ESTIMATING THE ECONOMIC RATE OF RETURN TO RESEARCH IN THE SOUTH AFRICAN DECIDUOUS FRUIT INDUSTRY

By

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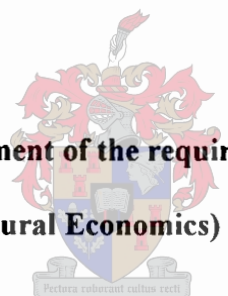

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Declaration

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

Histories gesien is kommersiële landbou-navorsing in Suid Afrika deur die owerheid ondersteun, maar as gevolg van die onlangse politieke veranderinge in Suid Afrika is hierdie toedrag van sake besig om te verander. Die politieke oorgang in die land het gepaard gegaan met 'n verandering in ekonomiese beleid, wat 'n inkorting van owerheidsbefondsing aan die Landbounavorsingsraad meegebring het. Hierdie Raad is in 1992 gestig, met die primêre doel om groter privaatsektor betrokkenheid in navorsing vanuit die betrokke sektor te verseker, as gevolg van die verwagte onttrekking van owerheidsteun. As gevolg hiervan, is daar nou 'n toenemende erkenning aan die behoefte om navorsingsprojekte te evalueer in terme van die ekonomiese opbrengs op sulke investering, sodat besluitnemers geldige bewyse het waarvolgens bestedingsprioriteite gemaak kan word.

Hierdie studie gebruik die bekende produksie-funksie benadering om die ekonomiese voordele van navorsing in die Suid-Afrikaanse sagtevrugte bedryf te evalueer. Die studie begin met 'n oorsig oor die sagtevrugtebedryf, insluitend 'n analise van die navorsingstruktuur wat tans heers. Bogenoemde word gevolg deur 'n beskrywing van die bestaande *ex post* metodes om ekonomiese voordele van navorsing te evalueer, sowel as die wyse waarop die data vir die analiese ingesamel is.

Die resultate wys dat daar 'n beduidende statiese verhouding is tussen besteding op navorsing en pryse en die opbrengs behaal deur produsente in die bedryf. Hierdie resultate moet egter met sorg geïnterpreteer word, en meer moeite moet gedoen word om te verseker dat die nodige data ingesamel word. Nietemin toon die resultate dat verhoogde navorsingsbesteding in die bedryf geregverdig is.

Abstract

Historically, commercial agricultural research in South Africa has been state supported, but due to recent political changes in South Africa this is changing. The political transition has been accompanied by changing economic policies, causing a tightening of public funds allocated to agricultural research. In 1992 the Agricultural Research Council was formed, primarily to enable greater industry involvement in research as a result of the expected long term budget cuts in publicly funded research. As a result there has been an increased recognition of the need to evaluate research in terms of the economic returns to investment so that decision makers have hard evidence on which to prioritize their investments.

This study employs the well known production function approach to evaluate the economic benefits of publicly funded research in the South African deciduous fruit industry. In reporting the results of the research the study proceeds from an overview of the deciduous fruit industry, as well as an analysis of the structure of deciduous fruit research in South Africa. This is followed by a description of the economics of research expenditure, a description of *ex post* methods of evaluating the economic benefits of research, and the manner in which the data for the analysis was collected. The analysis suggests there is a statistically significant relationship between research and development and industry output as well as industry prices and output. However the results should be interpreted with care, and more effort should be made to ensure that required data are

gathered. Nevertheless, the results show that increased research expenditure in the industry is justified.

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Table of Contents

List of Figures.

List Of Tables

CHAPTER ONE

INTRODUCTION

1.1 Problem Statement

Agricultural research in South Africa has shared two main characteristics throughout the 20th century: it has largely been funded by the state, and it has focused almost exclusively on the needs of commercial farmers (Lipton, 1996). State support to agriculture had its origin in the 19th century, especially in the former Cape colony, but was given new impetus in 1911 when the Department of Agriculture was established after the formation of the Union. In this process 18 divisions were established to take responsibility for various aspects of agricultural research and extension (Roseboom *et al*, 1995). It was only in April 1992, after an extended period of deregulation that had already started in the 1980's, that most of the agricultural research resources and the accompanying activities of the state were transferred to the newly formed Agricultural Research Council (ARC).

However, this was done before the 1994 elections that resulted in a new majority representative government taking office. As a result, further changes to the agricultural research system were widely expected. First, the new government of South Africa has priorities that differ widely from those of the previous regime. The result is that state funding for agricultural research that was aimed at benefiting white commercial farmers has been redirected to focus on the research needs of small farmers. Secondly, the budget restrictions that have resulted from the new more conservative economic policies of the government have resulted in a reduced allocation of funds to the ARC.

These changes have created a need for a more careful allocation of scarce funds within the ARC. It is, therefore, vital that the costs and benefits of research conducted at the various research institutes of the ARC should be evaluated to provide decision-makers

with a guide to the economic returns of the funds spent. It is in this light that this study attempts to evaluate the internal rate of return to research by employing statistical analysis that uses costs of research and the associated benefits of this investment. In this way an optimal allocation of funds, between the different industries in the agricultural sector, to emerging and established farmers respectively and to different research projects can be ensured.

1.2 Research Methods

Econometric evaluations in economics were developed from a desire to further understand economic phenomena, and have been regarded as a creative synthesis of theory and evidence (Townsend, 1997). The use of econometrics in evaluating the returns to research began with the thought "that some sort of cost-and-returns calculation is possible and should be made" (Griliches, 1958, p. 385). Griliches' study attempted to estimate the economic returns to research on hybrid corn in the United States. In that study he estimated the expenditures on research, and the social returns to research, which he took to be approximately equal to the increase in corn production, plus a price change adjustment. The resulting vector of figures was adjusted to take account of cost and time value of money considerations. The flow of returns was then divided by the expenditure estimates to arrive at an estimate of the returns to the investment.

Since Griliches' study, numerous others have been conducted in an attempt to refine the methodology and arrive at a more accurate estimate of the economic benefits from investment in research (Ruttan, 1982). Different techniques have been used to estimate these returns, and as a result there is a wide range of estimates of the return to various types of research. The analytical techniques followed in these studies fall into two main categories: *ex post* and *ex ante* procedures (Norton and Davis, 1981).

The *ex post* techniques fall into two categories:

- Those using measurements of the consumer and producer surplus directly to estimate an average rate of return to research (the production function approach).

- Those that estimate a marginal rate of return by treating research as a variable in a production function.

The *ex ante* approaches fall into four groups, namely:

- Techniques that use scoring models to rank research activities;

- Techniques that employ benefit cost analysis to establish rates of return to research;

- Techniques that use simulation models; and

- Techniques that use mathematical programming algorithms to select an optimal mix of research activities.

The *ex ante* approaches are used mainly for appraising the expected return to future research expenditure in order to prioritise funding, whereas the *ex post* techniques normally use historical data to evaluate the efficiency of past research expenditures. In this study ordinary least squares regression analysis and the popular production function approach is used in an attempt to place an economic value on the benefits of research in deciduous fruit in South Africa. The analysis focuses on past research at the industry level, and aims to provide guidance to decision makers on how best to allocate funds.

1.3 Outline of The Study

Chapter Two provides an overview of the South African deciduous fruit industry, and compares this industry with that of some other countries in the Southern Hemisphere. A review of the history of the marketing of agricultural products in South Africa is given,

with a brief description of those aspects of the new Marketing of Agricultural Products Act, No.47 of 1996 that will have a significant impact on the industry. It covers the history of the marketing of deciduous fruit, and the changes that have led to the current arrangements in the industry. The chapter briefly discusses the likely impact of these changes as well as a description of the current industry structure.

Chapter Three outlines the history of agricultural research in South Africa, with the focus on the history of research in the deciduous fruit industry. Agricultural research in this country has changed over the years, often due to changes in government policy. Since the formal establishment of research institutions after Union in 1910 the State has supported research, mostly to the benefit of the commercial farming sector. In recent years, one of the most notable changes in state enterprises has been the movement towards the reorientation of the services rendered, the commercialisation of services, and in some cases, privatisation of the institutions themselves.

State enterprises in the agricultural sector, including those in the research sector, have not escaped the effects of this shift in government policy. The agricultural research sector has been under pressure to cut costs and find alternative sources of funding. Under the guidance of the Department of Agriculture, the funding mechanism has changed to allow industry to take a more active role and to make researchers more responsive to industry needs.

This chapter describes the changes in agricultural research and describes the evolution of research in the deciduous fruit industry. The recently formed Agricultural Research Council and the transitions that have resulted from deregulation in the deciduous fruit industry towards the end of 1997 are described.

This is followed in **Chapter Four** by an analysis of the economics of research, with a view to expanding choices on the optimal sources of funding for agricultural research. The funding of research is a contentious issue in the agricultural economics literature. The division between where the product of research becomes a private rather than a

public good is usually vague, hence the uncertainty about private or public provision. The general view is that as the appropriability of research increases, so should private investment increase.

The first part of this chapter describes the economic theory of research, including possible funding methods, whereas the second part briefly outlines a model of competitiveness. These two parts act as the basis for the discussion, in the final section, of a possible future agricultural research structure and the manner in which the research industry for deciduous fruit in South Africa could conduct itself.

Chapter Five starts with an overview of the history of attempts to measure the returns to agricultural research. A survey of earlier measurements shows that the estimated returns to research in agriculture range from a negative 48 percent to positive 130 percent. The majority of these studies estimate returns to be between 30 percent and 60 percent. A later survey, however, shows that the returns are slightly lower than those estimated in the earlier reports, but that they are generally in excess of 20 percent.

In this chapter the analytical techniques that are typically used to estimate returns to research in agriculture, namely *ex post* and *ex ante evaluation* techniques, are described.

In the first part of **Chapter Six** the data used to analyse the returns to research in the deciduous fruit industry in South Africa, and the way in which these were collected, are described. This consists of a documentation of the costs of research, and the type of data available. An outline is given of the methodology used for obtaining the final data series, which is then presented in tabulated form.

The scope of the analytical section of this study covers the returns to research in deciduous fruit in South Africa at the industry level. This study makes use of regression analyses to estimate these returns. These estimates were based on lagged regressions of seven, twelve and eighteen years respectively. The results show returns that are high by comparison with earlier studies of the returns to research in agriculture, but that are

plausible given the strong growth in the industry in the past decade, and good communication of research results to the farmers.

Chapter Seven includes a summary of the study, along with a conclusion regarding the possible policy implications that can be drawn from the investigation. These implications include the need to constantly monitor research and its impact on the wider socio-economic environment within which it is being conducted.

CHAPTER TWO

AN OVERVIEW OF THE SOUTH AFRICAN DECIDUOUS FRUIT INDUSTRY

2.1 Introduction

To appreciate fully the analysis that is central to this study, it is important to see where the deciduous fruit industry has come from and where it is going. The analysis in Chapter Five uses, as well as other variables, the total cost of research in deciduous fruit and a series that expresses the value of output as part of a production function in an attempt to estimate the economic rate of return to research. The reader, therefore, requires some knowledge of the growth of the industry over the years to aid in an objective evaluation of the final result from the economic rate of return to research calculations for the industry.

This chapter describes trends in the production of fruit in the industry, and compares this with the industry in a number of other Southern Hemisphere countries. A review of the history of the marketing of agricultural products is given, with a brief description of those aspects of the new Marketing of Agricultural Products Act, No.47 of 1996 that will have a significant impact on the industry. Changes that have occurred in the deciduous fruit industry are also described, together with predictions of the likely impacts of the recent deregulation.

2.2 Deciduous Fruit Production

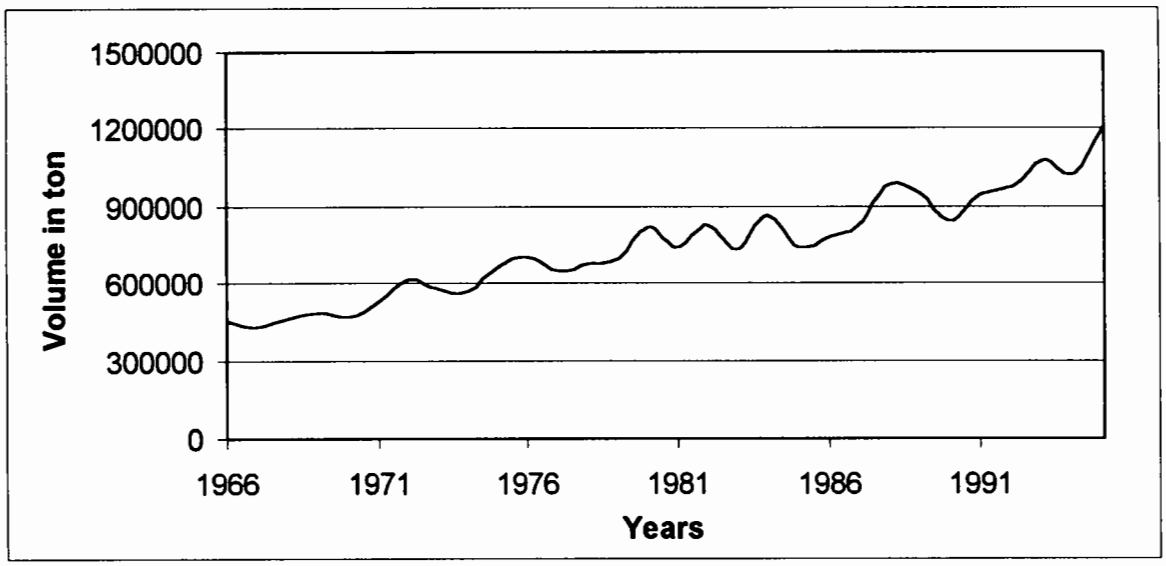
By international standards, South African has a poor natural resources base. Rainfall is unreliable and the country as a whole is subject to severe and recurrent droughts, sometimes broken by devastating floods. Of the 99-1-million hectares of available

agricultural land, only approximately 15 - 17 percent are suitable for crop production, and less than 5 percent is irrigable (Abstract, 1997). Furthermore, only a small proportion of the land suitable for cropping is in the Western Cape, which is the heart of the deciduous fruit industry.

