were not immediate, as the impact of the water retention factor was minimised by the irrigation. The yields did however show an improvement after the fourth year of production, in comparison with the clean cultivation method of tillage. The adoption factors per year were therefore adjusted to account for the time lags, and a total increase in production in tons per year was determined. The short lag times used in this analysis are consistent with the study by Townsend and Van Zyl (1997), who evaluated the rate of return to research investment in the wine industry.

In attributing a numerical value to the increased tonnage achieved above, the increase in production is converted into litres of must. This was achieved by using the average yield in litres per year taken from the KWV statistical yearbook. From this the increase in litres per year attributed to the cover crop techniques was achieved. The litre values were then broken down into good and distilled wine categories, based on the percentage breakdown of total wine production per year. The "total payment to producers" price for the different category wines was then used to convert the litres into a monetary value. The prices used were adjusted to account for inflation, using the P.P.I. index for wine products.

The projected benefit contribution, expressed in real terms, was adjusted by a factor that included the effect of time preference. The discount rate of seven percent was used for this purpose. The process was conducted for each year from 1980 through to 1996. The real cost values were then included into the calculation and the resultant difference achieved per year.

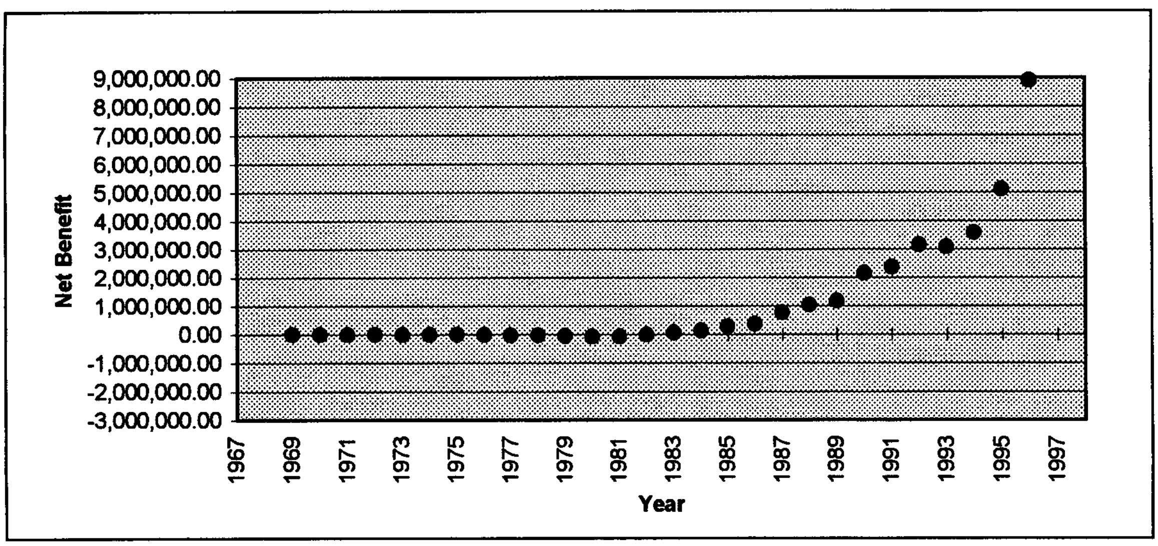

Figure 5.5 Net benefit flow.

The net benefit/loss achieved is shown in Appendix 8. The rate of return (ROR) for the annual capital flow showed a rate of return of 37 percent on investment. This ROR is a great deal higher than the opportunity cost of capital, indicating that the research investment has proven profitable for the industry. The NPV at discount rate of 7 percent is R5.6 million (1996 constant values). Table 5.2 illustrates the results achieved.

Table 5.4. Financial analysis for total Chenin Blanc production

Year	Total Cost (R)	Total Benefit (R)	Net Benefit (R)	Accumulated Net Benefit (R)
1969	936.133	0	(936.133)	(936.133)
1970	1,882.260	0	(1,882.260)	(2,818.392)
1971	3,222.958	0	(3,222.958)	(6,041.351)
1972	8,055.721	0	(8,055.721)	(14,097.071)
1973	11,001.253	0	(11,001.253)	(25,098.324)
1974	11,768.365	0	(11,768.365)	(36,866.690)
1975	17,574.477	0	(17,574.477)	(54,441.167)
1976	17,839.320	0	(17,839.320)	(72,280.486)
1977	41,505.797	0	(41,505.797)	(113,786.283)
1978	34,973.019	0	(34,973.019)	(148,759.302)
1979	52,374.757	0	(52,374.757)	(201,134.059)
1980	98,078.623	40439.762	(57,638.862)	(258,772.921)
1981	103,233.032	45388.607	(57,844.425)	(316,617.346)
1982	102,155.674	112937.015	10,781.341	(305,836.005)
1983	104,865.340	174971.130	70,105.790	(235,730.215)
1984	66,574.968	224964.817	158,389.849	(77,340.366)
1985	88,734.755	377891.928	289,157.173	211,816.807
1986	100,981.430	470541.736	369,560.306	581,377.113
1987	101,785.176	917960.828	816,175.653	1,397,552.766
1988	72,809.840	1154591.191	1,081,781.351	2,479,334.117
1989	118,927.141	1376345.733	1,257,418.592	3,736,752.709
1990	214,304.563	2389441.809	2,175,137.246	5,911,889.955
1991	469,912.993	2857468.302	2,387,555.309	8,299,445.264
1992	374,632.662	3594674.932	3,220,042.270	11,519,487.534
1993	416,258.453	3583182.939	3,166,924.486	14,686,412.020
1994	221,665.245	3918494.594	3,696,829.349	18,383,241.368
1995	253,621.110	5568089.185	5,314,468.075	23,697,709.443
1996	359,721.738	9678872.561	9,319,150.824	33,016,860.267
			IRR	37%
			NPV @ (6%)	R7,631,265.53
			NPV @ (7%)	R6,036,281.52
			NPV @ (8%)	R4,786,597.27

5.2.4.2. Region specific analysis

In order to illustrate the importance of making the distinction between the irrigated and dry land research results, an analysis using a similar approach as the one used above was conducted using two growing regions. The variance between the two regions stems from the difference in the percentage of irrigated and dry land vineyards. The Stellenbosch region is estimated to be 45 percent irrigated and the Robertson area is 99 percent irrigated.

5.2.4.2.1. Methodology

The approach is similar to that used above for the total Chenin Blanc production analysis, but will need to be adjusted to account for the region specific data. The adjustments are the same for both regions and will be considered at the same time. Firstly, total tonnage of Chenin Blanc grapes had to be estimated for the Stellenbosch and Robertson regions, which was obtained from the KWV. Secondly, a new ratio had to be determined splitting irrigated and dry land vineyard production. The average harvest achieved for dry land vineyards in the Stellenbosch region is seven tons/hectare, and for irrigated vineyards 12 tons/hectare. Therefore, together with the acreage split of 45 percent irrigated and a 55 percent dry land vineyard, a split of 58 and 42 percent were achieved for the irrigated and dry land breakdown respectively. A similar approach for the Robertson region, using a ton per hectare split of 40 and 10 for irrigated and dry land, was used and achieved a 99 and one percent split respectively.

Thirdly, the revenue saved from using the technology needed to be included in the analysis. This was achieved by determining the total hectares under Chenin Blanc in the two regions, applying the relevant adoption rate, and arriving at the total hectares of Chenin Blanc vineyards under cover crop practices. The capital saved per hectare was then used to determine the total revenue saved. The calculation arriving at the cost savings for the two regions is shown in Appendix 5 and 6.

Lastly, the cost data had to be adjusted to reflect the cost attributed to the specific regions. This was achieved by determining the contribution that each region made toward the total industry production, and using the percentage to determine the proportion of the total research cost which could be allocated to the specific regions. The lack of available data once again required that certain values needed to be estimated.

5.2.4.2.2. Results of region specific analysis

The results achieved are in line with the theoretical understanding of the research, in that the use of cover crop practices has shown to be more effective under dry land conditions. The reason being that the inter-row crop has the ability to prevent water runoff, thereby improving water retention and reducing nutrient loss. This would therefore explain the three percent internal rate of return achieved for the Robertson region, and the 25 percent internal rate of return achieved for the Stellenbosch region.

The higher production per hectare of the Robertson region is outweighed by the superior research results achieved for the dry land vineyards. Diagrammatic illustrations of the results achieved are shown in Table 5.5 and 5.6 below. The financial cost benefit flow of the two regions is illustrated in Appendix 9 and 11. The net benefit flow chart for the two regions is shown in Appendix 10 and 12.

Table 5.5. Financial Analysis for Chenin Blanc Production in the Robertson Region

Year	Total Cost (R)	Total Benefit (R)	Net Benefit (R)	Accumulated Net Benefit (R)
1969	141.356	0	-141.356	-141.356
1970	287.986	0	-287.986	-429.342
1971	489.890	0	-489.890	-919.231
1972	1200.302	0	-1200.302	-2119.534
1973	1661.189	0	-1661.189	-3780.723
1974	1706.413	0	-1706.413	-5487.136
1975	2618.597	0	-2618.597	-8105.733
1976	2711.577	0	-2711.577	-10817.310
1977	6391.893	0	-6391.893	-17209.202
1978	5315.899	0	-5315.899	-22525.101
1979	8118.087	0	-8118.087	-30643.189
1980	15496.422	0	-15496.422	-46139.611
1981	15175.256	167.565	-15007.691	-61147.302
1982	14608.261	182.107	-14426.155	-75573.457
1983	16463.858	351.673	-16112.185	-91685.642
1984	9853.095	3520.203	-6332.893	-98018.535
1985	12777.805	3848.342	-8929.463	-106947.997
1986	16560.955	10504.712	-6056.242	-113004.240
1987	17099.910	15809.562	-1290.347	-114294.587
1988	12159.243	18454.350	6295.107	-107999.480
1989	18790.488	20082.182	1291.693	-106707.787
1990	33217.207	38703.740	5486.533	-101221.254
1991	73306.427	44762.626	-28543.801	-129765.056
1992	63312.920	55181.506	-8131.414	-137896.469
1993	73677.746	71286.350	-2391.396	-140287.865
1994	38791.418	72977.844	34186.426	-106101.439
1995	43369.210	110078.205	66708.995	-39392.444
1996	57195.756	161905.748	104709.992	65317.548
			IRR	3%
			NPV @ (6%)	(R19,206.05)
			NPV @ (7%)	(R21,445.87)
			NPV @ (8%)	(R22,494.70)