Over 170 deciduous fruit varieties are grown in South Africa, mostly in the South-western parts of the country. The main cultivation districts include the Elgin/ Grabouw valley, the Villiersdorp/Vyeboom area, The Hex River valley, Stellenbosch, Franschhoek, Paarl, the Wellington Ceres/Bokkeveld/Piketberg, area, the Koo/Barrydale/Ladismith region and the Langkloof. Outside the Western Cape, mostly table grapes are grown in the Lower Orange River region, along the Vaal River and in the Waterberg district, while there has been a recent establishment of stone fruit production in the eastern Free State.

In 1995, the total value of deciduous fruit production (stone fruit, pome fruit and table grapes) was R2367m, of which R1136,7m or 48 percent was exported (Abstract,1998). Deciduous fruit made up 38 percent of the average gross income of all South African horticultural product exports and 24 percent of total agricultural output in the Western Cape. The industry contributed 6 percent of the country's gross value of agricultural production. This production was achieved by 2165 growers, on 53000 hectares. Figure 2.1 illustrates the growth in production achieved by the deciduous fruit industry since 1966.

From Figure 2.1 it is evident that industry output grew steadily, from some 500000 tons in 1966 to some 700000 tons in 1981. Although industry output fluctuated considerably from the mid-70s to the mid-80s, there appeared to be little growth. However, since the late 1980's the rate of growth in output has increased considerably, to some 1200000 tons in 1996.



Source: Adapted from Abstract(1997)

Figure 2.1: Deciduous Fruit Production 1966-1995.

Table 2.1 below shows the composition of industry exports by fruit type since 1975. The most striking feature of industry exports has been the relatively faster growth in the exports of table grapes as compared to the exports of apples. In 1975 the 139000 tons of apple exports constituted 61 percent of total deciduous fruit exports. Although the volume of apples exported grew to more than 171 000 tons in 1995, this represented only a third of total exports. It is estimated that, by 2000, apples will make up only a quarter of total exports. By contrast, table grape sales in foreign markets grew from 57 000 tons or a quarter of total exports, to almost 200 000 tons in 1995.

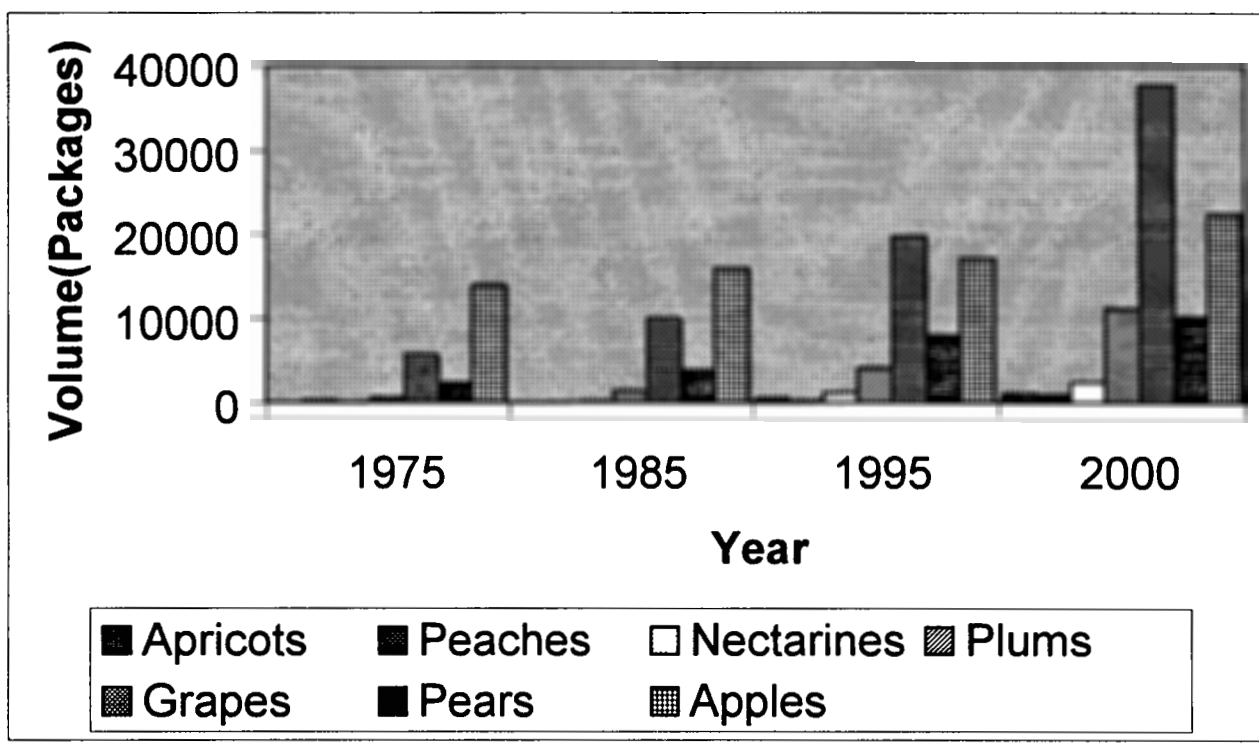
During these years the quantity of plums and apricots exported grew faster than any of the other fruit types, from less than 2,5 percent in 1975 to an expected 12-13 percent by 2000 in the case of plums, and from a negligible 140 tons to over 10 000 tons over the same period in the case of apricots. These trends are also illustrated in Figure 2.2 below.

Table 2.1: Unifruco Deciduous Fruit Exports (tons).

Fruit	1975	%	1985	%	1995	%	2000[1]	%
Apricots	140	-	310	0,1	4920	1,0	10800	1,3
Peaches	2450	1,1	760	0,2	2490	0,5	9140	1,1
Nectarines	0	-	1580	0,5	11360	2,2	24680	2,9
Plums	5550	2,4	13810	4,4	41880	8,2	110820	12,9
Grapes	57060	25,0	99700	31,7	197560	38,8	377520	43,9
Pears	23850	10,5	38690	12,3	80160	15,7	101610	11,8
Apples	139010	61,0	159310	51,0	171190	33,6	225000	26,2
Total	**228060**	**100**	**314160**	**100.2[2]**	**509560**	**100**	**859570**	**100.1[2]**

Notes: [1] Estimate. [2] These figures do not add to 100 due to rounding errors.

Source: Unifruco



Source: Unifruco

Figure 2.2: Unifruco Deciduous Fruit Exports 1975 – 1995 and 2000 (predicted).

Comparable production figures for apple production for South Africa, New Zealand, Argentina and Chile are shown in Table 2.2.

Table 2.2: Comparable Production Statistics for Apples.

	South Africa	New Zealand	Argentina	Chile
Actual yield (tons/ha)	40	45	35	42
Potential yield (tons/ha)	55	62	55	60
Potential Net Farm Income (US$/Ha)	6642	4956	9409	9858
Development costs (US$/Ha):				
Land and Water	3500	13800	3000	3000
Orchard establishment	15000	13800	7500	7500
Housing	6000			
Equipment	5200	4400	5200	5200
Packing Facilities	6667	6000	6667	6667
Total Investment (US$/Ha)	**36367**	**38000**	**22367**	**22367**

Source: Muller (1996). The potential production figure is calculated with specific reference to chilling units, colour development and natural resources. The figure for net farm income is based on potential production, potential prices, costs and the varietal mix grown.

According to these data the average yield for apples in South Africa is comparable to the yield in competitor countries, although it seems as if the potential yield is lower than that of New Zealand and Chile. South African producers harvest some 40 tons of apples per hectare at present, while it is estimated that the potential yield is 55 tons/ha. This compares favourably with the yield achieved by farmers in Argentina and Chile, although their lower establishment costs result in a net farm income that is more than 50 percent higher. By contrast, South African yields are lower than those achieved in New Zealand although the net farm income is higher.

As can be seen from the Table, the discrepancy in net farm income per hectare is largely due to the level of investment required to develop orchards. South African producers pay more for the development of a hectare of fruit trees than their counterparts in Chile and

Argentina. While the cost of land and water, equipment and packing facilities is similar between the countries, South African producers have to provide housing for permanent farm workers, and their orchard establishment costs are higher. These latter costs are probably the result of poorer soils and the lower availability of water in South Africa. In addition, producers in the South American countries do not compensate for the fact that they do not have to provide worker housing by paying higher wages. The Organisation for Economic Co-operation and Development (OECD) has calculated that the average income for a permanent worker in the Cape fruit industry is around 250 European Currency Unit (ECU) per month compared with 183 ECU per month in South America (Muller, 1996).

2.3 Marketing

The first controls over the marketing of agricultural products in South Africa were introduced in 1934 as a result of the recommendations of the Viljoen Committee (De Swardt, 1983). As a result regulations were introduced in the deciduous fruit industry in an attempt to improve the profitability of the farmers. This was followed in 1937 by the promulgation of the Marketing Act. Under this legislation, producers of an agricultural commodity could call for the introduction of a scheme to market their produce. A Control Board was then set up to administer the scheme. Producers of the commodity formed a majority of the members of the board. The National Marketing Council acted as an advisory and investigative body under the Marketing Act.

This control over agricultural marketing in terms of the Marketing Act of 1937 (and the revised and consolidated Marketing Act, No 59 of 1968) built on state support to commercial farmers through actions such as the Land Bank Act of 1912 and the Co-operatives Societies Act of 1922, etc. The Marketing Act was based on the argument that the inelastic demand for farm products, the adverse climate in South Africa, the lack of information and the risks inherent to a free market system were all factors that justified state intervention in the agricultural sector.

Provision was made in this legislation for a system of control over the movement, pricing, quality standards and marketing supply of a major portion of farm production in South Africa. In addition, a range of marketing parastatals were set up in many of the former homelands, together with a complex set of agency agreements with different Control Boards. New schemes had to be passed by the Minister, with assistance from the National Marketing Council. The most important areas of control of the Act, pertaining to the export and importation of agricultural commodities, were:

- To prohibit the import or export of a product altogether;
- To prohibit the import or export of a product except with a permit issued by the Director General of Agriculture on such conditions as may be determined;
- To confer on the Director General or a Control Board the right to import or export a product;
- To prohibit the import or export of a product except by a Control Board or a person authorised thereto by the Board, on conditions that the Board may determine.

Since the early 1980s there has been a substantial shift in farm policy in South Africa. Until the advent of the first democratically elected government in the country in 1994, these changes largely took the form of a relaxation of control within a pre-existing institutional order. For the agricultural sector, the change in the constitutional order in the period after 1994 was accompanied by a process of dismantling of the existing marketing institutions, and a substantial restructuring of other support institutions such as the Land Bank, the Development Bank of Southern Africa and the Agricultural Research Council. As a result, the sector was faced with changes that included a move to the establishment of market-related interest and exchange rates as a result of liberalisation in the financial markets in the early 1980s; the decline in real producer prices of commodities such as maize and wheat; an extensive deregulation of controlled marketing; a shift away from settlement schemes to farmer support programmes in the former homelands; the introduction of certain elements of labour legislation to agriculture and the scrapping of the Land Acts in 1991 (Kassier, 1993).

Until the promulgation of the Agricultural Products Standards Act of 1990 the Marketing Act also covered grades, classes, standards of composition and marking requirements of products, while a prohibition could be placed on the sale of a product unless graded, marked and packed in a specific manner. Since 1990, this function has been regulated under the Agricultural Products Standards Act, other than where a Board is entitled to buy a product or act as agent in receipt thereof, in which case the Board may prescribe conditions pertaining to grading, packing and marking (Kassier, 1993).

The Deciduous Fruit Board (DFB) was formed on 6 October 1939. The Board was formed under the auspices of the 1937 Marketing Act, and was given statutory powers to arrange all exports of deciduous fruit (Von Hoesselin, 1978). Although the Board was formed in 1939, a single channel export system was only instituted during the 1946/47 production season when exports were resumed after the Second World War..

Changes and adjustments to the marketing scheme were made regularly, but perhaps the most significant was the formation of Unifruco in 1987, and the board's decision to appoint this organisation as its sole agent to export on its behalf (*Deciduous Fruit Grower*, October 1997, p. 373). In terms of this appointment Unifruco were delegated seven export monopolies by the DFB covering all the main export markets, and were given statutory powers that essentially made it 'the' industry. Unifruco recorded industry information and controlled the dissemination of this information. All decisions pertaining to export marketing were centralised in Unifruco and it controlled the entire associated infrastructure.

In 1992 the Kassier Report on South African Marketing schemes appeared, calling for the deregulation of the Control Boards. The deregulatory sentiments of this report were also supported by the African National Congress, and eventually taken up in the new Marketing of Agricultural Products Act of 1996. Since the Kassier report, deregulation has swept through the South African marketing scene. In the deciduous fruit industry this manifested itself in the issuing of permits by the DFB to a wide range of other marketers

during the 1996/97 and 1997/8 seasons, and the scrapping of the deciduous fruit scheme in 1997.

The latest change in the marketing of agricultural products has come about with the promulgation of the Marketing of Agricultural Products Act, No. 47 of 1996, which states that a statutory measure may only be introduced if the Minister of Agriculture is satisfied that such a measure will directly and substantially advance one or more of the objectives of the Act without substantially prejudicing any of the other objectives. The objectives of the Act are to:

a) Increase market access for all market participants;
b) Promote the efficiency of the marketing of agricultural products;
c) Optimise export earnings from agricultural products; and
d) Enhance the viability of the agricultural sector.

In addition the Act states that no statutory measure or prohibition which is likely to be substantially detrimental to food security, to the number of employment opportunities within the economy or to fair labour practices may be instituted. The Act makes provision for the establishment of the National Agricultural Marketing Council (NAMC), which replaces the National Marketing Council. The NAMC differs somewhat from its predecessor in terms of its composition, its powers and functions, and the procedures to which it must adhere.

Unlike the National Marketing Council, whose members were officials of the Department of Agriculture, appointed by the Minister, the members of the NAMC have to have 'practical knowledge and experience' of one or more of the following:

- The commercial production of agricultural products;
- Agricultural product-related trade and industry;
- Agricultural economics, including agricultural marketing and international trade;

- Consumer issues relating to agricultural products, including issues relating to previously disadvantaged communities;
- The production and marketing of agricultural products by small-scale and previously disadvantaged farmers.

Two persons from each of the above categories are appointed to serve on the council. The minister appoints these members after a selection committee, appointed by the minister, has submitted its recommendations to the parliamentary committees responsible for agriculture.

The NAMC also has wider powers than its predecessor had, namely:

- The staff of the NAMC are explicitly under control of the Chairperson of the Council;
- The minister approves the budget of the Council after consultation with the Minister of Finance and, in keeping with standard procedures, the funds are channelled through the Department, ' ... The chairperson of the Council shall ensure that proper books and financial records are kept.'
- Where the council makes recommendations regarding the implementation of a statutory measure the minister has to publish his or her reasons for accepting, rejecting or referring back those recommendations in the Government Gazette within thirty days of such a decision.

The first two points above illustrate the independence of staff of the Council that was not enjoyed by members of the previous council. In addition the following conditions proscribe the actions of the NAMC (Vink, 1998):

- The NAMC has to involve all directly affected groups in the deliberations on the introduction, amendment or abolition of statutory powers;
- The NAMC has to include minority reports from among its members in any advice or recommendation to the minister;

- The NAMC has to monitor statutory measures applied and evaluate and review such measures at least every two years;
- All meetings of the NAMC are open to the public unless explicitly ruled otherwise by the Chairman.

The result of these changes was that statutory intervention in the marketing of agricultural products came to an end. In the deciduous fruit industry this meant that anyone was allowed to export produce, subject only to the ruling quality and phytosanitary requirements. The industry reacted by reorganising the structures that had been created to server the interests of the farmers. A free market for exports was created. On 1 October 1996, the new formal structures for the industry were adopted and the 1996/97 season was the first season of deregulated trade. *The Deciduous Fruit Grower* (December 1996, p. 445) reported that the DFB had already issued 70 permits for the export of deciduous fruit by the date of its publication. During the time that Unifruco was sole exporter of South African deciduous fruit, it exported fruit to markets in 26 European countries, as far west as Canada and as far east as Hong Kong. It, therefore, selected the retailers of South African fruit. Since deregulation, deciduous fruit farmers have been free to choose how to export their fruit and to whom to sell their produce in foreign markets. On 30 September 1997, the Deciduous Fruit Board was abolished and a new structure formed.

Advantages and Disadvantages of Deregulation

The full effects of deregulation on the deciduous fruit industry will most likely only be felt after a number of years. Deregulation has seen the entry of many exporters and with it the freedom of producers to choose the channels through which their fruit is to be exported. With this change, the controlled environment of the industry has been lost as the industry enters a new free-market era. This section describes the changes likely to occur in the industry, based on the findings of a committee of the National Agricultural Marketing Council (1997). The experience thus far points to the following disadvantages of the new, deregulated marketing environment:

- In the regulated market, quality standards were easy to maintain, as producers were required to export through a single channel. This feature has been lost in the changes;

- Many producers have lost the advantage of selling under the "Cape" brand, which has been retained by Unifruco;

- Under the single channel regime, Unifruco was able to address industry problems on a countrywide basis. The industry was well co-ordinated under Unifruco and information was readily available. Logistical problems were also easier to handle;

- On the marketing side, the gains from economies of scale in the use of marketing infrastructure have been lost. This infrastructure also supported emerging farmers.

- Unifruco was able to maintain high (protected) producer prices. South African fruit received a 30 percent premium over ruling world prices due to the industry being controlled by a single exporter.

- Research was also maintained and controlled by a central body.

- Unifruco had an active advertising campaign in Europe that proved to be generic advertising for the entire industry. Although producers previously effectively paid for this advertising, it was minimal as the cost was spread across the whole industry and all products were sold under the "Cape" brand. These marketing benefits are lost as individual exporters market their products individually.

On the other hand, deregulation also has a number of potential advantages:

- The free market structure now in place allows for freedom of choice. The industry is likely to respond better to market forces as decision making has been

decentralised. The South African marketing chain may, therefore, become more competitive as many players in the market compete with each other for produce.

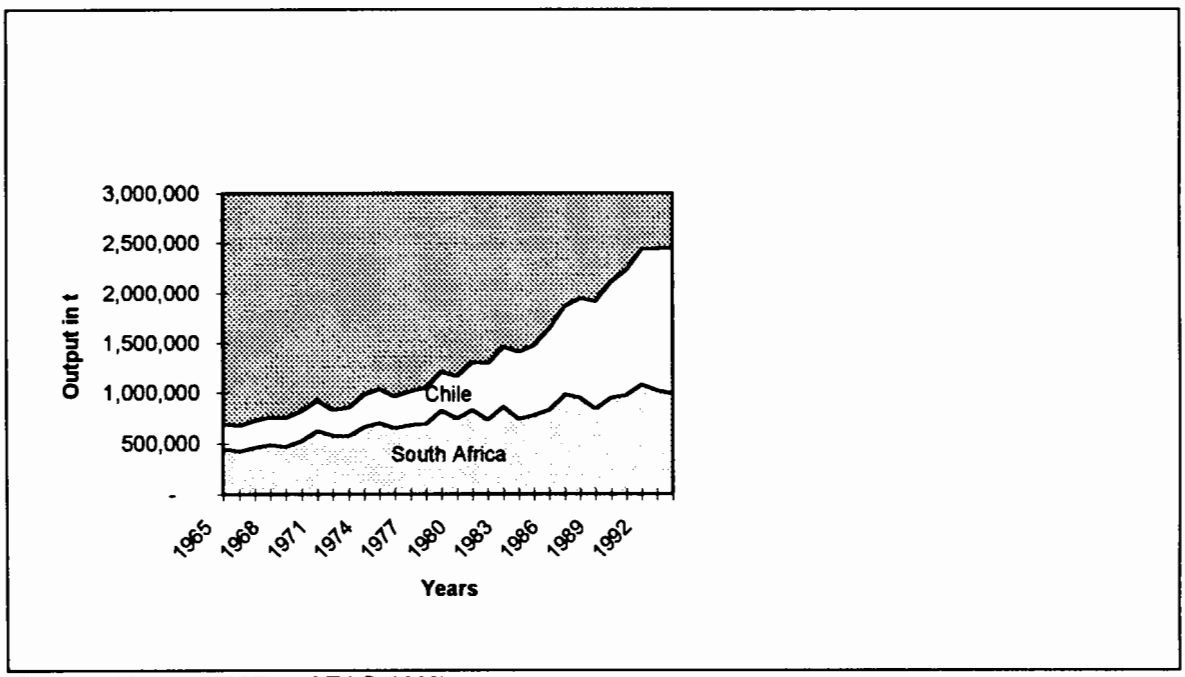
- Export sales are also likely to grow considerably, as Unifruco was unable to exploit new or smaller markets. Producers can now exploit niche markets where there is the potential for better prices. This should result in a greater diversity of destination see (Table 2.3) and, therefore, less risk to the industry as a whole.

- As sources of information will no longer be readily available, producers will now have to pay for information. This should encourage the source to provide necessary and applicable information that is pertinent and current that can be readily accepted and applied.

Figure 2.3 and Table 2.3 below show some of the consequences of the level of control exercised in the South African deciduous fruit industry, when the deciduous fruit industry is compared with that of Chile over the past 20 years. Figure 2.3 shows that deciduous fruit production in South Africa grew at a relatively slow rate between 1975 and 1995. At least part of the explanation lies in the sanctions against South Africa's exports during the 1980s. However, it could be argued that sanctions also allowed bureaucrats to maintain the degree of centralisation that was achieved. The Marketing Act also limited market access to certain sectors of the population. Nevertheless, the effect of the withdrawal of economic sanctions on South Africa can be seen by the increased industry growth from the late 1980s onwards (Figure 2.1).

The free markets and greater property rights that existed in Chile over this period attracted foreign investment in the Chilean deciduous fruit industry which translated into growth of production of more than 400 percent in a period in which the South African production only grew by 100 percent. Vink (1998) illustrates the point further with reference to comparative data for apple exports, which grew by 66 percent for South Africa, compared to more than 800 percent for Chile in the period 1975-1995. Besides these institutional differences, because the Chilean farmers had access to independent

export marketing companies, they had no need to tie up capital in packing facilities. Therefore, these farmers had the added advantage that they were able to invest a greater proportion of retained earnings in production capacity than their South African counterparts.



Source: Abstract(1997) and FAO(1998).

Figure 2.3: Comparative Industry Production, SA and Chile, 1965-1994.

Further it could be argued that single-channel exporting leads to a concentration of sales on a few markets. In this regard the destinations of apples exported from four Southern Hemisphere countries in 1995 are shown in Table 2.3.

Table 2.3 shows the effect a single exporter had on the markets South Africa sold to in comparison to other deciduous fruit producing industries. In the case of New Zealand and Chile the result of a deregulated marketing regime was that sales were spread more evenly and to more markets than in the case of South Africa with its regulated industry.

This wider exposure reduces the vulnerability of producers to the risk of changes in a single market.

Table 2.3: Apple Export Markets: 1995 (percent per region)

REGION	South Africa	New Zealand	Argentina	Chile
Europe	79	60	95	50
North America	13	20	2	5
Middle East	5	*	*	19
Far East	2	18	*	4
Other	1	2	3	22

Source: Unifruco.

Quality Control and Shipping

Quality control has been conducted by the Perishable Products Export Control Board (PPECB), established in 1926, to ensure that all producers have a share of the export space available. The DFB had not then been formed and the PPECB dealt with individual exporters.

A 2 percent sample of every consignment of fruit submitted for export is still inspected by the independent inspectors of the Perishable Products Export Control Board. This inspection is conducted at the ports where the fruit is exported.

Most fruit from South Africa is exported by ship, with the notable exception of early-season fruit that is flown to its destination markets. Under the single channel arrangement, all deciduous fruit was shipped from the ports by International Harbour Services, which is a wholly owned subsidiary of Unifruco. This export fruit was accepted at about 80 intake depots spread throughout the production areas, and from there it was transported by rail and road to the ports.

2.4 The New Industry Structure

The structure of the representative bodies in the industry in the post-deregulation era is illustrated in Figure 2.4. Since the abolition of the Deciduous Fruit Board, a new body has been formed to represent the South African producers of apple and pears (pome fruit), stone fruit and table grape producers. This body is known as the Deciduous Fruit Producers Trust (DFPT).

The DFPT aims to provide a communal cost-effective system that will interact with farmers to provide necessary activities such as research and development, plant improvements, certification, domestic generic promotions and general information distribution. Its priority is to collect information regarding developments, opportunities, production levels, industry figures, statistics and norms (Figure 2.4) (SAAPPA, 1997)

The DFPT consists of the three main industry representative bodies, namely:

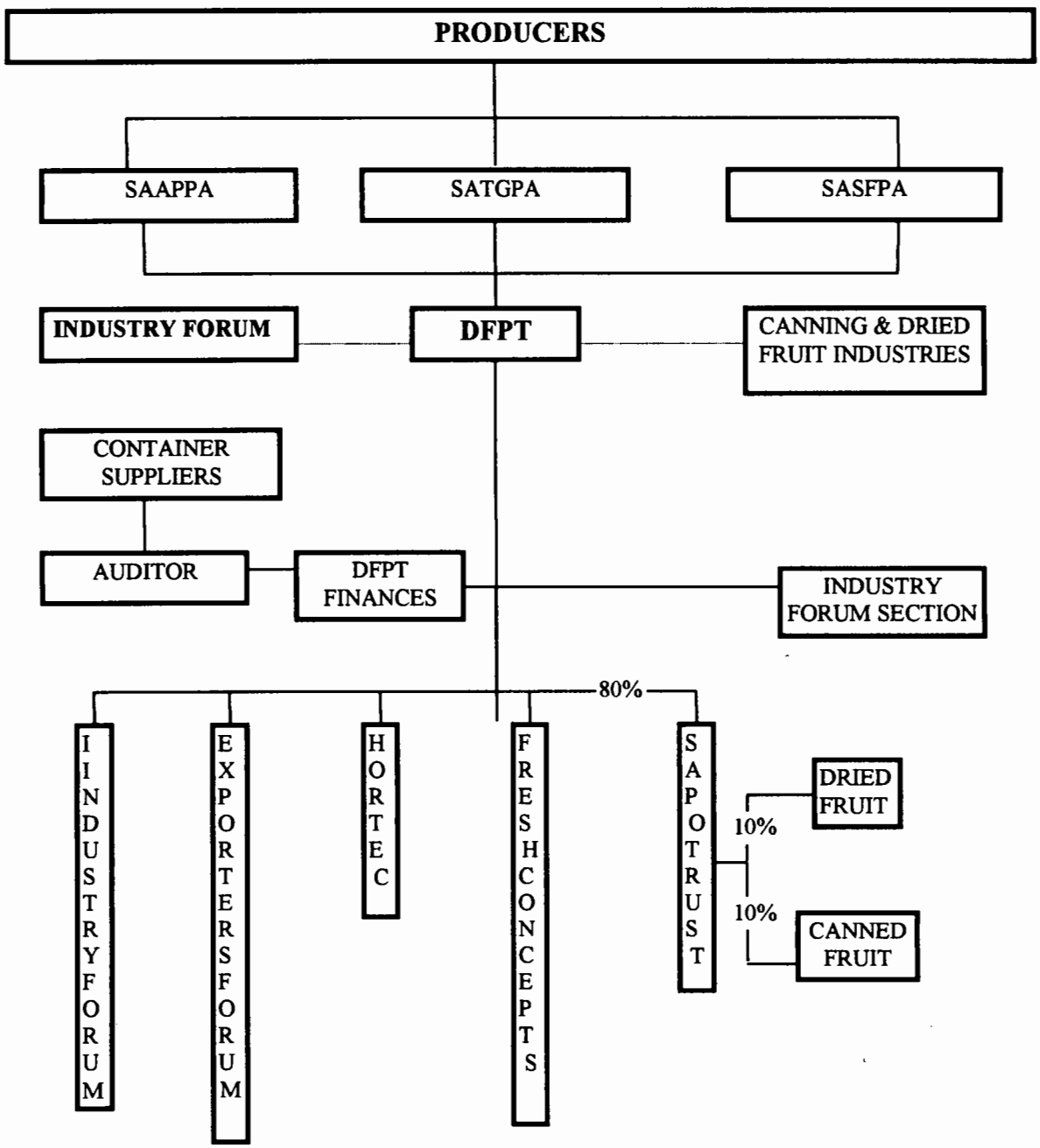
- **SAAPPA**: South African Apple and Pear Producer Association
- **SATGPA:** SA Table Grape Producers Association
- **SASFPA**: SA Stone Fruit Producers Association.