Table 5.6. Financial Analysis for Chenin Blanc Production in the Stellenbosch Region

Year	Total Cost (R)	Total Benefit (R)	Net Benefit (R)	Accumulated Net Benefit (R)
1969	114.676	0	-114.676	-114.676
1970	233.400	0	-233.400	-348.076
1971	396.424	0	-396.424	-744.500
1972	986.826	0	-986.826	-1731.326
1973	1342.153	0	-1342.153	-3073.479
1974	1423.972	0	-1423.972	-4497.451
1975	2117.724	0	-2117.724	-6615.176
1976	2158.558	0	-2158.558	-8773.733
1977	4939.190	0	-4939.190	-13712.923
1978	4196.762	0	-4196.762	-17909.685
1979	6127.847	0	-6127.847	-24037.532
1980	11377.120	3776.058	-7601.062	-31638.594
1981	12800.896	3405.228	-9395.668	-41034.262
1982	13995.327	11601.437	-2393.891	-43428.152
1983	14786.013	15186.468	400.455	-43027.698
1984	8321.871	14300.009	5978.138	-37049.560
1985	12511.600	22441.453	9929.852	-27119.708
1986	12420.716	24444.261	12023.545	-15096.163
1987	11908.866	42721.047	30812.182	15716.019
1988	8445.941	48782.609	40336.668	56052.687
1989	14865.893	72043.548	57177.656	113230.343
1990	27645.289	104399.317	76754.028	189984.371
1991	58269.211	110367.922	52098.711	242083.082
1992	44581.287	148520.121	103938.834	346021.916
1993	51199.790	139817.328	88617.538	434639.455
1994	21723.194	116176.374	94453.180	529092.634
1995	26883.838	190905.942	164022.104	693114.739
1996	37770.782	396047.789	358277.006	1051391.745
			IRR	25%
			NPV @ (6%)	R232,185.97
			NPV @ (7%)	R181,501.40
			NPV @ (8%)	R141,981.14

5.2.5. Conclusion

The study conducted by Townsend and Van Zyl (1997) uses a production function model to estimate the returns to investment in the wine industry. The data collected for the analysis was limited to that retrieved from Nietvoorbij, as it was assumed that the private research conducted in the wine industry was negligible and therefore excluded. Therefore the return of between 40 and 60 percent achieved from the study can be representative of the industry, institution and crop level returns on investment in the wine industry. The analysis above is conducted on the project level, and has shown to achieve returns consistent with those achieved in the macro-level studies, maintaining a good record of returns for the industry.

The similarity of the results achieved from the two methods of analysis used above goes along way in cementing a certain amount of credibility to the results achieved. However, the production function method, which achieved a return of 44 percent, uses the cost of the research as a proxy for the change in industry yield. This poses the question of "had the research been unsuccessful, but cost the same as for the projects analysed above, would the returns have been the same?". In other words, does making use of cost data allow for an association with the outcome of the research project. It is true that even a failed research project has some worth to society in that the knowledge gained will prevent future resources from being expended. However, can a research project that results in unique findings be on par with a failed project, because of the cost similarity?

The answer to the above question must be no! The research, which developed high yielding hybrid seed, will have had a far larger impact on society than research which concentrates on maintaining soil fertility for example. This is however not to say that the research which "maintains" rather than "progresses" is not important, but on a monetary basis a difference must occur.

The cost benefit approach therefore attempts to take into account the potential that the results of the research will have on society and the monetary gains that can be achieved. In the case of the region specific study a big difference exists in the results achieved between irrigated and dry land vineyards. This is however not taken into account in the case of the production function approach, but considered in the estimation of the benefit data for the cost benefit approach and evident from the region specific analysis.

Both approaches do however have shortcomings in the methodology and completeness of the data used. The exclusion of the opportunity cost of land, even though deemed negligible in Chapter Four, from both approaches may lead to an over estimation of the returns. In the case of extension, the study conducted by Townsend and Van Zyl (1997) illustrated the effect of extension on the ROR estimations. The quality adjusted yield excluding extension yields a ROR of 61 percent, and the ROR including extension amounts to 45 percent. The inclusion of extension would therefore prove valuable to the result achieved. However in the case of the 11 cover crop related projects conducted from 1969, the adjustment of the extension index used in the study above would be insignificant, whilst a lack of available extension cost data dating back to 1969 exists to collect a true extension cost from the KWV. This will result in a slight inflation of the ROR.

On the other hand the exclusion of the non-quantifiable benefits such as sustainability and the use of environmentally friendly farming techniques, are excluded from the study and will result in an underestimation of the returns. The preferred lag structure will also have an effect on the ROR. In the case of the production function approach, a lag of six years was estimated using a polynomial lag model, which according to the trial plot results should have been one year for dry land vineyards and four years for irrigated vineyards. Therefore in using a six-year lag the resultant ROR would have been underestimated.

Both approaches have their merits and shortcomings, and are stepping stones in the right direction to achieve a more thorough means of analysis. However, there is and will never be one absolute means of analysis because of the lack of holistic historically standard cost and benefit data. In most cases the lack of available and reliable data, forces the analyst into a position whereby it is necessary to adapt the methodology to suit the data, and therefore result in a diversion away from the standard methodology used.

The rate of returns achieved for both the production function and cost benefit methodologies is high enough to warrant an increase in funding for the wine industry. The problem however stems from the fact that the wine industry has historically been a white dominated industry, in terms of both production and consumption. It is true to say that in the past large volumes of wine was consumed by black South Africans, however the problem is that the wine that was being consumed was not the focus of research. The majority of research trends endeavoured only to increase the production of noble red wines and improve the quality for export purposes. The industry will therefore be required to shift its research focus in a more socially accepted direction, with the aim of servicing the entire South African population.

CONCLUSIONS

The post apartheid era in South Africa has witnessed a number of predictable happenings in the wine industry. Firstly, the dropping of sanctions dramatically increased exports as the world reacquainted itself with the taste for South African wines. This increase in demand for good wine saw producers become more quality conscience and resulted in an increase in the production of good quality wines at the expense of average quality wines.

Secondly, the new opportunities which existed for wine produce in the international arena, has had an impact on the manner in which the cooperatives sell their produce. Historically, wholesalers controlled the purchase of wine from the cooperatives, owing to the fact that the local market was stagnant and that no export opportunities existed (Ewert et al, 1998). The new-found demand both locally and internationally, has seen the direct sale of produce by the cooperative on the national and export market. This has had the negative effect of putting strain on the relationship which the producer and cooperative enjoyed in the past. The increased options available to the producer have often resulted in producers moving between the highest bidders.

Thirdly, the conversion of the KWV into a company set the scene for much discussion as the historical controlling body was removed from the picture. The discussions that were to follow centred on how the conversion should be carried out and what the consequences to the industry would be. The details of the conversion are still being discussed, and the consequences will only be known in the future. The duty of the industry is however, to maintain as much control of the future as possible through the continuation of essential functions within the wine industry. These functions include research funding, surplus wine control and the dissemination of industry related information. The breakdown of statutory control within the wine industry will have an enormous effect on the above functions, and it is the responsibility of the industry to ensure that all is not forgotten and discontinued.

Lastly, the need for the Government of National Unity to correct the injustice caused by the apartheid Government of the past, has seen the reduction in state funding for wine industry research. The movement of funds away from this predominantly white orientated industry has resulted in a number of the research institutes having to streamline both staff and facilities. Furthermore, the lack of available funds and the requirement for research themes to be socially acceptable has created the situation whereby researchers should be forced to submit social and financial cost benefit analyses with project proposals. The contribution of research funds by private investors has become of interest to the research institutes, as an alternative source of funding. The attracting of private investors however will require that researchers set-up thorough cost benefit analysis, arriving at possible rate of return on investments. The difficulty with private investment is the matter of securing the benefits back to the investor, and preventing the use thereof by other producers. This problem of free riders can partially be dealt with through the use of patents, but will not stop a neighbouring farmer from seeing what production methods are being exercised in the adjacent fields. Intervention will therefore be required to facilitate the funding of research by private investors.

The above goes so far as to say that the doors of the world have opened for the wine industry, taking into account the improved market opportunities. This will however, only continue if the South African wine industry can compete in the international arena. Therefore, in order to stay ahead, sufficient research will need to be conducted to explore the boundaries of the South African wine industry. Research does however not come cheap, and with the depletion of state funds, the industry will have to turn to the private investor. The majority of research funding will continue to be sourced from the state, it is however the shortcomings which will have to be secured from the private industry. This can be achieved through either the imposition of levies, on bottling or packing material for example, or the direct investment in research by a private investor. In the case of the latter, a private investor will want an estimate of the possible returns on his/her investment, which will require a suitable method of evaluation.

Historically researchers have used many different research evaluation methods in determining the returns to research. These methods have differed predominantly as a result of the variations in data availability, the *ex post* or *ex ante* requirements of the study and the level on which the study has been conducted. The major pitfall in most rate of return studies is the inconsistency of data with which researchers are presented for evaluation. In the case of this study the lack of data had to be overcome through numerous manipulations of the data. This may have the negative effect of casting doubt on the results achieved. It is therefore of vital importance that research institutions maintain a thorough source of project related information, and that this information is collected in an uniformed manner.

Project related data would need to include all relevant costing, including capital and overhead contributions. The researchers should therefore be involved in determining the necessary financing of such research projects, as this will help to create the necessary awareness for the collection of *ex post* data, and improve the researchers ability to set-up *ex ante* project proposals. Researchers will need to become involved in all spheres of the development of a research project. This can go as far as including the extension of the knowledge gained from the research project, as many researchers are of the impression that the impetus of the research is lost through transferring the extension function to another party.