These bodies co-ordinate and handle all fruit production-related matters at producer level. Producers of the various fruit types elect the respective councils for each Association. The constitutions of these bodies provide for area based representation.

The functions of the respective industry members are as follows:

- **DFPT:** Deciduous Fruit Producers Trust. This is an umbrella body established to handle and co-ordinate all matters of common concern to role players in the industry. All members of producer associations (those who have made their financial contributions) are beneficiaries of the DFPT. The three primary

associations nominate three trustees each that is, the Trust has nine trustees with a chairman.



Source: Rabe (1997)

Figure 2.4: Deciduous fruit industry structures

- **DFPT Finances.** This body receives and administers all the financial contributions from producers in terms of approved budgets according to the fruit kind and function. Each of the three councils nominates a Director to this body.

- **Industry Forum.** The industry forum acts as an inclusive forum and decision-making entity for all directly affected parties in the (fresh) deciduous fruit industry with limited statutory powers.

- **Exporters' Forum**. The exporters' forum will act as an inclusive forum for all exporters of fresh deciduous fruit. Aspects to be addressed include grading regulations, phytosanitary clearance, shipping, accreditation and a code of ethics for exporters, etc.

- **Hortec (Pty) Ltd**. Hortec will draw up and manage the industry research budget and contract out most research projects to the Agricultural Research Council, the University of Stellenbosch and other research bodies. It will house industry services such as maturity indexing, fruit size and laboratories. Hortec will have ten directors, elected by the producers, and split according to contribution by fruit kind, one from new farmers, two from the Exporters Forum and one appointed by the DFPT.

- **SAPO Trust**. The SAPO Trust will draw up and manage the plant improvement budget. Eighty percent of this budget will come from the DFPT, 10 percent from the canning industry and 10 percent from the dried fruit industry. There will be ten trustees, from each of the three primary fresh fruit groups elected by producers, one each nominated by the dried fruit and canning fruit industries, one from new farmers and one appointed by the DFPT.

The funding mechanism, as from 1 October 1997, has been based on the Deciduous Fruit Producers Trust, on behalf of the three producer associations, entering into formal agreements with producers and packhouses. The carton and container manufacturers and

distributors agreed to supply the DFPT Finances with their sales figures. The DFPT will then invoice the producers and packers for the levy (*Deciduous Fruit Grower*, November 1997).

The Processing Industry.

The contribution of the processing industry to the deciduous fruit industry has not been included in the analysis in Chapter 6, but has continued and will continue to constitute an important part of the industry. The reader should realise that the history of the processing industry is not included in the data collected for this study. However, this section shows the processing industry in perspective of the new industry structure.

On 30 September 1997, the Dried Fruit Board was abolished, bringing an end to all restrictions on the marketing of dried fruit. A new body, the Dried Fruit Technical Services was established to serve the needs of the industry. This body will receive funding from the Minister of Agriculture of R 3.5million per annum (*Deciduous Fruit Grower*, October 1997).

The Canning Fruit Board was also abolished in September 1997 and replaced by two further organisations: the Canning Fruit Producers Association (CFPA) and the South African Fruit and Vegetable Canners Association (SAFVCA). CFPA was formed to serve the interests of the fruit growers, whereas SAFVCA served the canners. In addition the Canning Fruit Forum has been established to represent all those involved in the industry (canners, fruit producers, labourers etc.) and to discuss critical issues. A voluntary levy will be collected from farmers. The canners will gather information on a farmer's output and a levy will be paid accordingly. The Canning Fruit Forum has no personnel and, therefore, no need for funding for this purpose.

2.5 Review

The South African deciduous fruit industry competes successfully in international markets considering that the natural conditions within which it operates are relatively poor. Like other agricultural industries in South Africa, it has been regulated and its marketing controlled by a central body under the deciduous fruit scheme. It seems feasible to argue that the control that was exercised in terms of the scheme contributed to the relatively slow growth in output of the industry, although the sanctions that South Africa faced in the 1980s also had an effect.

Now, however, the industry has been deregulated, and producers are free to choose through whom they market their fruit. With this new system, a non-statutory body has been formed to address those needs that are normally ignored on account of their public goods nature. These changes have been welcomed by the industry, which is now able to expand its production more freely in response to foreign demand. Producers can now choose their own exporters and foreign markets. This freedom should, hopefully, spur growth in the industry.

Part of the new structure is specifically orientated towards research and the research needs of the industry. Hortec should ensure that these needs are not neglected and in the process should address sustainability in the long term. This new structure is entirely non-statutory and allows farmers total freedom in production and marketing decisions. The body has been formed so as to maximise farmer participation and should, therefore, be responsive to their needs.

CHAPTER THREE

DECIDUOUS FRUIT RESEARCH IN SOUTH AFRICA

3.1 Introduction

The history of agricultural research in South Africa has been marked by frequent change, often due to changes in government policy. Since the formal establishment of research institutions after the formation of the Union in 1910 the State has supported research, mostly to the benefit of large-scale (white) commercial farmers. In recent years, one of the most notable changes in the operation of state enterprises in South Africa has been the movement towards the reorientation of the services rendered, the commercialisation of services, and in some cases, privatisation of the institutions themselves. This has either been the result of pressure to perform better or the withdrawal of state funding from these enterprises due to priorities that differ from the former government.

State enterprises in the agricultural sector, including those in the research sector, have not escaped the effects of this shift in government policy. Agricultural research institutes have been under constant pressure to cut costs and find alternative sources of funding on account of recent political changes. Under the guidance of the Department of Agriculture, the funding mechanism for research has changed to allow industry to take a more active role in funding research projects and to make researchers more responsive to industry needs.

This chapter describes the changes in agricultural research in South Africa and describes the evolution of research in the deciduous fruit industry. The recently formed Agricultural Research Council and the transitions that have resulted from deregulation in the deciduous fruit industry towards the end of 1997 are described.

3.2 The History of Agricultural Research in South Africa[1]

Agriculture became a responsibility of central government under the South Africa Act of 1910. As a result, the Department of Agriculture was formed a year later. At its inception the Department consisted of 18 divisions, including one for the horticultural sector. In 1913, the administration of agricultural education was transferred from the Department of Education to the Department of Agriculture (DOA).

In 1920, all extension activities were transferred to the agricultural colleges, and the Faculty of Agriculture at the University of Stellenbosch was transferred from the Department of Education to the Department of Agriculture. The Faculties of Agriculture at the Universities of Pretoria and Natal followed the same course in 1940 and 1948 respectively.

During its first 12 years, the DOA increasingly emphasised the importance of agricultural education. However, this emphasis gradually shifted to focus attention on the provision of extension services to farmers. In 1924, a new extension service was established in an effort to develop stronger links with the farming community, as well as to co-ordinate extension between the colleges and the various divisions within DOA. In 1925, a new division of Economics and Markets was established. The colleges were transferred to the Extension Division, which was then reconstituted as the Division of Agricultural Education and Extension. The restructuring of departmental services continued through the 1930's and the 1940's. In 1939, the division of Plant Science was split into three new divisions: Horticulture, Entomology, and Botany and Plant Pathology. At the same time, other departments of the DOA also experienced radical changes.

The dynamic nature of the country's agricultural economy, and the far-reaching technological developments that occurred after World War II, caused continual reorganisation within the DOA to ensure that it adapted to these changes. The first post-

[1] This section is based on Roseboom *et al*, (1995).

war reorganisation took place in 1952/53. At that time, the Technical Services (responsible for most of the agricultural research conducted within the DOA) was divided into three main branches, 10 national divisions (another one was added in 1960), three special institutes (a fourth added in 1956) and six agro-ecological entities (increased to seven in 1961). A Director of Technical Services was appointed to assist the head of the DOA in co-ordinating and implementing research and extension policy.

Department of Agricultural Technical Services: 1958-1984.

In 1958, the DOA was split into the Department of Agricultural Technical Services (DATS) and the Department of Agricultural Economics and Marketing (DAEM). DATS focused largely on production issues and provided services such as agricultural research, education and extension, and regulatory and control services. DAEM, on the other hand, covered policy issues and provided the industry with vital economic, marketing and production statistics. In 1962, DATS was reorganised into two bodies: the Directorate of Agricultural Research (DAR) and the Directorate of Field Services (DAFS). DAR was given responsibility for the research institutes and DAFS for the three service divisions. These changes, however, did not affect research at the regional level.

In 1970 a senior deputy secretary was appointed, the two directorates were merged to form a single Directorate of Technical Services, the number of Chief Directors was increased to six, and the heads of all regional agencies, institutes and divisions were upgraded to the rank of director. The number of national divisions was increased from four to six, to include a Soil Protection Division and an Agricultural Information Division. The Institute for Crops and Pastures was established, bringing the number of research institutes to 11. However, the Crops and Pastures Division was disbanded in 1981. In the same year the Grain Crops Research Institute was established.

In the early 1970's the administrative responsibility for the Faculties of Agriculture and Veterinary Sciences was transferred to the Ministry of Education. However, DATS

continued to finance research at the universities as well as a substantial but declining number of research positions at the various faculties.

In 1967, the Division of Economics and Markets was split into Agricultural Production Economics and Agricultural Market Research. The Agricultural Credit Act of 1966 led to the establishment of the Department of Agricultural Credit and Lands (DACL). In 1980, DATS, DAEM, and DACL were amalgamated into the Department of Agriculture and Fisheries (DAF). The Institute for Sea Fisheries was initially placed under the control of DAF, but was transferred to the Department of Environmental Affairs (DEA) in 1982. At the same time, DAF was renamed the Department of Agriculture and Water Supply (DAWS).

In the three years of its existence, DAF/DAWS also underwent several changes. Cotton research was transferred to the Tobacco Research Institute; the Inspection Services Division was renamed the Division of Agricultural Product Standards; the Division of Agricultural Marketing Research became the Division of Economic Services; the Financial Assistance Branch became a fully-fledged division as did the subdivision Biometrics and Datametric Services.

Department of Agricultural Development: 1985 - 1992.

In 1984, the Tricameral Constitutional dispensation was introduced and the administrative agencies responsible for agriculture were divided into various own affairs and general affairs departments. In the process, separate own departments for the different racial groups were created. A Department of Agriculture was formed for each of the administrations for the Houses of Representatives (Coloureds), Delegates (Asians), and Assembly (Whites). DAWS was split into a "white own affairs" department (Department of Agricultural Development) and a "general affairs" department (the Department of Agriculture).

The Department of Agricultural Development (DAD) performed similar functions to the DAWS. It took over all the research responsibilities from DAWS. (The other Departments of Agriculture did not conduct any research.) In other words virtually 100 percent of South Africa's agricultural research effort was targeted towards "white commercial agriculture".

As a result of extensive deregulation and efforts to privatise public services within DAD, most of the services that fell under DAD were transferred to the newly established Agricultural Research Council (ARC) in April 1992.

3.3 The Agricultural Research Council

The Agricultural Research Council (ARC) is a statutory body established under the Agricultural Research Act, No 86 of 1990 with the mandate to conduct and undertake research and development and technology transfer (Van Rooyen *et al*, 1996). The mission of the ARC is to promote agriculture and related sectors through research, technology development and transfer. This mission is served by focusing on science capacity building and by ensuring that technological needs are met to promote competitiveness and enhance social welfare. The ARC employs approximately 4600 people at its 16 research stations, including 707 research scientists and more than 670 technologists.

The ARC has a diversified funding base, which depends largely on the type of research project or service that is being conducted. The sources of funding are detailed in Table 3.1 below.

Table 3.1: ARC Funding Policy.

Type of project/service	**Target Source of income.**
Demand driven research on behalf of primary commercial agriculture and related generic technology development	ARC 70 percent Client 30 percent
Constitutional responsibilities of national and Provincial Departments of Agriculture	ARC covers indirect costs National and/or Provincial Departments cover direct costs
Other Government Departments Capacity building projects	100 percent (negotiable) ARC 70 percent, Client 30 percent - if focused on industry problems or 50/50 if undertaken in collaboration with overseas scientific institutions, or 100 percent ARC
Farming systems and development: Small-scale agriculture	ARC – indirect costs National Provincial Departments – direct costs from their own budgets
Secondary agricultural industries with exclusive benefit to the client	Client – 100 percent
Consultations services and projects	Client – 100 percent
Projects beyond our borders	Client – 100 percent
PRT – not an industry – special kind of donor to the benefit of an industry as a whole	ARC 70 percent, Client 30 percent or aim at external funding by means of funding collaboration with other interested parties as agreed upon or direct costs
Development aid projects e.g. RDP projects	Client – 100 percent
Forming of consortiums with other institutions require full funding e.g. Scientific councils	Client – 100 percent

Source: Van Rooyen et al, 1996, p.19.

Governance of the ARC

The governance structure of the ARC includes a Board with audit, financial and investment committees. Internally, the senior officers include the President, Deputy President, three Vice Presidents and the Internal Auditor. The Vice Presidents are responsible for the three main areas of research covered by the ARC, namely Plant Sciences, Animal Sciences and Specialist Institutes (Van Rooyen *et al,* 1996).

3.4 The History of Deciduous Fruit Research

In this study the total cost of all research projects focusing on deciduous fruit at Infruitec, which forms part of the Plant Sciences division of the ARC, has been estimated. As background, a history of research in the industry is provided in order to place the results of the study into context. This history is followed by a description of the institutional changes that have marked research efforts in the industry.

The fruit industry of South Africa has its origins in 1652 with the arrival of Jan van Riebeeck who planted "some medlars and quince pips"(Stander, 1983:3). The industry, however, effectively became commercialised in the late 1800's when a growing demand for fruit in Europe, coupled with severe diseases in the grain and grape industries, stimulated the experimental growing of deciduous fruit in the Cape. This development resulted largely from contributions from the private sector and the Cape Government between 1886 and 1896. Formal structures for the industry were created during the period 1896 - 1910. The Western Province Fruit Exporters Association (WPFEA) was formed after a meeting of exporters in 1899. By 1904, WPFEA had formed the Board of Horticulture whose purpose was to give advice on pest control and industry-related research.

However, not much research was conducted and the Board was mainly involved with fruit inspection. Stander (1983) reports that pomological research was conducted at all South African Agricultural Colleges by 1914, but initially the idea of research met with resistance and funds allocated by the industry were inadequate for worthwhile research.

As the main focus of the industry was to supply the European market, it is understandable that the first formal research conducted (in 1925) was on pre-cooling and refrigerated transportation (Kotze, 1987).

It was not until 1935, after a visit to East Malling Research Station in England by a Miss Kathleen Murray, that the importance of research was brought to the attention of the Minister and Secretary for Agriculture. Following her interview with the Minister and also the pre-war economic depression, a new research station was established in Stellenbosch in 1935. It was given assistance and direction by the East Malling Station Director. In 1937 the Western Province Research Station (WPRS) was established in Stellenbosch with its main focus on fruit tree and grape research, and with additional responsibility for winter rainfall horticultural crops. Two experimental farms were purchased from Rhodes Fruit Farms for field practice (Stander, 1983).

The research station started successfully and managed to service the industry well with less than 20 graduate scientists at its inception. The service it provided was especially appreciated during the war years when pesticide supplies were restricted and exports came to a halt. It was at this time that the main focus of the research moved from attempts to improve the appearance of the fruit to adding nutritional value. In 1946 a separate dehydration and cold storage laboratory was established, and nine experimental farms were purchased to help cope with increased field practice needs. These laboratories were closed down in 1948 and their responsibilities were moved to the WPRS in 1949.

This merger of scientific minds caused various styles of analysis that resulted in improved problem-solving capabilities. In 1962, the name of the WPRS was changed to the Fruit and Food Technology Research Institute. By 1964, this Institute had developed to such an extent that the University campus could no longer accommodate needed expansions, and it was moved to separate grounds in Stellenbosch.

In addition, the work performed by the Institute had country-wide implications, and it was therefore necessary to locate specialist divisions elsewhere. The Division of

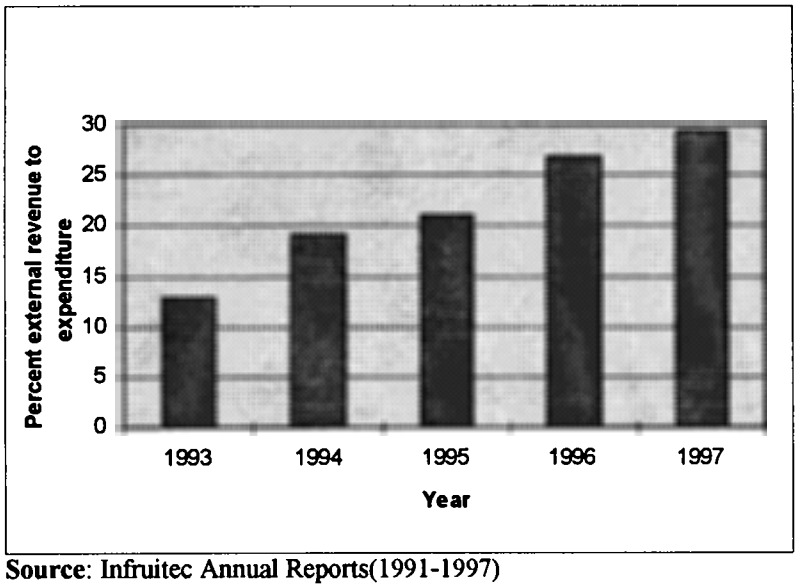
Agricultural Engineering was, for example, established in 1965 and of Agricultural Meteorology in 1970, while research on ornamental flowers was transferred to Roodeplaat. The Institute again changed its name to the Fruit and Fruit Technology Research Institute (FFTRI) in 1970. In 1982, research on table grapes was transferred to what is now Nietvoorbij. In the same year, FFTRI assumed country-wide responsibility for deciduous fruit research. Accordingly, a research unit was established at Roodeplaat (Kotze, 1987).

In 1986/87 the institute suffered the first of a series of cuts in its long-term budget estimates. In the following year finances recovered slightly. However, six jurisdictions of research were passed on to the universities, their funding to be a responsibility of the state. The 1989/90 FFTRI annual report (pg. 1) stated that insufficient funding was hampering the FFTRI in maintaining its research programme, and stressed the need for the restructuring of research funding in a manner that would allow the industry to contribute in accordance with its priorities.

Industry funding had been received from as early as 1988/89, and contributions have increased steadily ever since. This resulted in the establishment of Unifruco Research Services (URS) "to rationalize the development of technology for the industry and to allocate and manage industry research funds" (*Deciduous Fruit Grower*, September 1996 p. 314). The last financial year of FFTRI, was 1990/91, and on 1 April 1992 the institute became part of the autonomous Agricultural Research Council and gained the new name of Infruitec.

Despite financial cutbacks, Infruitec has maintained a high level of research activity, and has an established base of local and international clients. At the same time, the industry has agreed to meet a major part of the research costs. In 1996, half of industry funds were allocated to URS and R2,6 million to Infruitec, with the balance going to wine research (*Deciduous Fruit Grower*, September 1996 p. 314). In addition the ARC is able to fund projects that are supported by the industry. The Council's currently aims to secure 30 percent of project costs from the industry, with the balance to be covered by government.

The increase in external revenue compared to total costs at Infruitec is shown in Figure 3.2 and Table 3.2 below.



Source: Infruitec Annual Reports(1991-1997)

Figure 3.1: Percent External Revenue of Total Expenditure at Infruitec

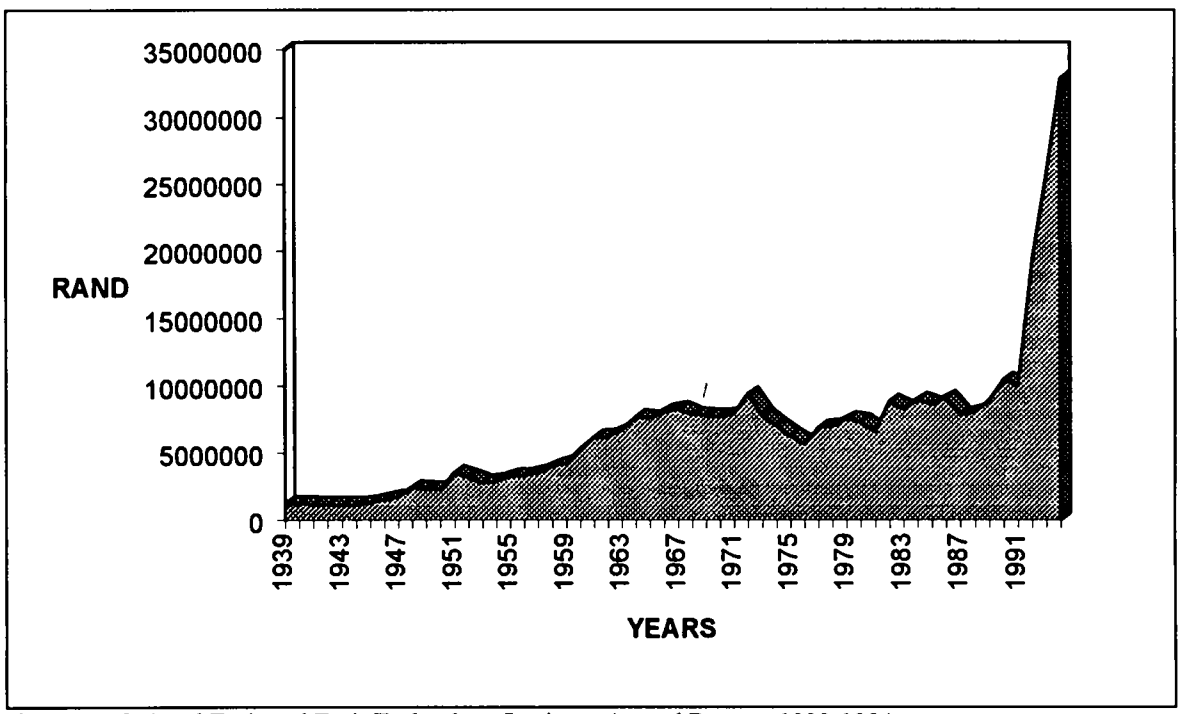
Table 3.2: Percent External Revenue of Total Expenditure at Infruitec

Year	1993	1994	1995	1996
Percentage	12,9%	19,0%	20,0%	26,9%

Source: Infruitec Annual Reports(1991 – 1997)

Figure 3.1 and Table 3.2 illustrate how the contributions of the industry to research have increased as a percentage of the total costs of research at Infruitec. These contributions are expected to increase as the new structures in the industry begin to operate and attract more funds to be allocated to research. The continual withdrawal of government funding will also cause the private sector to contribute an increasing percentage of the research bill.

Figure 3.2 shows the growth in funds invested in research at Infruitec. These figures are expressed in 1997 terms. The effect of the change in the funding regime at Infruitec is well illustrated by the sharp upturn in research expenditures after 1989 as a result of the industry been able to contribute to the overall research bill since 1989.



Source: National Fruit and Fruit Technology Institute, Annual Reports 1939-1994

Figure 3.2: Deciduous Fruit Research Expenditures, 1939 - 1994.

3.5 The New Era

On 30 September 1997 the Deciduous Fruit Board (DFB) was abolished, giving rise to the need for a new industry co-ordinating body. As a result the Deciduous Fruit Producers Trust was developed. As explained above, the research funding arm of the Trust, Hortec, has been charged with the responsibility to allocate funds between the appropriate research organisations that serve the industry. In this section, the changes in the organisation of research and the funding of that research are explained.

After deregulation, URS was split into two separate bodies. One is a commercialised research services division operating on a per client basis where the user pays for services previously provided by the industry free of charge. These services include services such as maturity indexing, release dates, fruit-size predictions and weather data. The other body is Hortec (Pty) Ltd., which will manage the industry research budget from the DFPT and contract out most research projects to the ARC (Infruitec), various departments of the University of Stellenbosch and other research bodies (for example, the South African Sugar Association). Hortec's function is also to house industry services such as maturity indexing, fruit size predictions and laboratories. The funds that it allocates to Infruitec are required to cover 30 percent of project costs, with the balance being funded by the state.