The importance with which researchers considered minimum tillage practices is evident from the length of time that the concept has managed to captivate the interests of researchers. The use of inter-row mulch proved a lot more effective than most researchers would have imagined. Not only did the practice reduce soil compaction, the primary purpose of the research, but it also improved water infiltration, reduced soil erosion and weed infestation, and proved to be an environmentally friendly means of production. The research idea went through a number of "unsuccessful" years, before the technique of growing a cover crop in between the rows of vines proved to be the most successful and cost effective. The technique as described in Chapter Three, is still undergoing research as researchers strive to improve the dry matter density that is produced by the grain crop. It has been estimated that this minimum tillage practice has been used for as many as 50 years, and is currently being used by approximately 50 percent of the industry.

It may seem that the major objective of this study is to arrive at a return on investment for the capital expended on a project level, with particular reference to cover crop research. This is however not the case. The importance of this study is the method that is used to arrive at this value, as it is this knowledge which will be of most use in the future. The cover crop research has been conducted, and a return of between 36 and 44 percent is excellent, but it is *ex post* and thus of limited use to future analysts. It is however important that future research be evaluated using a suitable approach so as to instil confidence in the minds of the investor. It is therefore the method of evaluation that should be considered as the essence of this study.

In order to arrive at a suitable means for measuring the rate of return, it was decided that two methods would be used. The first method, a production function approach, attempts to determine the rate of return using the cost of research as a proxy for the change in yield. This method, which is used effectively for industry level studies, may come under a certain amount of criticism because of the broad nature of the data used for this project level study. However, the method is effective in so much that the results are achieved, by keeping all other variables constant, and changing the research value to firstly include and then exclude the cost of cover crop research. This therefore, is a direct indication of the difference in the total research contribution, had the cost of the cover crop research not been included.

The achieved return of 44 percent is a probable return and consistent with the return achieved for the wine research institution (Townsend and Van Zyl, 1998). Once again however, a certain amount of criticism can be directed at the production function approach for two specific reasons. Firstly, the use of cost data creates the situation where the dependent variable does not have any association with the independent variable. How can the cost of the research have an impact on the industry yield? And secondly, the use of cost data cannot possibly account for the potential of the research. Furthermore, in the case of the study in question, the use of cost data does not account for the variation between the results achieved for the dry land and irrigated vineyards. This approach has however been used effectively in many past studies, and has therefore been included in this study. The results should however be considered with caution.

The second method, the cost benefit approach, makes use of the results achieved from the research and works upward to achieve a rate of return. This is unlike the production function approach which works in a downward manner from industry related data, to achieve the contribution to a project level study. The cost benefit approach is a low-level approach, which is easily moulded to suit the available cost and benefit data. The shortcomings of this approach, are the inability to attribute a numerical value to all the required costs and benefits. This can however be partially ascribed to the lack of available data and the fact that of the benefits and costs can be qualitative in nature. Furthermore, the use of trial plot data can result in an overestimation of the returns because not all producers follow researched procedures as instructed. The importance of this approach is the ability to be used as an effective *ex ante* evaluation tool. The ease with which the approach can be adapted allows for the manipulation of data to be included in the evaluation.

It is possible that both approaches may have underestimated the returns through neglecting the environmental benefits from the minimum tillage technology. The reduction in the use of herbicides and the limited number of tractor trips will have a beneficial affect on the environment. Furthermore, these practices will have a beneficial effect on the sustainability of the vineyard, thereby extending the life span thereof.

The rate of return achieved from both approaches are however suitable, and comparable with the project level study conducted on the Russian Wheat Aphid research project (Marasas, 1997). The study by Thirtle et al (1998), which surveys the rate of return studies of research conducted under the ARC, shows that a broad range of research results are possible for all levels of analysis, and that the returns achieved for this study are not uncommon.

The result achieved should not merely be considered as a suitable end to a means, but as an effective indicator that research has important monetary value to the industry. The true value of research will become more apparent as research institutions impose the necessary requirements for effective data collection. The improved availability of data will not only highlights the returns to *ex post* research, but will also assist in the *ex ante* evaluation of research.

The success of agricultural research in the wine industry will stem from the ability of research institutions to conduct research that will be socially accepted in the new

South Africa. Furthermore, it is imperative that research institutions do not lose sight of the importance of conducting maintenance research, thus preventing the industry from falling behind. Most importantly, the field of research will have to become financially driven, so as to capture the necessary investment and maintain suitable returns from research conducted.

The ability to maintain a progressive research program in the wine industry will go a long way to ensure that international competitiveness is preserved and strengthened. The emphasis of research should however not only strive to meet financial requirements, but also social, environmental, and economical needs of the industry.

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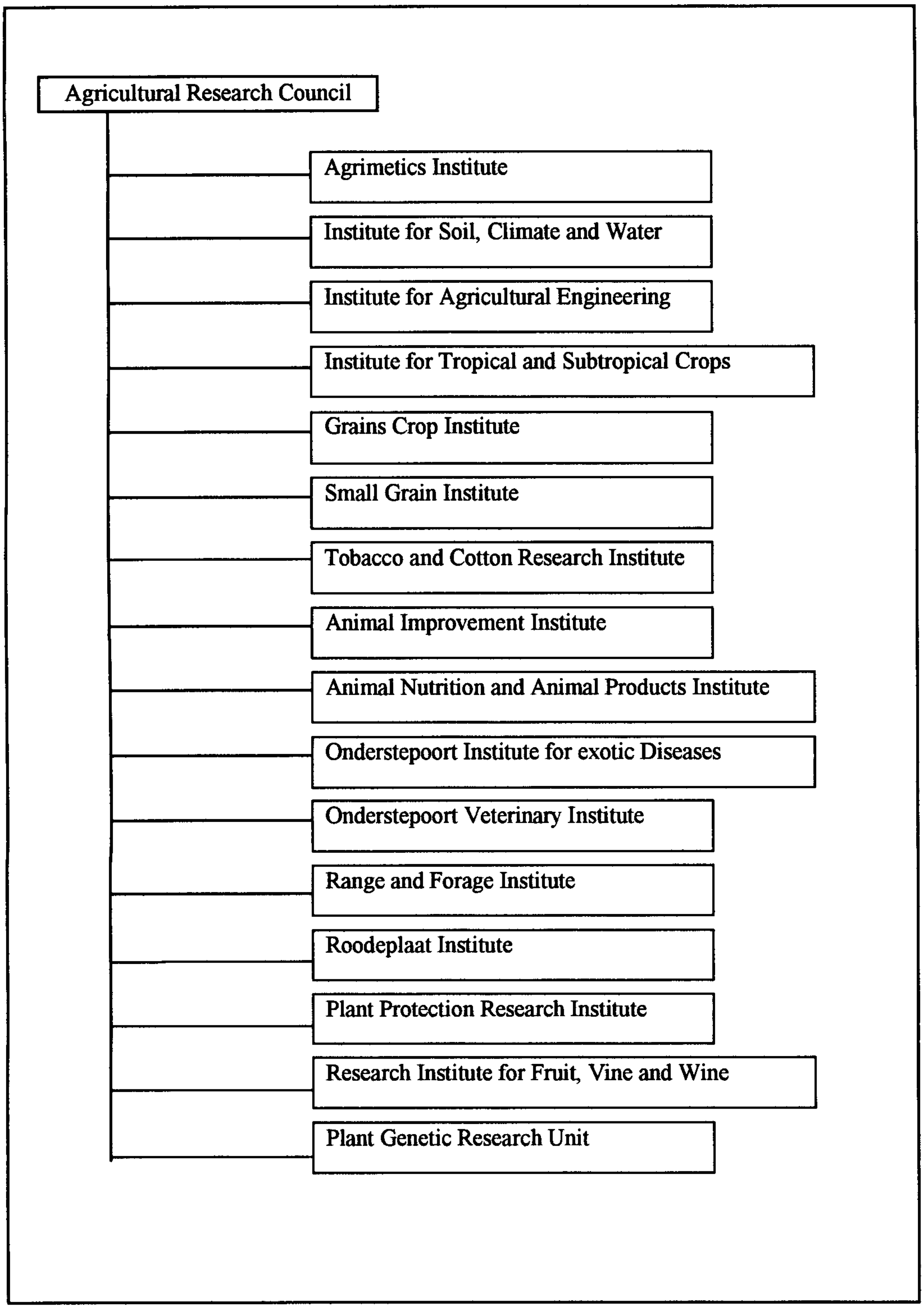
APPENDIX

Appendix 1: Structure of the Agricultural Research Council



Appendix 3 - Total Cost for Cover Crop Research (Industry & Region Specific)

Project Identification	SWI 49/1	SWI 49/2	SWI 49/3	SWI 49/4	SWI 56/3	WW 2/2	WW 2/3	WW 2/5	WW 2/7	WW 2/8	WW 2/9
Year											
1969/70	2,171.17										
1970/71	4,359.70										
1971/72	6,457.03										
1972/73	6,085.70	9,173.12									
1973/74	11,893.25	10,055.16									
1974/75	16,841.79	11,201.80									
1975/76	18,005.81	12,701.26									
1976/77	16,000.00	14,112.51									
1977/78	14,500.00	15,700.16			36,382.58						
1978/79		17,464.23			43,146.91						
1979/80		19,757.51		19,209.24	48,812.67						
1980/81		44,983.62	37,839.16	29,009.01	41,675.99						
1981/82		51,863.46	43,626.32	27,102.90	64,066.63						
1982/83			37,505.28	46,135.00	73,436.92						
1983/84			42,068.24	58,474.88	82,371.38						
1984/85			46,965.07		68,969.69						
1985/86			72,858.93		80,246.72						
1986/87			64,771.74		95,119.33						
1987/88					110,482.25	27,616.00					
1988/89						45,661.50	45,296.00				
1989/90						63,707.00	86,558.93				
1990/91						88,815.00	106,906.11	63,588.00			
1991/92						100,391.00	91,909.00	327,254.00			
1992/93						65,020.00	79,339.00	104,794.00	28,149.00	72,816.00	112,596.00
1993/94						56,871.40	86,545.90	67,582.89	31,882.39	139,883.41	84,321.18
1994/95							65,238.18	52,908.35	36,311.26	117,870.55	
1995/96							41,791.51		54,856.49	195,755.68	
1996/97							45,898.30		62,739.82	227,550.42	
TOTAL	96,314.45	207,012.83	345,634.74	179,931.03	744,711.07	448,081.90	649,482.93	616,127.24	213,938.95	753,876.06	196,917.18