Hortec Allocation of Funds

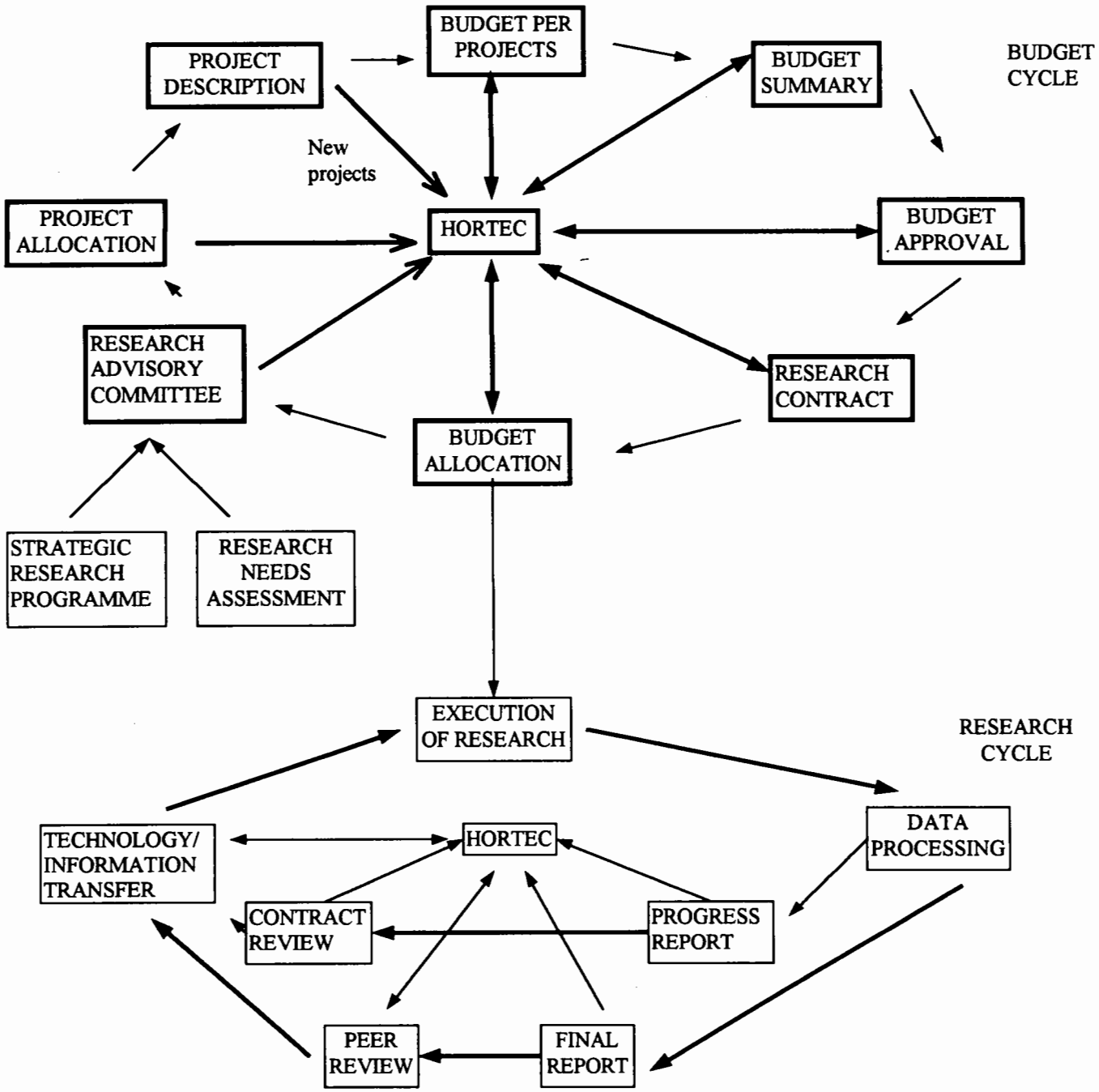
Hortec will allocate funds under the following arrangement: a research advisory council for each fruit kind, namely pome fruit, stone fruit and table grapes will be formed and all interested parties are invited to attend each meeting. At the meetings research priorities will be set according to a rank ordering, and new projects and ideas may also be submitted. The rank ordering is ascertained according to priorities set by the producers. The costs of projects are also taken into account, and projects are selected based on an assessment of priorities together with the availability of funds.

The funds are allocated on the basis that the most important projects receive funding until there are no funds left to be allocated across projects. The "Research Needs Assessment" refers to a circular that was distributed in 1996 in an attempt to obtain feedback from producers pertaining to research requirements and their importance to producers. The "Strategic Research Programme" refers to a programme (not yet finalised) that will prioritise long-term projects. Hortec is required to maintain funding of long-term projects. This is necessary as the Research Advisory Committee puts an emphasis on short-term projects, with the result that long term strategic projects could be neglected.

The lower half of Figure 3.3 refers to the research cycle on a project basis, with the project review process occurring in October. The technology/information transfer process will be carried out in the form of field days and publications in popular magazines and scientific journals.

3.6. Review

Agricultural Research in South Africa has experienced many changes since its inception at the beginning of the 20th century. Formal research in deciduous fruit began in the 1930's and has developed consistently since then. The State supported all research until political changes forced Government funding allocated to institutions to be reduced. These financial restrictions have resulted in changes in the structure and source of funding and the establishment of the Agricultural Research Council (ARC). The ARC is structured in a way that allows external funding to play an important and much needed role in its own research. The deciduous fruit industry reacted immediately and offered support as well as developing its own facilities to carry out research for the industry. After the industry deregulated, the industry formed a new body, Hortec, to co-ordinate research in the industry and attend to long-term research needs. Hortec will allocate funds among projects according to priorities laid down by the producers.



Source: Rabe, 1997

Figure 3.3: Deciduous Fruit Research Management in South Africa.

CHAPTER FOUR

THE ECONOMICS OF RESEARCH AND THE ROLE OF THE STATE

4.1 Introduction

All public institutions in South Africa have been subjected to varying degrees of transformation, commercialisation and, in some cases, privatisation over the past years. The timing and sequencing of these processes has differed from one institution to the other. Before the removal of apartheid and the advent of a new government, radical institutional changes were already sweeping through the country. Public institutions in the agricultural sector did not escape attention, as the diverse experience of institutions such as the Land Bank, the Agricultural Credit Board, the Development Bank of Southern Africa, the National Marketing Council, and the Agricultural Research Council etc. can attest.

In the case of agricultural research, the first changes were brought about with the creation of the autonomous Agricultural Research Council from the diverse research functions of the Department of Agriculture in 1992. With the advent of the new, democratically elected government, therefore, the institution had already experienced some change. In practical terms this meant that a part of the funding for agricultural research would no longer be funded directly by the taxpayer, but would come from industry. At the same time the institution was granted more autonomy than had been the case in the past. However, as Control Boards under the Marketing Act still controlled the marketing of the largest portion of agricultural production, statutory levies were in place to secure industry funding.

Three further changes have taken place since the democratic elections in 1994. **First,** the new Marketing of Agricultural Products Act has effectively lead to the abolition of the

Control Boards, as was explained earlier. The main implication for agricultural research has been that statutory funding of research by the various industries has come to an end[1]. **Second,** the agricultural research function did not escape the effects of the tight fiscal policies under the government's new macroeconomic priorities under the Growth, Employment and Redistribution (GEAR) strategy. **Third,** the government has signalled that it has a new set of priorities for agricultural research, and that the available funding should be reallocated to basic research, and applied research that addresses the problems of emerging farmers rather than only those of the commercial farming sector. Thus, the advent of a democratic government in South Africa has necessitated a 'new look' agricultural research financing system.

The funding of research is a contentious issue in the agricultural economics literature. The division between where the product of research becomes a private rather than a public good is usually very vague, hence the uncertainty about private or public provision of research. The general view is that as the appropriability of research increases, so should private investment increase.

The first part of this chapter describes the economic theory of research, including possible methods of financing agricultural research, whereas the second part briefly outlines a model of competitiveness. These two parts act as the basis for the discussion, in the final section, of a possible future agricultural research structure and the manner in which the research industry for deciduous fruit in South Africa could conduct itself.

4.2 The Case for Publicly Funded Research

Public involvement in research has been justified due to the public good nature of the products of research. Research produces knowledge which is a public good in that it is both non-rival in consumption and non-price excludable (Lindner, 1993). Private goods can readily be bought and sold because property rights can be exchanged. Public goods

[1] At the time of writing, it was not clear how many industries would request statutory powers to place levies on producers in order to fund research and other collective activities, and how many would attempt to provide for such funding on a voluntary basis.

do not lend themselves to profitable merchandising even though there may be considerable gains for producers and consumers (Watson, 1996). The characteristics of these products make it difficult to appropriate returns to those involved in the development of the knowledge. Public provision of research is also seen as justified, as the initial adopters of research gain from a price advantage, but in due course the industry price drops and consumers become the beneficiaries of the research. They should, therefore, be footing the bill (Watson, 1996).

In a free market, due to the free rider problem associated with public goods, the market will fail to provide those goods, causing a need for public intervention. Market failure can also arise due to the risk as well as the indivisibilities involved in research. The risk in investing in research arises as a result of the lag between investment and return, and of the uncertainty associated with such investment. The indivisibilities involved with the technology required to carry out research can result in a monopoly situation, requiring Government intervention to maximise social welfare (Echeverria and Thirtle, 1994). These arguments prevail under certain conditions, but not across the entire spectrum, due to the different characteristics of research across the continuum (Echeverria, 1995).

The Research Continuum

The research process can be seen as a continuum of activities, with basic scientific research at one extreme, followed by strategic and then applied research, with adaptive research at the other end of the spectrum (Thirtle and Echeverria, 1994).

Basic research is carried out to increase basic or fundamental knowledge of a subject or system without having immediate benefits. This requires a large resource base, and equipment that is often expensive. It is generally too costly to be carried out privately, partly because of the long lag time between new inventions and their application in practice. The benefits of basic research can usually be brought in from public research. Strategic research attempts to broaden knowledge by "finding theoretical solutions to hypothetical problems" (Blake, 1978, cited by Donovan, 1986). Applied research on the other hand is conducted

with a view to discovering new products or services with the aim of improving an organisation's profitability. Adaptive research uses existing knowledge to modify or make products or processes that will also improve the competitiveness of an enterprise.

The research continuum covers different areas such as mechanical, chemical, biological and managerial research. The optimal roles of the public and private sectors vary between these areas of research. Generally, the choice between private or public provision rests on characteristics such as the difference in the levels of appropriability, which arises as a result of differences in patent enforceability, economic life and the ability of rivals to imitate innovations (Echeverria and Thirtle, 1994).

Figure 4.1 describes the two extremes of an appropriate relationship between the private and public sector in financing agricultural research.

Area/Type	Basic	Strategic	Applied	Adaptive
Managerial	Public			
Biological				
Chemical				
Mechanical				Private

Source: Echeverria and Thirtle,1994, Food Policy, Vol.19 No. 1 p 38.)

Figure 4.1: The Research Continuum

In general, it is argued (Echeverria and Thirtle,1994, Lindner,1993) that the private sector will cover the areas of research where it is possible to appropriate returns from the knowledge gained within a reasonable period of time, whereas the public sector will cover those areas of research where this is not feasible. The feasibility is determined by the patent enforceability of the knowledge generated in the research process. The primary objective of public institutions charged with the responsibility for research and

development should be to lay the foundations for innovations by carrying out basic research (Lindner, 1993, Donavan, 1986).

Possible Funding for Research

Townsend (1996) discusses five possible options for funding agricultural research:

- *Commercialise the results.* The funding will take place in the form of a joint venture between the private and public sector. This is only appropriate for areas of research where there is a high degree of appropriability, which is usually associated with a shorter lag time between the generation of research results and the concomitant income stream. As the level of appropriability increases the more incentive there is for private sector funding of the research.

- *Fund research in universities.* Universities offer a large source of human resources and are cost effective participants in research, partly because of the cross-subsidisation that takes place between the research, teaching and community service aspects of their task.

- *Farmer-managed levy on agricultural research.* Farmer producer associations can impose a levy on farmers who will then pay according to their output. In this way, the more farmers benefit from research, the more they will pay for it. This system also results in a more demand-driven type of research as the producer groups can put pressure on the relevant facilities to perform necessary research.

- *Competitive bidding system.* In this system, research institutions compete with each other for funding by bidding for it. There is some scepticism about this kind of structure due to transaction costs and the erratic supply of funds resulting from this kind of system.

- *Private companies*. There is no universal rule for funding which depends largely on the research infrastructure in the country.

In similar vein, Echeverria (1995) describes a feasible set-up for research funding and execution in Latin America (Figure 4.2).

FUNDING		**EXECUTION (The number of asterisks indicates the potential importance of the funding source)**				
SOURCE	EXAMPLE	Public research institute	University	Non profit, NGO's	Research Corporation	Private Company
Public sector agricultural budget	Public funds targeted to agriculture	***	**	*	**	*
Public sector science and technology budget	Public funds targeted to support science	**	***		**	*
Charges for services	Charges for pre-release pesticide screening	**	**		***	*
Foundation	Endowment for research	**	**	**	**	**
Internat-ional Donors	Grant or loan from a donor or development bank	***	***	***	*	*
Joint Ventures	Market testing and development of a product developed by the public sector	**	**		***	***
Farmer Financing	Levy or check off on commodity sales	**	**	***	***	
Charges for research products	Royalties for inbreds	**	*	**	***	***

Source: Echeverria (1995) World Bank Technical Paper No. 330. P. 9.

Figure 4.2: Alternative Means of Financing and Executing Agricultural Research at the National Level.

Market Structures and Research

Private sector research and development is more likely to occur in a highly concentrated market with fewer participants (Alston and Pardey; 1996, Shah, 1994). Conversely, market failures in research and development are more common in a market where many companies use similar technology (Alston and Pardey, 1996). While there are exceptions to this generalisation (Shah, 1994) it is evident that a sector such as agriculture, with its characteristic structure of small to medium scale businesses, has in the past been more dependent on state-funded research than in the case of more concentrated industries. According to Nelson (1982) in a highly concentrated market structure it is more likely that firms will conduct in-house research than in a decentralised market, as the free rider problem will not be as prevalent. Nelson and Winter (1982) also found that more concentrated markets not only invest more in R&D, but also that technical advance is more efficient. They state that, where R&D is profitable, the larger companies grow faster than their imitators and the smaller firms are eliminated.

Shah (1994) extends Nelson and Winter's (1982) finding by proposing the hypothesis that "success breeds success". The hypothesis states that those companies who invest in research successfully will invest more and will widen the gap between themselves and their competitors. Shah (1994) provides a review of studies where this hypothesis has been tested and proven.

4.3 Creating a Competitive Research Structure

Many reviews and opinions are expressed in the literature regarding the contributions of research to the development of industries and the necessity of research in the progress of and development of industries (cf. e.g. Ruttan, 1982: 237-61). As a result, it could be argued that a competitive research industry is necessary to maintain an industry's competitiveness.

4.3.1 Industry Competitiveness

Porter (1990) argues that the competitiveness of an industry (or country) depends on what he terms factor conditions; demand conditions; firm structure, strategy and rivalry; and related and supporting industries:

- Factor conditions consist of the state (quantity, quality, availability, price, etc.) of factors of production, such as labour and infrastructure, that are necessary to compete in a given industry.

- Demand conditions refer to the size and nature of demand in the home market that, he argues, determines the ability of a firm to compete in the international market.

- Firm strategy, structure and rivalry refers to the conditions in the nation governing how companies are created, organised and managed, and the nature of domestic rivalry.

- Related and supporting industries make up the chain of providers of goods and services and of downstream industries that are strategically aligned in pursuit of market share.

Porter(1990) argues that these four determinants interact with each other in determining the overall competitiveness of a nation or industry. This section describes some of the ways in which the determinants interact with each other.