Appendix 3 (Continued) - Total Cost for Cover Crop Research (Industry & Region Specific)

Total Cost of Technology (Rands)	P.P.I Base - 1991	P.P.I Base - 1996 1.943	Total Real Cost of Technology (Rands)	Time Preference 1996 terms 7% discount rate	Total Cost in 1996 terms	Stellenbosch contribution to total tonnage (%)	Cost attributed to Stellenbosch Region (R)	Robertson contribution to total tonnage (%)	Cost attributed to Robertson Region (R)
2,171.17	12.60	6.48	140.80	6.6488	936.13	12.25	114.68	15.10	141.36
4,359.70	13.50	6.95	302.91	6.2139	1,882.26	12.40	233.40	15.30	287.99
6,457.03	16.70	8.59	554.98	5.8074	3,222.96	12.30	396.42	15.20	489.89
15,258.82	18.90	9.73	1,484.26	5.4274	8,055.72	12.25	986.83	14.90	1,200.30
21,948.41	19.20	9.88	2,168.86	5.0724	11,001.25	12.20	1,342.15	15.10	1,661.19
28,043.59	17.20	8.85	2,482.50	4.7405	11,768.37	12.10	1,423.97	14.50	1,706.41
30,707.07	25.10	12.92	3,966.79	4.4304	17,574.48	12.05	2,117.72	14.90	2,618.60
30,112.51	27.80	14.31	4,308.43	4.1406	17,839.32	12.10	2,158.56	15.20	2,711.58
66,582.74	31.30	16.11	10,725.89	3.8697	41,505.80	11.90	4,939.19	15.40	6,391.89
60,611.14	31.00	15.95	9,670.33	3.6165	34,973.02	12.00	4,196.76	15.20	5,315.90
87,779.42	34.30	17.65	15,495.80	3.3799	52,374.76	11.70	6,127.85	15.50	8,118.09
153,507.78	39.30	20.23	31,049.18	3.1588	98,078.62	11.60	11,377.12	15.80	15,496.42
186,659.31	36.40	18.73	34,968.60	2.9522	103,233.03	12.40	12,800.90	14.70	15,175.26
157,077.20	45.80	23.57	37,025.92	2.7590	102,155.67	13.70	13,995.33	14.30	14,608.26
182,914.50	43.20	22.23	40,668.59	2.5785	104,865.34	14.10	14,786.01	15.70	16,463.86
115,934.76	46.30	23.83	27,626.24	2.4098	66,574.97	12.50	8,321.87	14.80	9,853.10
153,105.65	50.00	25.73	39,399.29	2.2522	88,734.75	14.10	12,511.60	14.40	12,777.80
159,891.07	58.30	30.01	47,975.55	2.1049	100,981.43	12.30	12,420.72	16.40	16,560.95
138,098.25	72.80	37.47	51,742.42	1.9672	101,785.18	11.70	11,908.87	16.80	17,099.91
90,957.50	84.60	43.54	39,603.73	1.8385	72,809.84	11.60	8,445.94	16.70	12,159.24
150,265.93	89.50	46.06	69,216.68	1.7182	118,927.14	12.50	14,865.89	15.80	18,790.49
259,309.11	100.00	51.47	133,458.11	1.6058	214,304.56	12.90	27,645.29	15.50	33,217.21
519,554.00	117.10	60.27	313,122.87	1.5007	469,912.99	12.40	58,269.21	15.60	73,306.43
397,694.00	130.50	67.16	267,107.91	1.4026	374,632.66	11.90	44,581.29	16.90	63,312.92
467,087.17	132.10	67.99	317,561.58	1.3108	416,258.45	12.30	51,199.79	17.70	73,677.75
272,328.34	129.10	66.44	180,944.87	1.2250	221,665.25	9.80	21,723.19	17.50	38,791.42
292,403.68	147.20	75.76	221,522.50	1.1449	253,621.11	10.60	26,883.84	17.10	43,369.21
336,188.54	194.30	100.00	336,188.54	1.0700	359,721.74	10.50	37,770.78	15.90	57,195.76
4,452,028.38					3,469,396.80		413,545.17		562,499.17

Appendix 4: Cost Saving as a result of Technology use. - Total Chenin Blanc Production

Year	Total Ha of Chenin Blanc	Adoption of Technology	% chenin blanc production of surface area	Adoption of chenin blanc producers	Hectares Under Cover crop	Saving per ha on Chemical Clean Tillage	Time Value of savings in 1996 terms	Revenue saved per year (Rands)
1980	29398.04	2.885	0.280	0.808	848.020	4.780	24.160	20488.485
1981	26736.16	3.846	0.292	1.123	1028.314	4.780	21.964	22585.857
1982	28338.02	7.692	0.306	2.354	2179.847	4.780	19.967	43525.552
1983	28992.16	8.654	0.312	2.700	2508.937	4.780	18.152	45542.334
1984	29421.33	10.577	0.318	3.363	3111.871	4.780	16.502	51351.653
1985	29761.96	12.500	0.323	4.038	3720.245	4.780	15.002	55809.959
1986	30357.84	12.500	0.327	4.088	3794.730	4.780	13.638	51752.134
1987	30892.90	18.269	0.329	6.011	5643.896	4.780	12.398	69973.521
1988	31002.62	18.269	0.332	6.065	5663.941	4.780	11.271	63838.223
1989	30689.45	19.231	0.329	6.327	5901.817	4.780	10.246	60472.110
1990	29374.48	20.192	0.319	6.441	5931.385	4.780	9.315	55250.065
1991	28685.90	20.192	0.312	6.300	5792.346	4.780	8.468	49049.943
1992	28148.58	22.115	0.304	6.723	6225.166	4.780	7.698	47922.807
1993	27694.36	24.038	0.297	7.139	6657.298	4.780	6.998	46590.420
1994	27448.24	25.962	0.293	7.607	7125.985	4.780	6.362	45336.802
1995	26758.37	29.808	0.285	8.495	7976.051	4.780	5.784	46131.884
1996	26514.72	33.654	0.280	9.423	8923.222	4.780	5.258	46918.302

Appendix 5: Cost Saving as a result of Technology use. - Robertson Region Only

Year	Total Ha of Chenin Blanc	% Chenin Blanc in Robertson Region	Total Chenin Blanc in Robertson Region (Ha)	Adoption of Techn. in Robertson Region	% chenin blanc of Robertson Region	Adoption of Chenin Blanc producers in Robertson Region	Hectares Under Cover crop	Saving per ha Clean Tillage Chemical	Time Value of savings in 1996 terms	Revenue saved per year
1980	29398.04	9.060	2663.462	0.000	0.278	0.000	0.000	4.780	24.160	0.000
1981	26736.16	9.100	2432.991	0.962	0.292	0.281	6.831	4.780	21.964	150.038
1982	28338.02	9.150	2592.929	0.962	0.306	0.294	7.629	4.780	19.967	152.334
1983	28992.16	9.200	2667.279	1.923	0.312	0.600	16.004	4.780	18.152	290.499
1984	29421.33	9.260	2724.415	1.923	0.318	0.612	16.661	4.780	16.502	274.935
1985	29761.96	9.450	2812.505	1.923	0.323	0.621	17.470	4.780	15.002	262.079
1986	30357.84	9.500	2883.994	1.923	0.327	0.629	18.136	4.780	13.638	247.335
1987	30892.90	9.600	2965.719	2.885	0.329	0.949	28.146	4.780	12.398	348.954
1988	31002.62	9.700	3007.255	2.885	0.302	0.871	26.198	4.780	11.271	295.275
1989	30689.45	9.800	3007.566	2.885	0.299	0.863	25.940	4.780	10.246	265.793
1990	29374.48	9.900	2908.073	3.846	0.299	1.150	33.443	4.780	9.315	311.516
1991	28685.90	10.000	2868.590	3.846	0.294	1.131	32.437	4.780	8.468	274.680
1992	28148.58	10.000	2814.858	4.808	0.288	1.385	38.975	4.780	7.698	300.038
1993	27694.36	10.300	2852.519	4.808	0.278	1.337	38.125	4.780	6.998	266.814
1994	27448.24	10.300	2827.169	5.769	0.270	1.558	44.039	4.780	6.362	280.181
1995	26758.37	10.600	2836.387	5.769	0.258	1.488	42.219	4.780	5.784	244.184
1996	26514.72	12.800	3393.884	5.769	0.245	1.413	47.971	4.780	5.258	252.233

Appendix 6: Cost Saving as a result of Technology use. - Stellenbosch Region Only

Year	Total Ha of Chenin Blanc	% Chenin Blanc in Stellenbosch Region	Total Chenin Blanc in Stellenbosch Region (Ha)	Adoption of Techn. in Stellenbosch Region	% chenin blanc of Stellenbosch Region	Adoption of Chenin Blanc producers in Stellenbosch Region	Hectares Under Cover crop	Saving per ha Clean Tillage Chemical	Time Value of savings in 1996 terms	Revenue saved per year
1980	29398.0	16.050	4718.385	0.962	0.410	0.394	18.601	4.780	24.160	449.415
1981	26736.2	16.150	4317.890	0.962	0.430	0.413	17.853	4.780	21.964	392.119
1982	28338.0	16.250	4604.928	1.923	0.420	0.808	37.194	4.780	19.967	742.655
1983	28992.2	16.300	4725.723	1.923	0.402	0.773	36.533	4.780	18.152	663.157
1984	29421.3	16.200	4766.255	1.923	0.403	0.775	36.938	4.780	16.502	609.553
1985	29762.0	16.100	4791.676	1.923	0.410	0.788	37.781	4.780	15.002	566.772
1986	30357.8	15.980	4851.182	1.923	0.402	0.773	37.503	4.780	13.638	511.467
1987	30892.9	15.950	4927.418	2.885	0.405	1.168	57.566	4.780	12.398	713.702
1988	31002.6	15.900	4929.417	2.885	0.407	1.174	57.873	4.780	11.271	652.289
1989	30689.4	15.800	4848.933	3.846	0.395	1.519	73.666	4.780	10.246	754.813
1990	29374.5	15.600	4582.418	3.846	0.369	1.419	65.035	4.780	9.315	605.793
1991	28685.9	15.700	4503.687	3.846	0.347	1.335	60.107	4.780	8.468	508.989
1992	28148.6	15.600	4391.178	4.808	0.328	1.577	69.245	4.780	7.698	533.068
1993	27694.4	15.500	4292.626	4.808	0.315	1.514	65.009	4.780	6.998	454.955
1994	27448.2	15.300	4199.581	4.808	0.304	1.462	61.378	4.780	6.362	390.501
1995	26758.4	15.200	4067.271	5.769	0.292	1.685	68.518	4.780	5.784	396.294
1996	26514.7	16.100	4268.869	8.654	0.283	2.449	104.546	4.780	5.258	549.704

Appendix 7: Financial Cost Benefit Flow for total Chenin Blanc Production

Year	Total Chenin	Tonnage Breakdown		Without Technology		Tonnage increase a.r.o		Total Increase	Adoption	Accumulated	Lag Structure	
	Blanc Tonnage	Irrigated*	Dryland*	Irrigated**	Dryland**	Cover Crops		in Tonnage	Rate	Adoption	Irrigated***	Dryland***
	(tons)	0.875	0.125	0.95	0.8	Irrigated	Dryland	(Tons)		Rate	4 yr	1 yr
1969												
1970												
1971												
1972												
1973												
1974												
1975												
1976												
1977												
1978												
1979												
1980	283691	248229.70	35461.4	235818.2	28369.1	12411.5	7092.3	19503.8	2.88	2.88	0.00	0.87
1981	264421	231368.07	33052.6	219799.7	26442.1	11568.4	6610.5	18178.9	0.96	3.85	0.00	1.15
1982	278548	243729.50	34818.5	231543.0	27854.8	12186.5	6963.7	19150.2	3.85	7.69	0.00	2.31
1983	292499	255936.63	36562.4	243139.8	29249.9	12796.8	7312.5	20109.3	0.96	8.65	2.02	2.60
1984	277227	242573.63	34653.4	230444.9	27722.7	12128.7	6930.7	19059.4	1.92	10.58	2.69	3.17
1985	274843	240487.63	34355.4	228463.2	27484.3	12024.4	6871.1	18895.5	1.92	12.50	5.38	3.75
1986	235924	206433.50	29490.5	196111.8	23592.4	10321.7	5898.1	16219.8	0.00	12.50	6.06	3.75
1987	293517	256827.38	36689.6	243986.0	29351.7	12841.4	7337.9	20179.3	5.77	18.27	7.40	5.48
1988	306056	267799.00	38257.0	254409.1	30605.6	13390.0	7651.4	21041.4	0.00	18.27	8.75	5.48
1989	328256	287224.00	41032.0	272862.8	32825.6	14361.2	8206.4	22567.6	0.96	19.23	8.75	5.77
1990	336507	294443.63	42063.4	279721.4	33650.7	14722.2	8412.7	23134.9	0.96	20.19	12.79	6.06
1991	349842	306111.75	43730.3	290806.2	34984.2	15305.6	8746.1	24051.6	0.00	20.19	12.79	6.06
1992	370036	323781.50	46254.5	307592.4	37003.6	16189.1	9250.9	25440.0	1.92	22.12	13.46	6.63
1993	331952	290458.00	41494.0	275935.1	33195.2	14522.9	8298.8	22821.7	1.92	24.04	14.13	7.21
1994	331855	290373.13	41481.9	275854.5	33185.5	14518.7	8296.4	22815.0	1.92	25.96	14.13	7.79
1995	341075	298440.63	42634.4	283518.6	34107.5	14922.0	8526.9	23448.9	3.85	29.81	15.48	8.94
1996	349401	305725.88	43675.1	290439.6	34940.1	15286.3	8735.0	24021.3	3.85	33.65	16.83	10.10

* See Paragraph 5.2.4.2.1.

** See Paragraph 5.2.4.1.

*** See Paragraph 5.2.4.1.

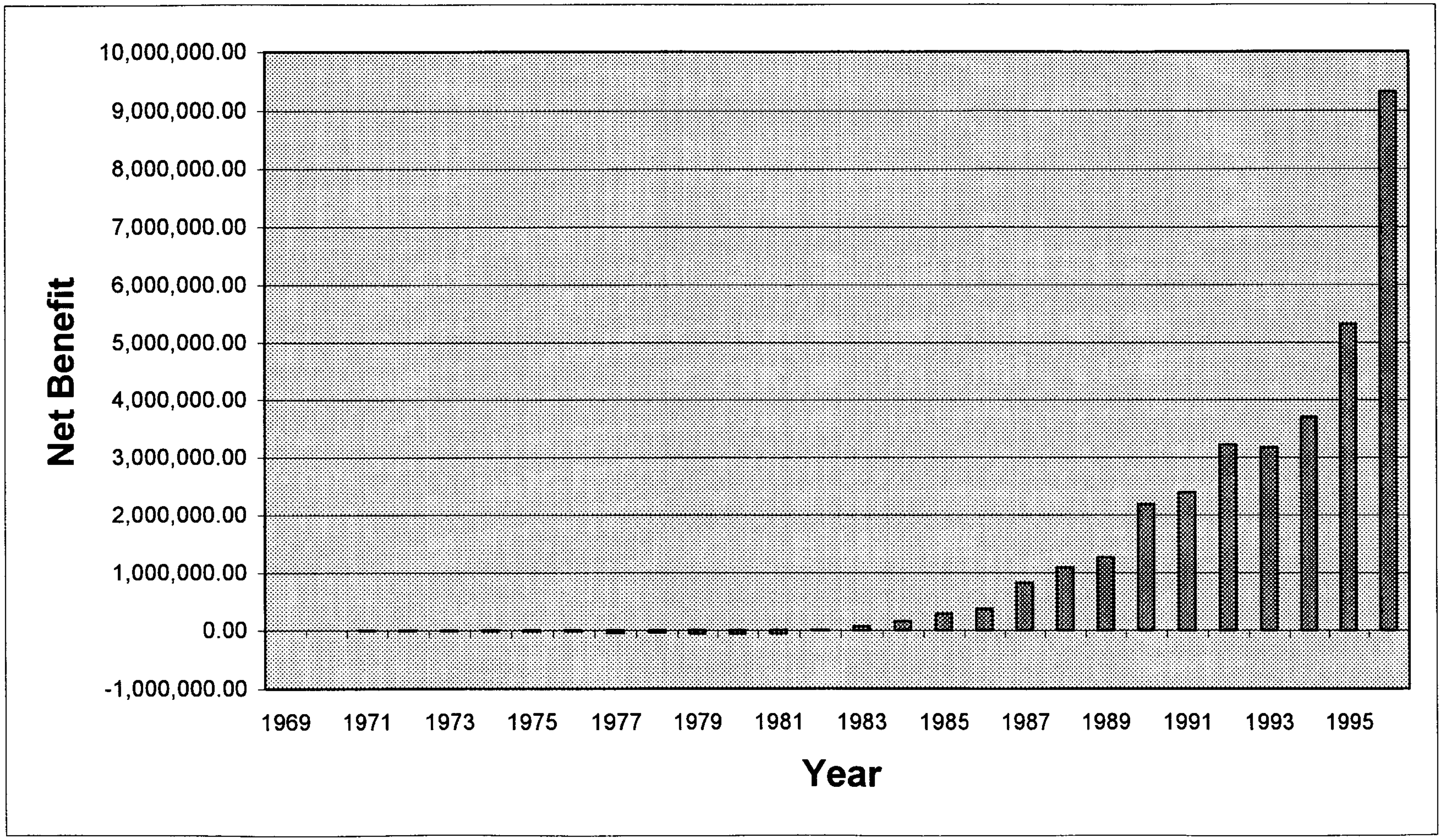
Appendix 7 (Continued): Financial Cost Benefit Flow for total Chenin Blanc Production

Increase in Tonnage per year		Total Increase per year	Average Yield per ton	Increase a.r.o Cover Crop	% Breakdown of Total Production		Total Breakdown of Production (Litres)		Nominal Price of Produce (R/Litre)		P.P.I. 90 Base	P.P.I. 96 Base	Real Price of Produce (R/Litre)	
Irrigated	Dryland	(Tons)	(Litres)	(Litres)	Good	Distilled	Good	Distilled	Good	Distilled		1.943	Good	Distilled
0.00	168.78	168.8	889.0	150040.9	0.457	0.543	68568.7	81472.2	0.289	0.140	39.3	20.23	0.059	0.028
0.00	209.76	209.8	878.8	184334.2	0.496	0.504	91429.8	92904.5	0.318	0.131	36.4	18.73	0.060	0.024
0.00	441.93	441.9	900.7	398026.1	0.463	0.537	184286.1	213740.0	0.381	0.171	45.8	23.57	0.090	0.040
406.05	522.07	928.1	891.5	827448.5	0.484	0.516	400485.1	426963.4	0.415	0.139	43.2	22.23	0.092	0.031
513.14	604.77	1117.9	893.1	998400.6	0.506	0.494	505190.7	493209.9	0.444	0.158	46.3	23.83	0.106	0.038
1017.45	708.58	1726.0	887.4	1531728.4	0.588	0.412	900656.3	631072.1	0.485	0.188	50	25.73	0.125	0.048
982.54	608.24	1590.8	922.3	1467213.4	0.549	0.451	805500.2	661713.2	0.551	0.331	58.3	30.01	0.165	0.099
1494.04	1105.98	2600.0	904.5	2351592.1	0.489	0.511	1149928.5	1201663.5	0.659	0.327	72.8	37.47	0.247	0.123
1841.12	1153.23	2994.3	882.8	2643318.8	0.460	0.540	1215926.6	1427392.1	0.763	0.305	84.6	43.54	0.332	0.133
1974.67	1301.98	3276.6	890.6	2918111.8	0.466	0.534	1359840.1	1558271.7	0.874	0.304	89.5	46.06	0.403	0.140
2958.59	1401.44	4360.0	897.9	3914958.7	0.525	0.475	2055353.3	1859605.4	1.002	0.411	100	51.47	0.516	0.212
3075.83	1456.97	4532.8	903.8	4096525.8	0.547	0.453	2240799.6	1855726.2	1.035	0.423	117.1	60.27	0.624	0.255
3424.61	1687.84	5112.5	899.8	4600290.6	0.535	0.465	2461155.5	2139135.1	1.180	0.402	130.5	67.16	0.793	0.270
3225.76	1645.80	4871.6	897.2	4370856.7	0.618	0.382	2701189.5	1669667.3	1.280	0.306	132.1	67.99	0.870	0.208
3224.82	1776.94	5001.8	894.2	4472671.0	0.699	0.301	3126397.0	1346274.0	1.280	0.562	129.1	66.44	0.850	0.373
3630.07	2096.87	5726.9	908.2	5201325.5	0.793	0.207	4124651.1	1076674.4	1.390	0.588	147.2	75.76	1.053	0.445
4042.05	2425.23	6467.3	901.2	5828311.0	0.875	0.125	5099772.2	728538.9	1.680	0.596	194.3	100.00	1.680	0.596