Influences on Factor Creation

A cluster of domestic rivals for a specific market will, especially if the goods or services being provided emanate from technological innovation, stimulate the rapid development of skilled human resources, related technologies, market-specific knowledge and specialised infrastructure. Companies may invest in factor creation themselves via trade

organisations, or singly. Related and supporting industries that draw on similar skills, inputs and infrastructure further stimulate government bodies, educational institutions, and individuals to invest in relevant factor creation or factor-creating mechanisms. A disproportionate level of demand will thus drive resources into relevant factor creation.

Influences on Demand Composition and Size

Domestic rivalry probably acts as the biggest influence on demand. Fierce domestic rivalry will create product awareness and stimulate innovative marketing that can and has created demand. Active domestic rivalry can also upgrade domestic demand as competitors innovate to capture market demand. Domestic rivalry can also drive foreign demand by creating a prestigious image within the country. Related and supporting industries can create a "pull through" demand effect for complementary goods. Related industries can also create a prestigious product image, such as "Swiss made". Factor creating mechanisms may attract foreign students and companies that will stimulate foreign demand for a good. One of the most important spin-offs from these effects is to enhance the competitiveness of domestic industry in foreign markets.

Influences on Related and Supporting Industries

A large source of positive factor conditions influences related and supporting industries where skills, knowledge and technology are created in an industry spill-over effect to benefit them. An increasing demand will stimulate suppliers to satisfy the demand and replace imports. The largest influence, again, is domestic rivalry. A large group of rivals will stimulate the emergence of more specialised suppliers, as well as related industries.

Influences on Domestic Rivalry

Demand conditions enhance the domestic rivalry when they seek multiple sources and encourage new entrants to satisfy the demand. Sophisticated buyers may enter the market themselves so as to ensure that the quality of products and services they seek is available.

The more sophisticated the domestic buyers are, the more the rivals will innovate and compete with each other to win market share. Related and supporting industries create an environment that is conducive to investment in a particular industry. For example, a large downstream industry can create a market structure conducive to investment where inputs from these industries are required. Factor conditions and factor creating mechanisms affect domestic rivalry in a similar manner to related and supporting industries by creating an environment that is conducive and encourages investment.

4.3.2 Comments on Domestic Rivalry

Porter(1990)continually stresses the importance of domestic rivalry and its potentially positive effects on the competitiveness of an industry or nation. He summarises the most important influences as:

- Stimulating new rivals through spin-offs
- Creating and attracting factors of production
- Upgrading and expanding home demand
- Encouraging and upgrading related and supporting industries
- Channelling government policy in more effective directions.

4.3.3 The Role of The State

Porter(1990) recognises that the government has an important role to fulfil in influencing competitiveness, but stresses that this role should be partial and will only succeed when working in tandem with the main determinants of competitiveness. In general, in cases where Government has been too active as a helper or supporter, industries have suffered in the long run as a consequence and have become uncompetitive. The proper role of Government is as a pusher and challenger. At a broad level, Government's most essential role is to act as a signaller and an influence on how companies compete by identifying and highlighting important priorities and challenges. Porter(1990) stresses that the tendency of government-business co-operation and collaboration between industries

usually results in an industry that is less competitive rather than one where rivalry is prevalent.

Government policy should recognise that these determining factors act as a system and that policies in many areas are interdependent. The underlying philosophy is that the system must be seen as a whole, and that consideration of changes in one part must take account of the effect of these changes on other parts of the system. Government must be careful to not overstate or overplay its role in creating national competitive advantage because this can lead to an economy of dependent, backward looking and ultimately unsuccessful companies. At the same time Government must recognise the areas where it has a legitimate influence in creating conditions for economic prosperity. Arguably, one of the key roles that government can play relates to the system of technological innovation.

4.4 South African Deciduous Fruit Research in Context

This section is intended to provoke thoughts on improving the deciduous fruit research structure, as well as providing guidelines for Government involvement and funding. The South African Government is under constant pressure to review its expenditure priorities and assess expenditure in view of the changed political climate in this country. In this discussion, these revised priorities are assessed against the view that publicly provided research has a crowding-out effect, i.e. that private entities will regard publicly-funded research as a substitute for research paid by the private sector. Therefore, should an area of research be publicly funded, the private sector will not provide it. While this discussion may display a bias towards the private provision of research, this is because the aim is to stress, for reasons mentioned above, a climate of minimal government support. The belief that a company in a non-competitive environment will not be as proactive or innovative as in a competitive market will become evident.

On the **demand side** of the research industry, more than 2165 South African farmers are producing deciduous fruit: all of them are dependent on research to maintain their

domestic and international competitiveness. There are also extensive and competitive industries in, among others, South America, the USA, Canada, Europe, Australia and New Zealand, and the East. The global market stretches beyond these areas and offers many opportunities for increased production and therefore increased research needs. Opportunities arise for a South African research industry to conduct research that is locally as well as internationally applicable. The South African industry could make good earnings on selling products only applicable in foreign markets. These earnings could act as an excellent financial base to provide funding to conduct research for South African conditions.

The **factor conditions and factor creating mechanisms** in South Africa are well geared to provide skills for the research industry. There are agricultural faculties at the Universities of Pretoria, Stellenbosch, Natal, Orange Free State, Fort Hare, the North and Zululand, as well as the Medical University of Southern Africa. In addition, other tertiary institutions such as technikons and agricultural colleges have been charged with the responsibility of training people in many of the skills required by the industry. Although many of these institutions may not specialise in the deciduous fruit industry, they offer training in agricultural sciences that create the skills needed in research.

There are four main players in the supply of research to the industry that could potentially **compete** with each other, namely:

- ARC: Infruitec/Nietvoorbij;
- The South African Plant Improvement Organisation (SAPO);
- Unifruco Research Services(URS); and
- The Department of Horticultural Science at the University of Stellenbosch (US), and to a lesser extent at other Universities.

A number of other related research stations that operate under the ARC are also involved in work that is important to the needs of the deciduous fruit industry[2]. After the abolition

[2] E.g. the Institutes responsible for soil science and water-related issues; plant pathology, etc.

of the Deciduous Fruit Board, a new commercial research service (URS) was formed as a subsidiary of Unifruco. These organisations currently represent the extent of existing domestic rivalry. Porter(1990) stresses the potentially positive effects of this rivalry, and refers to several situations where it has driven companies to become more innovative and to market themselves more aggressively. Both these features of domestic rivalry have led to market growth on both the demand and supply side. They could be very productive as competitive pressures are applied to researchers to innovate and create new techniques and discover new ideas that may not have been considered in a controlled research industry.

In the book *"Imagination in research"*, Ladd (1987) describes situations where freedom of expression has reaped greater benefits from research than a situation where researchers are expected to work under guidelines regarding the type of research they should do and what they should produce. The aggressive marketing associated with domestic rivalry in a research industry that has many players competing for market share could also increase awareness of the benefits of research among deciduous fruit producers. Researchers at Infruitec and Nietvoorbij, for example, view poor extension as a reason for the low adoption rates prevalent in the industry. Not only would marketing and advertising be a means of disseminating information but, as the rivalry grows, so research firms may extend their marketing campaigns to encompass extension. In a controlled, single-channel market there are few competitive forces driving research firms to invest resources in extension even though the increased effect of research and extension on the productivity of research is considerable (Evenson and Feder, 1991).

While concentrated markets have been known to provide more research than decentralised markets (Shah, 1994; Alston and Pardey 1996), this does not necessarily mean that bigger companies conduct more research (Shah, 1994). It also does not mean that the supply of research in a competitive market cannot be organised in a manner that captures the scale economies of the research function. The geographic dispersion of the primary producers of deciduous fruit in South Africa lends itself to a decentralised market structure. In addition, deregulation has brought about a significant increase in the number

of firms in the marketing chain, including the rapid entry of new market participants exporting deciduous fruit. This decentralisation is likely to increase in due course.

Therefore, it is unlikely that primary producers and other market participants will operate within a concentrated market. A more concentrated market could allow for a system where exporters would conduct research and carry out extension to their suppliers (Umali-Deininger, 1997). However, the structure of the South African deciduous fruit industry is not conducive to companies conducting in-house research and thought, therefore, must be given to a research industry that combines the benefits of specialised research organisations, public institutions and government and private sector funding. It is also important that funding comes from the users of research so that a more demand-driven system is created which will lead the type of research in the correct direction (Echeverria *et al*, 1996).

One major disadvantage of over-reliance on private sector funding of research is that, as government funding decreases, the private sector crowds out the basic science end of the research spectrum, as it is often more interested in short-term benefits (Lyons *et al*, 1996). As the basic science end of the spectrum forms a base from which adaptive and more marketable research is conducted, the necessity for government funding cannot be ignored and it is important to establish the best means of allocating government funds between the "domestic rivals." Historically, the best option appeared to be block grants, where the funding has been based on a formula (Tisdell, 1996). The most effective formulas have been based on a productivity index that considers outputs such as publications, inventions etc. relative to the cost of their production. In these instances, the funding allocation is long term and consistent.

The other popular mechanism for allocating public research funds is competitive bidding. However, there is much scepticism about this approach due to the transaction costs associated with the bidding process and the opportunity cost of scientist's time spent in preparing the bids (Tisdell 1996; Townsend, 1996; Huffman and Just, 1994). Tisdell (1996) refers to situations where competitive bidding systems have actually decreased

efficiency and output due to the amount of time invested in preparing the bids and the negative effect of the erratic supply of funds on long-term research projects and knowledge creation. Tisdell (1996) also refers to situations where block grants have resulted in creating competition between the respective research stations.

Thus, there is much scope for an industry body such as Hortec to use block grants to create a competitive environment between the relevant South African research stations. No matter what form of funding allocation is chosen, the final method used must be associated with a continual system of evaluation and assessment of the quality of research produced, to ensure that the research that has been conducted is maintained at the required level of quality.

Large parts of the domestic rivalry and factor creating mechanisms in the industry can also act as a spur to **related and supplier industries**. The main research institutions, including the Universities and other tertiary education institutions, URS, Infruitec and SAPO, can all co-ordinate their research and provide each other with much needed information. However, consideration must be given to earlier comments on domestic rivalry. Porter(1990) refers to situations where companies going into joint ventures often become backward looking and are less competitive or productive than those companies in industries where there is domestic rivalry.

Although the research organisations need to co-ordinate their efforts, therefore, this should not be at the expense of the creation of a competitive environment, encouraged through the use of formula funding. Porter(1990) proposes that the government has an important role as a signaller and director of such efforts, and it should, therefore, endeavour to direct and signal the research industry correctly. Should too much co-operation evolve it could erode possible and necessary competition that may be required to ensure the long-term sustainability of an important industry.

Should vigorous domestic rivalry emerge, it is possible that it will pull on the other determinants of competitiveness and strengthen them, and in the process stimulate growth in the research industry.

Government Participation

The biggest determinant of private investment in research is whether the research investment can be appropriated. This depends largely on whether research results can be patented, and the institutional environment surrounding patents. At Infruitec the research conducted falls under the responsibility of seven departments: namely horticulture; evaluation and breeding; soil and irrigation technology; plant pathology and biotechnology; pest management; processing technology; and post harvest biology. The Government's most prominent role in acting as a pusher and challenger, and working in tandem with the other determinants of competitiveness will be in creating a suitable legal environment for patents. In South Africa, applications for patents take more than six months and the cost of registration is between R12 000 and R 30 000. An international patent costs R400 000 to register with an annual renewal fee of R30 000.

South Africa is a member of the *Union Internationale Pour la Protection des Obtentions Végétales* (UPOV) which has harmonised international plant breeders rights and strengthened patenting laws applicable to plant breeders (ISNAR, 1993). UPOV covers 24 countries and its 1991 revision of patenting laws provides patent protection for inventions that display novelty, inventiveness, non-obviousness and industrial application and usefulness. The patent lasts 17-20 years and prohibits the commercial use of protected matter. Much work conducted at Infruitec in the departments of breeding and evaluation, horticulture and plant technology and pathology can be patented and privately provided. Therefore, these departments in South Africa have some security. The scope for private investment is considerable and should be encouraged, and Government involvement slowly withdrawn.

However, much of research conducted in these departments is high risk, as there is a long time lag from when the research is carried out until the benefits are evident. For example, if a plant variety is patented, the researchers are unaware of the market price the new variety will fetch and how worthwhile the cost of patenting the product will be. Many varieties take 16 years from establishing themselves to actual marketing and the risk of an uncertain outcome from the research investment, as well as the costs associated with the time lags, means that this kind of investment is likely to engender minimal private investment. However, where a patent can earn quicker returns there should be no need for public funding.

Part of the Government's participation in the research industry, therefore, must be to create a more favourable patenting environment. The six months it takes to register a patent could discourage investors due to the time lag and the risk of information leaks. The Government's role as a provider of public goods should be to strengthen and streamline the legal environment surrounding patents so that inventions are easily patented and frequently released on to the market. The Government has a definite role in creating an institutional environment that encourages new market participants by streamlining patent application procedures. In the process, a new industry will hopefully evolve which the government can signal and direct to be competitive, and maintain the competitiveness of an industry working in comparatively poor conditions.

However, there is a large amount of research conducted at Infruitec, consuming vast resources and producing knowledge, and that cannot be patented. In the processing technology and post harvest biology departments, much of the research conducted creates knowledge where appropriation is not possible, but the knowledge can be kept secret due to the working environment in the companies associated with these areas of research. The benefit of competitiveness, resulting from each company conducting similar research, should be weighed against the opportunity cost of researchers' time if these efforts were better co-ordinated.

Infruitec has established a productive department in this field and it would be wasteful if the gains of the experience and knowledge that have developed were lost to the industry. These two departments produce knowledge that is applicable world-wide and valuable funding could be sought from industries by selling that information. As the processing technology and post harvest biology departments produce knowledge applicable only to the deciduous fruit industry, they provide a classic example where a research department could be privatised and funding gained from levies or taxes.