Appendix 7 (Continued): Financial Cost Benefit Flow for total Chenin Blanc Production

Real Value of increase Production (Rands)		Total value of increase production per year	Time Preference 1996 terms	Revenue saved from techn.	Total Revenue from Technology	Total Cost of Technology	Net Benefit Per Year	Accumulated Net Benefit
Good	Distilled	(Rands)	7% discount rate	(See Appendix 4)	(Rands)	(Rands)	(Rands)	(Rands)
						936.13	-936.13	-936.13
						1,882.26	-1,882.26	-2,818.39
						3,222.96	-3,222.96	-6,041.35
						8,055.72	-8,055.72	-14,097.07
						11,001.25	-11,001.25	-25,098.32
						11,768.37	-11,768.37	-36,866.69
						17,574.48	-17,574.48	-54,441.17
						17,839.32	-17,839.32	-72,280.49
						41,505.80	-41,505.80	-113,786.28
						34,973.02	-34,973.02	-148,759.30
						52,374.76	-52,374.76	-201,134.06
4012.3	2303.8	6316.1	19951.3	20488.5	40439.8	98,078.62	-57,638.86	-258,772.92
5450.3	2273.8	7724.1	22802.7	22585.9	45388.6	103,233.03	-57,844.43	-316,617.35
16559.2	8598.8	25157.9	69411.5	43525.6	112937.0	102,155.67	10,781.34	-305,836.00
36961.5	13233.2	50194.7	129428.8	45542.3	174971.1	104,865.34	70,105.79	-235,730.21
53473.9	18569.4	72043.3	173613.2	51351.7	224964.8	66,574.97	158,389.85	-77,340.37
112477.7	30530.5	143008.2	322082.0	55810.0	377891.9	88,734.75	289,157.17	211,816.81
133244.5	65719.4	198963.9	418789.6	51752.1	470541.7	100,981.43	369,560.31	581,377.11
283846.2	147227.6	431073.7	847987.3	69973.5	917960.8	101,785.18	816,175.65	1,397,552.77
403740.0	189557.4	593297.3	1090753.0	63838.2	1154591.2	72,809.84	1,081,781.35	2,479,334.12
547644.3	218206.2	765850.4	1315873.6	60472.1	1376345.7	118,927.14	1,257,418.59	3,736,752.71
1060257.7	393359.7	1453617.3	2334191.7	55250.1	2389441.8	214,304.56	2,175,137.25	5,911,889.96
1398283.6	473084.1	1871367.7	2808418.4	49049.9	2857468.3	469,912.99	2,387,555.31	8,299,445.26
1951218.8	577566.5	2528785.2	3546752.1	47922.8	3594674.9	374,632.66	3,220,042.27	11,519,487.53
2350688.2	347361.3	2698049.5	3536592.5	46590.4	3583182.9	416,258.45	3,166,924.49	14,686,412.02
2658933.9	502716.6	3161650.5	3873157.8	45336.8	3918494.6	221,665.25	3,696,829.35	18,383,241.37
4343472.0	479619.4	4823091.4	5521957.3	46131.9	5568089.2	253,621.11	5,314,468.08	23,697,709.44
8567617.2	434209.2	9001826.4	9631954.3	46918.3	9678872.6	359,721.74	9,319,150.82	33,016,860.27
							IRR	37%
							npv @ 5%	R9,672,841
							npv @ 7%	R6,036,282

Appendix 8: Net Benefit Flow for Total Chenin Blanc Production



Appendix 9: Financial Cost Benefit Flow for Robertson Production Region

Year	Total Tonnage for Industry (Tons)	Robertson Contribution to Total Tonnage (%)	Total Production in Robertson (Tons)	% Chenin Blanc in Robertson	Total Chenin Blanc in Robertson (Tons)	Tonnage Breakdown Irrigated* 0.997	Tonnage Breakdown Dryland* 0.003	Without Technology Irrigated** 0.95	Without Technology Dryland** 0.8	Tonnage increase a.r.o Cover Crops Irrigated	Tonnage increase a.r.o Cover Crops Dryland	Total Increase in Tonnage (Tons)	Adoption Rate (Robertson)
1969		15.10											
1970		15.30											
1971		15.20											
1972		14.90											
1973		15.10											
1974		14.50											
1975		14.90											
1976		15.20											
1977		15.40											
1978		15.20											
1979		15.50											
1980	927324	15.80	146517.2	24.8	36336.3	36244.7	91.5	34432.5	73.2	1812.2	18.3	1830.5	0.00
1981	864195	14.70	127036.7	26.2	33283.6	33199.8	83.8	31539.8	67.1	1660.0	16.8	1676.8	0.96
1982	991483	14.30	141782.1	27.6	39131.9	39033.3	98.6	37081.6	78.9	1951.7	19.7	1971.4	0.00
1983	1022712	15.70	160565.8	28.2	45279.6	45165.5	114.1	42907.2	91.2	2258.3	22.8	2281.1	0.96
1984	1002053	14.80	148303.8	28.8	42711.5	42603.9	107.6	40473.7	86.1	2130.2	21.5	2151.7	0.00
1985	931034	14.40	134068.9	29.3	39282.2	39183.2	99.0	37224.1	79.2	1959.2	19.8	1979.0	0.00
1986	825687	16.40	135412.7	29.7	40217.6	40116.3	101.3	38110.4	81.0	2005.8	20.3	2026.1	0.00
1987	969241	16.80	162832.5	29.9	48686.9	48564.3	122.6	46136.1	98.1	2428.2	24.5	2452.7	0.96
1988	1015181	16.70	169535.2	30.2	51199.6	51070.7	129.0	48517.1	103.2	2553.5	25.8	2579.3	0.00
1989	1072775	15.80	169498.5	29.9	50680.0	50552.4	127.7	48024.8	102.1	2527.6	25.5	2553.2	0.00
1990	1061257	15.50	164494.8	29.9	49184.0	49060.1	123.9	46607.1	99.1	2453.0	24.8	2477.8	0.96
1991	1073750	15.60	167505.0	29.4	49246.5	49122.4	124.1	46666.3	99.2	2456.1	24.8	2480.9	0.00
1992	1111046	16.90	187766.8	28.8	54076.8	53940.6	136.2	51243.6	109.0	2697.0	27.2	2724.3	0.96
1993	1023509	17.70	181161.1	27.8	50362.8	50235.9	126.9	47724.1	101.5	2511.8	25.4	2537.2	0.00
1994	1020337	17.50	178559.0	27.0	48210.9	48089.5	121.4	45685.0	97.2	2404.5	24.3	2428.8	0.96
1995	1063915	17.10	181929.5	25.8	46937.8	46819.6	118.2	44478.6	94.6	2341.0	23.6	2364.6	0.00
1996	1148114	15.90	182550.1	24.5	44724.8	44612.1	112.7	42381.5	90.1	2230.6	22.5	2253.1	0.00

* See Paragraph 5.2.4.2.1.
** See Paragraph 5.2.4.1.
*** See Paragraph 5.2.4.1.

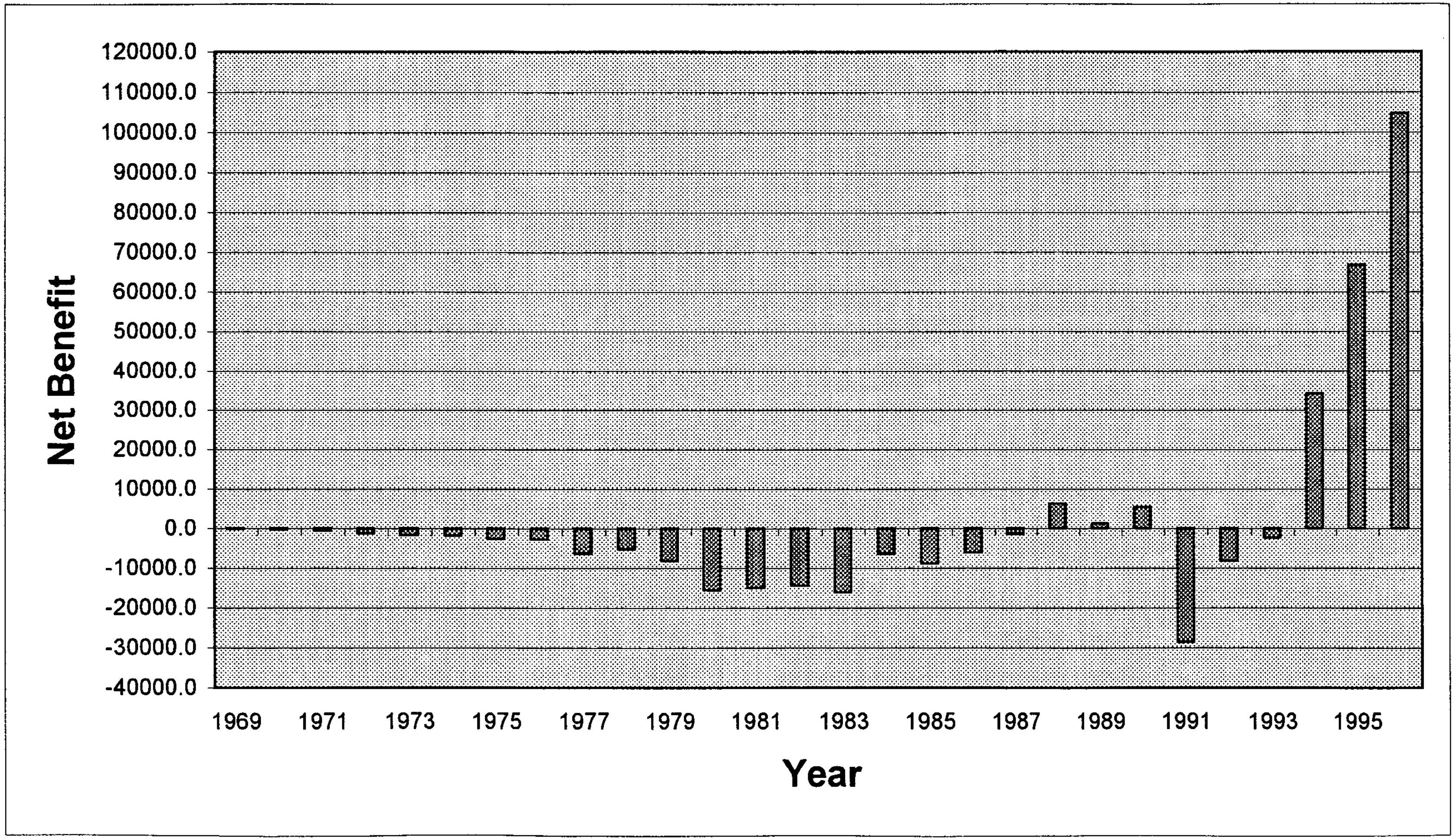
Appendix 9 (Continued): Financial Cost Benefit Flow for Robertson Production Region

Accumulated Adoption Rate	Lag Structure Irrigated** 4 yr	Lag Structure Dryland*** 1 yr	Increase in Tonnage per year Irrigated	Increase in Tonnage per year Dryland	Total Increase per year (Tons)	Average Yield per ton (Litres)	Increase a.r.o Cover Crop (Litres)	% Breakdown of Total Production Good	% Breakdown of Total Production Distilled	Total Breakdown of Production (Litres) Good	Total Breakdown of Production (Litres) Distilled	Nominal Price of Produce (R/Litre) Good	Nominal Price of Produce (R/Litre) Distilled	P.P.I. 90 Base	P.P.I. 96 Base 1.943	Real Price of Produce (R/Litre) Good	Real Price of Produce (R/Litre) Distilled
0.00	0.000	0.000	0.0	0.0	0.0	889.0	0.0	0.457	0.543	0.0	0.0	0.289	0.140	39.3	20.2	0.059	0.028
0.96	0.000	0.010	0.0	0.2	0.2	878.8	141.7	0.496	0.504	70.3	71.4	0.318	0.131	36.4	18.7	0.060	0.024
0.96	0.000	0.010	0.0	0.2	0.2	900.7	170.7	0.463	0.537	79.0	91.7	0.381	0.171	45.8	23.6	0.090	0.040
1.92	0.000	0.019	0.0	0.4	0.4	891.5	391.1	0.484	0.516	189.3	201.8	0.415	0.139	43.2	22.2	0.092	0.031
1.92	0.952	0.019	20.5	0.4	20.9	893.1	18662.6	0.506	0.494	9443.3	9219.3	0.444	0.158	46.3	23.8	0.106	0.038
1.92	0.952	0.019	18.8	0.4	19.2	887.4	17055.2	0.588	0.412	10028.5	7026.8	0.485	0.188	50	25.7	0.125	0.048
1.92	1.904	0.019	38.6	0.4	39.0	922.3	35936.3	0.549	0.451	19729.0	16207.3	0.551	0.331	58.3	30.0	0.165	0.099
2.88	1.904	0.029	46.7	0.7	47.4	904.5	42874.5	0.489	0.511	20965.6	21908.9	0.659	0.327	72.8	37.5	0.247	0.123
2.88	1.904	0.029	49.1	0.7	49.9	882.8	44006.5	0.460	0.540	20243.0	23763.5	0.763	0.305	84.6	43.5	0.332	0.133
2.88	1.904	0.029	48.6	0.7	49.3	890.6	43945.3	0.466	0.534	20478.5	23466.8	0.874	0.304	89.5	46.1	0.403	0.140
3.85	2.856	0.038	70.8	1.0	71.7	897.9	64392.3	0.525	0.475	33806.0	30586.3	1.002	0.411	100	51.5	0.516	0.212
3.85	2.856	0.038	70.8	1.0	71.8	903.8	64892.8	0.547	0.453	35496.3	29396.4	1.035	0.423	117.1	60.3	0.624	0.255
4.81	2.856	0.048	77.8	1.3	79.1	899.8	71183.6	0.535	0.465	38083.2	33100.4	1.180	0.402	130.5	67.2	0.793	0.270
4.81	3.808	0.048	96.6	1.2	97.8	897.2	87772.7	0.618	0.382	54243.5	33529.2	1.280	0.306	132.1	68.0	0.870	0.208
5.77	3.808	0.058	92.5	1.4	93.9	894.2	83950.3	0.699	0.301	58681.3	25269.0	1.280	0.562	129.1	66.4	0.850	0.373
5.77	4.760	0.058	112.5	1.4	113.9	908.2	103456.5	0.793	0.207	82041.0	21415.5	1.390	0.588	147.2	75.8	1.053	0.445
5.77	4.760	0.058	107.2	1.3	108.5	901.2	97816.8	0.875	0.125	85589.7	12227.1	1.680	0.596	194.3	100.0	1.680	0.596

Appendix 9 (Continued): Financial Cost Benefit Flow for Robertson Production Region

Real Value of increase Production (Rands)		Total value of increase production per year	Time Preference 1996 terms	Revenue saved from techn.	Total Revenue from Technology	Total Cost of Technology	Cost associated with Robertson	Net Benefit Per Year	Accumulated Net Benefit
Good	Distilled	(Rands)	7% discount rate	(See Appendix 5)	(Rands)	(Rands)	Region	(Rands)	(Rands)
						936.13	141.4	-141.4	-141.4
						1,882.26	288.0	-288.0	-429.3
						3,222.96	489.9	-489.9	-919.2
						8,055.72	1200.3	-1200.3	-2119.5
						11,001.25	1661.2	-1661.2	-3780.7
						11,768.37	1706.4	-1706.4	-5487.1
						17,574.48	2618.6	-2618.6	-8105.7
						17,839.32	2711.6	-2711.6	-10817.3
						41,505.80	6391.9	-6391.9	-17209.2
						34,973.02	5315.9	-5315.9	-22525.1
						52,374.76	8118.1	-8118.1	-30643.2
0.0	0.0	0.0	0	0.0	0.0	98,078.62	15496.4	-15496.4	-46139.6
4.2	1.7	5.9	17.52701455	150.0	167.6	103,233.03	15175.3	-15007.7	-61147.3
7.1	3.7	10.8	29.77263529	152.3	182.1	102,155.67	14608.3	-14426.2	-75573.5
17.5	6.3	23.7	61.17364624	290.5	351.7	104,865.34	16463.9	-16112.2	-91685.6
999.6	347.1	1346.7	3245.267731	274.9	3520.2	66,574.97	9853.1	-6332.9	-98018.5
1252.4	339.9	1592.3	3586.262904	262.1	3848.3	88,734.75	12777.8	-8929.5	-106948.0
3263.5	1609.7	4873.2	10257.3767	247.3	10504.7	100,981.43	16561.0	-6056.2	-113004.2
5175.1	2684.3	7859.4	15460.60796	349.0	15809.6	101,785.18	17099.9	-1290.3	-114294.6
6721.5	3155.8	9877.3	18159.07458	295.3	18454.3	72,809.84	12159.2	6295.1	-107999.5
8247.2	3286.1	11533.3	19816.38848	265.8	20082.2	118,927.14	18790.5	1291.7	-106707.8
17438.9	6469.9	23908.7	38392.22428	311.5	38703.7	214,304.56	33217.2	5486.5	-101221.3
22150.1	7494.1	29644.2	44487.94608	274.7	44762.6	469,912.99	73306.4	-28543.8	-129765.1
30192.6	8937.1	39129.7	54881.46791	300.0	55181.5	374,632.66	63312.9	-8131.4	-137896.5
47205.0	6975.5	54180.5	71019.53595	266.8	71286.3	416,258.45	73677.7	-2391.4	-140287.9
49907.2	9435.8	59342.9	72697.66286	280.2	72977.8	221,665.25	38791.4	34186.4	-106101.4
86393.5	9539.8	95933.3	109834.021	244.2	110078.2	253,621.11	43369.2	66709.0	-39392.4
143790.7	7287.4	151078.1	161653.5154	252.2	161905.7	359,721.74	57195.8	104710.0	65317.5
								IRR	3%
								npv @ 5%	-R15,271.88
								npv @ 7%	-R21,445.87

Appendix 10: Net Benefit Flow for Robertson Production Region



Appendix 11: Financial Cost Benefit Flow for Stellenbosch Production Region

Year	Total Tonnage for Industry (Tons)	Stellenbosch Contribution to Total Tonnage (%)	Total Production in Stellenbosch (Tons)	% Chenin Blanc in Stellenbosch	Total Chenin Blanc in Stellenbosch (Tons)	Tonnage Breakdown		Without Technology		Tonnage increase a.r.o Cover Crops		Total Increase in Tonnage (Tons)	Adoption Rate (Stellenbosch)
						Irrigated*	Dryland*	Irrigated**	Dryland**	Irrigated	Dryland		
						0.583784	0.416216	0.95	0.8				
1969		12.25											
1970		12.40											
1971		12.30											
1972		12.25											
1973		12.20											
1974		12.10											
1975		12.05											
1976		12.10											
1977		11.90											
1978		12.00											
1979		11.70											
1980	927324	11.60	107569.6	44.0	47330.6	27630.8	19699.8	26249.3	15759.8	1381.5	3940.0	5321.5	0.961538462
1981	864195	12.40	107160.2	43.5	46614.7	27212.9	19401.8	25852.2	15521.4	1360.6	3880.4	5241.0	0
1982	991483	13.70	135833.2	42.8	58136.6	33939.2	24197.4	32242.2	19357.9	1697.0	4839.5	6536.4	0.961538462
1983	1022712	14.10	144202.4	43.1	62151.2	36282.9	25868.4	34468.7	20694.7	1814.1	5173.7	6987.8	0
1984	1002053	12.50	125256.6	42.0	52607.8	30711.6	21896.2	29176.0	17517.0	1535.6	4379.2	5914.8	0
1985	931034	14.10	131275.8	41.3	54216.9	31650.9	22566.0	30068.4	18052.8	1582.5	4513.2	6095.7	0
1986	825687	12.30	101559.5	41.4	42045.6	24545.6	17500.1	23318.3	14000.1	1227.3	3500.0	4727.3	0
1987	969241	11.70	113401.2	41.2	46721.3	27275.1	19446.2	25911.4	15556.9	1363.8	3889.2	5253.0	0.961538462
1988	1015181	11.60	117761.0	40.7	47928.7	27980.0	19948.7	26581.0	15959.0	1399.0	3989.7	5388.7	0
1989	1072775	12.50	134096.9	39.5	52968.3	30922.0	22046.3	29375.9	17637.0	1546.1	4409.3	5955.4	0.961538462
1990	1061257	12.90	136902.2	36.9	50516.9	29490.9	21026.0	28016.4	16820.8	1474.5	4205.2	5679.7	0
1991	1073750	12.40	133145.0	34.7	46201.3	26971.6	19229.7	25623.0	15383.8	1348.6	3845.9	5194.5	0
1992	1111046	11.90	132214.5	32.8	43366.3	25316.6	18049.8	24050.7	14439.8	1265.8	3610.0	4875.8	0.961538462
1993	1023509	12.30	125891.6	31.0	39026.4	22783.0	16243.4	21643.8	12994.7	1139.1	3248.7	4387.8	0
1994	1020337	9.80	99993.0	30.4	30397.9	17745.8	12652.1	16858.5	10121.7	887.3	2530.4	3417.7	0
1995	1063915	10.60	112775.0	29.2	32930.3	19224.2	13706.1	18263.0	10964.9	961.2	2741.2	3702.4	0.961538462
1996	1148114	10.50	120552.0	28.3	34116.2	19916.5	14199.7	18920.7	11359.8	995.8	2839.9	3835.8	2.884615385

* See Paragraph 5.2.4.2.1.

** See Paragraph 5.2.4.1.

*** See Paragraph 5.2.4.1.

Appendix 11 (Continued): Financial Cost Benefit Flow for Stellenbosch Production Region

Accumulated Adoption Rate	Lag Structure Irrigated*** 4 yr	Lag Structure Dryland*** 1 yr	Increase in Tonnage per year Irrigated	Increase in Tonnage per year Dryland	Total Increase per year (Tons)	Average Yield per ton (Litres)	Increase a.r.o Cover Crop (Litres)	% Breakdown of Total Production Good	% Breakdown of Total Production Distilled	Total Breakdown of Production (Litres) Good	Total Breakdown of Production (Litres) Distilled	Nominal Price of Produce (R/Litre) Good	Nominal Price of Produce (R/Litre) Distilled	P.P.I. 90 Base	P.P.I. 96 Base 1.943
0.96	0.000	0.529	0.0	28.1	28.1	889.0	25017.6	0.457	0.543	11433.0	13584.5	0.289	0.140	39.3	20.2
0.96	0.000	0.529	0.0	27.7	27.7	878.8	24357.6	0.496	0.504	12081.3	12276.2	0.318	0.131	36.4	18.7
1.92	0.000	1.058	0.0	69.1	69.1	900.7	62267.5	0.463	0.537	28829.9	33437.6	0.381	0.171	45.8	23.6
1.92	0.433	1.058	30.2	73.9	104.1	891.5	92848.7	0.484	0.516	44938.8	47909.9	0.415	0.139	43.2	22.2
1.92	0.433	1.058	25.6	62.6	88.2	893.1	78730.0	0.506	0.494	39837.4	38892.6	0.444	0.158	46.3	23.8
1.92	0.865	1.058	52.8	64.5	117.2	887.4	104029.6	0.588	0.412	61169.4	42860.2	0.485	0.188	50	25.7
1.92	0.865	1.058	40.9	50.0	90.9	922.3	83847.6	0.549	0.451	46032.3	37815.3	0.551	0.331	58.3	30.0
2.88	0.865	1.587	45.5	83.3	128.8	904.5	116492.5	0.489	0.511	56964.8	59527.7	0.659	0.327	72.8	37.5
2.88	0.865	1.587	46.6	85.5	132.1	882.8	116638.5	0.460	0.540	53653.7	62984.8	0.763	0.305	84.6	43.5
3.85	0.865	2.115	51.5	126.0	177.5	890.6	158091.5	0.466	0.534	73670.7	84420.9	0.874	0.304	89.5	46.1
3.85	1.298	2.115	73.7	120.1	193.9	897.9	174084.8	0.525	0.475	91394.5	82690.3	1.002	0.411	100	51.5
3.85	1.298	2.115	67.4	109.9	177.3	903.8	160246.8	0.547	0.453	87655.0	72591.8	1.035	0.423	117.1	60.3
4.81	1.731	2.644	84.4	128.9	213.3	899.8	191945.6	0.535	0.465	102690.9	89254.7	1.180	0.402	130.5	67.2
4.81	1.731	2.644	75.9	116.0	192.0	897.2	172237.2	0.618	0.382	106442.6	65794.6	1.280	0.306	132.1	68.0
4.81	1.731	2.644	59.2	90.4	149.5	894.2	133708.0	0.699	0.301	93461.9	40246.1	1.280	0.562	129.1	66.4
5.77	2.163	3.173	80.1	117.5	197.6	908.2	179447.7	0.793	0.207	142302.0	37145.7	1.390	0.588	147.2	75.8
8.65	2.163	4.760	83.0	182.6	265.6	901.2	239316.5	0.875	0.125	209402.0	29914.6	1.680	0.596	194.3	100.0

Appendix 11 (Continued): Financial Cost Benefit Flow for Stellenbosch Production Region

Real Price of Produce (R/Litre)		Real Value of increase Production (Rands)		Total value of increase production per year	Time Preference 1996 terms	Revenue saved from techn.	Total Revenue from Technology	Total Cost of Technology	Cost associated with Stellenbosch	Net Benefit Per Year	Accumulated Net Benefit
Good	Distilled	Good	Distilled	(Rands)	7% discount rate	(See Appendix 6)	(Rands)	(Rands)	Region	(Rands)	(Rands)
								936.13	114.7	-114.7	-114.7
								1,882.26	233.4	-233.4	-348.1
								3,222.96	396.4	-396.4	-744.5
								8,055.72	986.8	-986.8	-1731.3
								11,001.25	1342.2	-1342.2	-3073.5
								11,768.37	1424.0	-1424.0	-4497.5
								17,574.48	2117.7	-2117.7	-6615.2
								17,839.32	2158.6	-2158.6	-8773.7
								41,505.80	4939.2	-4939.2	-13712.9
								34,973.02	4196.8	-4196.8	-17909.7
								52,374.76	6127.8	-6127.8	-24037.5
0.059	0.028	669.0	384.1	1053.1	3326.643482	449.4	3776.1	98,078.62	11377.1	-7601.1	-31638.6
0.060	0.024	720.2	300.5	1020.6	3013.109309	392.1	3405.2	103,233.03	12800.9	-9395.7	-41034.3
0.090	0.040	2590.5	1345.2	3935.7	10858.78198	742.7	11601.4	102,155.67	13995.3	-2393.9	-43428.2
0.092	0.031	4147.5	1484.9	5632.4	14523.31063	663.2	15186.5	104,865.34	14786.0	400.5	-43027.7
0.106	0.038	4216.7	1464.3	5681.1	13690.45527	609.6	14300.0	66,574.97	8321.9	5978.1	-37049.6
0.125	0.048	7639.1	2073.5	9712.6	21874.68119	566.8	22441.5	88,734.75	12511.6	9929.9	-27119.7
0.165	0.099	7614.6	3755.7	11370.3	23932.79358	511.5	24444.3	100,981.43	12420.7	12023.5	-15096.2
0.247	0.123	14061.1	7293.3	21354.4	42007.34494	713.7	42721.0	101,785.18	11908.9	30812.2	15716.0
0.332	0.133	17815.3	8364.4	26179.7	48130.32055	652.3	48782.6	72,809.84	8445.9	40336.7	56052.7
0.403	0.140	29669.2	11821.5	41490.7	71288.73557	754.8	72043.5	118,927.14	14865.9	57177.7	113230.3
0.516	0.212	47146.0	17491.4	64637.4	103793.5236	605.8	104399.3	214,304.56	27645.3	76754.0	189984.4
0.624	0.255	54697.7	18506.0	73203.6	109858.9335	509.0	110367.9	469,912.99	58269.2	52098.7	242083.1
0.793	0.270	81414.0	24098.8	105512.7	147987.0523	533.1	148520.1	374,632.66	44581.3	103938.8	346021.9
0.870	0.208	92630.8	13688.1	106318.9	139362.3727	455.0	139817.3	416,258.45	51199.8	88617.5	434639.5
0.850	0.373	79487.3	15028.4	94515.8	115785.8728	390.5	116176.4	221,665.25	21723.2	94453.2	529092.6
1.053	0.445	149851.5	16547.1	166398.5	190509.6484	396.3	190905.9	253,621.11	26883.8	164022.1	693114.7
1.680	0.596	351795.3	17829.1	369624.4	395498.0845	549.7	396047.8	359,721.74	37770.8	358277.0	1051391.7
										IRR	25%
										npv @ 5%	R297,344.73
										npv @ 7%	R181,501.40

Appendix 12: Net Benefit Flow for Stellenbosch Production Region