In contrast the soil and irrigation technology department is involved in work with much wider applications. This department is almost totally involved with researching techniques that are impossible to patent. The type of research they conduct has all the characteristics of basic science, and there is little scope for private funding of this kind of research.

The Government has a substantial role in funding research to maintain the integrity of the environment. Apart from a company conducting research in an attempt to create a certain corporate image, or a donor organisation giving funds to this cause, there are few economic incentives for a company to conduct research in this sphere. Thirtle *et al* (1997) note that, as the agricultural research industry in the United Kingdom has become privatised, environmental research has come under threat, leading to calls for more public provision of funding. Research pertaining to environmental concerns must be conducted if long-term sustainability of the industry is to be achieved.

4.5 Conclusion

There is no clear-cut rule or method that decision-makers can use when allocating funds for research. The boundaries between what should be privately and publicly provided are indistinct. Funding is an issue that needs focused thought so that, firstly, the required research is conducted and, secondly, it is conducted with optimal efficiency. The free rider and public good aspects of research can result in a below optimal level of research provision, and a need for Government intervention arises. Historically, the optimal

method of research allocation has been through block grants where research organisations are able to work and build on projects with the security of long term funding with their performance been evaluated by means of a formula.

More and more exporters have continued to enter the deciduous fruit industry in South Africa, causing increased decentralisation and developing a market structure that is not conducive to private in-house research. A research industry, therefore, needs to be created to meet the research requirements of the industry. The structure of the research environment in deciduous fruit may have a promising future when viewed in the light of Porter's(1990) identification of the main determinants of competitiveness. When viewed in this light, it is evident that a range of promising demand and factor creation mechanisms are present in the South African research industry.

However, in order to exploit this potential, domestic rivalry and related and supplier industries need to grow. There has been limited scope for these last two "determinants" to grow due to a history of publicly funded research. Nevertheless, it seems possible that the new post-deregulation deciduous fruit industry structure has created incentives for them to grow and thus to increase the competitiveness of the research industry and, concomitantly, the competitiveness of the deciduous fruit industry.

The DFPT and Hortec have a responsibility to act as a suitable "signaller" for the industry, as these bodies will be interacting directly with farmers and will therefore be answerable to farmer and industry needs. However, the Government also has a significant role to play in creating and maintaining a legal environment that will ensure the security of appropriate property rights so that investments are attracted to research with a promise of financial reward.

CHAPTER FIVE

METHODOLOGY FOR ESTIMATING THE RETURNS TO RESEARCH

5.1 Introduction

The first attempt at measuring the returns to research was Griliches' (1958) study on hybrid corn in the United States. Since then, numerous studies have attempted to calculate an exact figure to this value for agricultural research. Ruttan (1982) covers an extensive review of projects of this kind which were carried out prior to 1979. He reports documents estimating returns from a negative 48 percent to positive 130 percent. The majority of these studies estimate returns to be between 30 percent and 60 percent. Bottomley and Thirtle(1987, cited by Bottomley and Thirtle, 1988) update Ruttan and find the returns to these projects still to be in excess of 20 percent. Even though this figure reported by Bottomley and Thirtle (1987) is still impressive, more recent studies appear to have slightly lower returns than those in Ruttan's report. Returns to research projects fall into two major categories: *ex post* and *ex ante evaluation* with further sub categories.

Most of the studies mentioned in the reports listed above use an *ex post* technique evaluation. The next section describes two common *ex post* techniques used for research evaluation.

5.2 Ex Post Evaluations

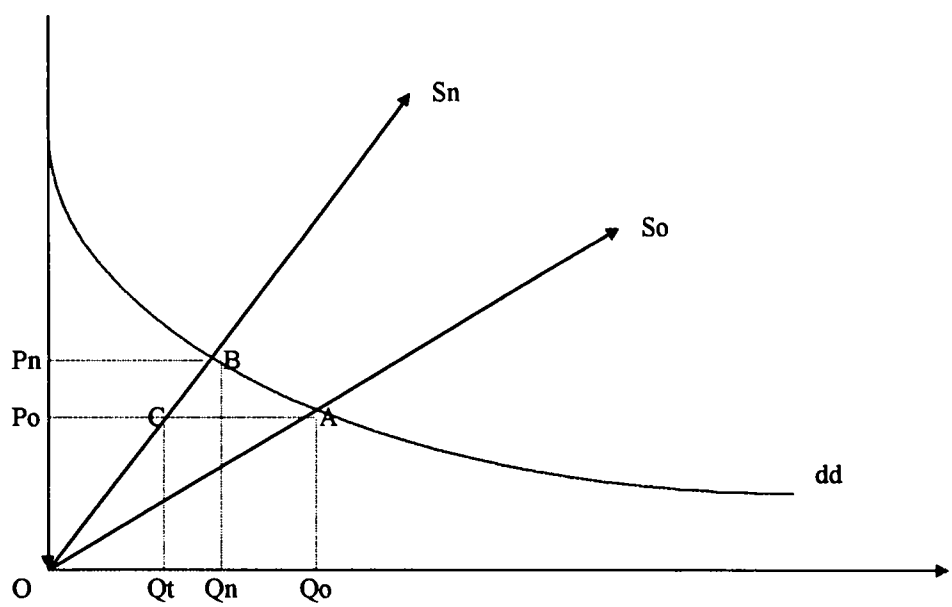
There are two groups of *ex post* evaluations which can be categorised as either supply models or production function models. Supply models are most popular in studies of "individual inventions", or single crops (Khatri) whereas, the production function is more commonly used at the aggregate or industry level.

Supply Models

Supply models evaluate research by quantifying the costs of products of increased production resulting from the research compared with the costs of the research. This section is based on Nagy and Furtan (1978), but a similar model may be found in Akino and Hayami (1975).

The gains in social welfare are expressed in terms of consumer surplus. Consumer surplus is a commonly used term which explains the area below the demand curve and above the relevant price horizontal (Willig, 1976). The change in consumer surplus is estimated by forecasting the shift in the supply curve caused by the technology developed in the research.

Nagy and Furtan (1978) use the following graph to describe consumer and producer surplus.



Source: Nagy and Furtan (1978).

Figure 5: Consumer and Producer Surplus.

The increased productivity attributable to research shifts the supply from Sn to So. The resulting gains are an increase in consumer surplus of ABC and producer surplus of ACO. Nagy and Furtan (1978) express supply and demand in terms of two-dimensional constant elasticity of supply and also constant elasticity of demand functions. The demand function is expressed as

$$Q = Hp^{-n} \qquad (1)$$

where Q = quantity demanded, H is the parameter of variables that influence demand other than its own price, p is the price corresponding to each quantity and n is the price elasticity of demand. The supply function is represented by

$$Q = Gp^{y} \qquad (2)$$

where q is quantity supplied, p is the price received by producers, Y is price elasticity of supply and G are the parameters of variables other than price that influence supply.

Sn is the supply curve before technology gained from research is adopted and it is assumed that this supply is a percentage 'h' less than the actual supply function So and can be specified as

$$q = (1 - h)\, Gp^{y} \qquad (3)$$

where h describes the percentage increase in supply due to new technology.

Since the supply function in comparative statistics is the marginal cost function derived from the production function, the rate at which the marginal cost function (h) shifts is related to the shift in the production function (k). The relationship between h and k is approximated as follows:

$$h \cong (1+y)\, k \qquad (4)$$

Once k and the demand and supply are estimated, the total social benefit from research can be estimated. Annual estimates can be made by substituting the production function shifter k, the price elasticity of demand (n), the price elasticity of supply (y), the annual product price (Po) and the annual market product (q) into the following approximation formulae:

$$\text{area} \quad ABC = \frac{1}{2} p_o q_o \frac{[k(1+y)]2}{y+n} \tag{5}$$

$$AOC = k\, p_o q_o \tag{6}$$

$$BPnPoC = \frac{poQoK(1+Y)}{y+n} \text{ X } [1- \frac{1/2k(1+Y)n}{y+n} - \frac{1}{2}k(1+y)] \tag{7}$$

The elasticity of demand and supply are estimated using a simple ordinary least squares regression using the usual variables affecting demand and supply, for example, price of substitutes and complements and quantities demanded. K is calculated by measuring the difference in productivity before and after research.

Two types of returns are then calculated using the following formulae:

The external rate of return:

$$r_e = \frac{100(ip+F)}{C} \tag{8}$$

The internal rate of return (r_i) is that rate of return that results in

$$\sum_{T=0}^{t} \frac{Rt-Ct}{(1+Ri)^t} = 0 \tag{9}$$

where Rt are the social returns to research for the respective year, Ct is the cost of research and T is the year in which research begins producing returns.

Production Function Approach

Production functions are used in measuring the returns to research as the research investment creates technical change which in turn affects production. These changes have a considerable time lag attached and, therefore, time series data are required (Bottomley and Thirtle, 1988). Since time series data for agricultural inputs are collinear, the number of input groups must be restricted and even then, if the full production function is fitted, parameter estimates for inputs which account for minor proportions of output may not be robust.

The model uses the well known Cobb-Douglas production function.

$$Y_I = \beta_0 \beta_1 X_{i1} \beta_2 X_{i2} \qquad (10)$$

This equation can be expressed as a logarithm as

$$Y_I = \beta_o + \beta_1 \ln Xi_1 + \beta_2 \ln X_{i2} \qquad (11)$$

where Y is output and the X_{ij}s are inputs (Gujarati, 1978). The β's are the elasticity of dependent variable (Y) with respect to the independent variables. For the purpose of returns to research studies R and D expenditures will be included as one of the dependent variables.

Due to the lagged effects associated with R and D expenditure, an appropriate model is required to capture the lagged structure of R and D. A common approach is as an Almon polynomial lag (see Townsend and Van Zyl, 1997: 10).

Townsend and Van Zyl(1997) use the following equation to determine the lag structure.

$$\ln \text{Yield}t = \ln\alpha + \ln\alpha \text{WEATHER} + \sum_{i=1}^{n} \beta \ln RD_{t-1} + U_t \qquad (12)$$

where Yield is tonnage of produce, R and D is research expenditure and weather is the weather index B is the elasticity of R and D at various lag lengths where n is the maximum lag of R and D that affects yield. U_t is the residual which accounts for variables not included in the model. Other variables may also be expected but due to risk of too few degrees of freedom restrictions are required.

To calculate the rate of return, the elasticities from equation (12) should be converted to value of marginal products. Following Townsend and Van Zyl(1997), each lag coefficient β_1 is the output elasticity of R and D for that year.

$$B_1 = \frac{\Delta \ln Yield_t}{\Delta \ln RD_{t-1}} = \frac{\Delta Yield}{\Delta RD_{t-1}} x \frac{RD_{t-1}}{Yield} \qquad (13)$$

(Thirtle and Bottomley, 1998)

Thus the marginal physical product of R and D is the elasticity multiplied by the average physical product

$$\text{MPP}_{t-1} = \frac{\Delta Yield_t}{\Delta RD_t} = B \frac{Yield}{RD_{t-1}} \qquad (14)$$

(Thirtle and Bottomley, 1998)

Replacing $\text{Yield}/\text{RD}_{t-i}$ by its geometric mean, and changing from continuous to discrete approximations gives:

$$\frac{\Delta Output}{\Delta RD_{t-1}} = B_1 \frac{\overline{Yield}}{\overline{RD_{t-1}}} x \frac{\Delta Value_t}{\Delta Yield} \qquad (15)$$

(Thirtle and Bottomley, 1998)

Then multiplying by the increase in the value of output divided by the change in quantity converts from output quantity to output value. Thus the value marginal product of RD in period t-i can then be written as:

$$VMP_{t-1} = \frac{\Delta Value_t}{\Delta RD_{t-1}} = B_1 \frac{\overline{Yield}}{\overline{RD_{t-1}}} x \frac{\Delta Value_t}{\Delta Yield} \qquad (16)$$

(Thirtle and Bottomley, 1998)

where $Yield/RD_{t-i}$ is an average and $\Delta Value_t/\Delta Yield_t$ is calculated as the average of the last five years minus the average for the first five years (due to fluctuations). $\Delta Value_t/\Delta Yield_t$ and $Yield/RD_{t-i}$ are constant price geometric averages. The marginal internal rate of return (MIRR) is calculated from

$$\sum_{i=1}^{n} \frac{VMP_{t-1}}{(1+r)^i} - 1 = 0 \qquad (17)$$

(Thirtle and Bottomley, 1998)

where n is the lag length by solving for r the MIRR is established.

5.3. Ex Ante Evaluation

There are four major groups of *ex ante* evaluation:

- those using scoring models to rank research activities,
- those employing benefit-cost analysis to establish rates of return to research,
- those using simulation models, and
- those using mathematical programming to select an optimal mix of research activities.

As the name *ex ante* implies these projects estimate future benefits from projects. Results of these projects are pure estimates and act as a guideline for research investment and prioritising future research expenditures (Norton and Davis, 1981).

5.4. Summary.

Broadly speaking, there are two kinds of research evaluations; *ex post* and *ex ante*. *Ex ante* is used to evaluate research that has not yet been conducted so that decision makers have a benchmark in prioritising research projects. *Ex post* evaluations are based on historical data and are used to put an economic value on the return to previous research projects. This study uses historical data to estimate the returns to research, for deciduous fruit at the industry level. It, therefore, uses the production function approach as this statistical approach is the best method to aggregate out the effect of variables that may be attributable to changes and growth in industry output.

CHAPTER SIX

DATA COLLECTION AND ANALYSIS

6.1 Introduction

Evaluating research has a long and detailed history, the earlier part of which has been reviewed by Ruttan (1982). The studies that Ruttan (1982) reviews are all *ex post* and make use of historical data, and the two techniques are the Index number approach and the Regression analysis approach.

The scope of the analytical section of this study only covers the returns to research in deciduous fruit in South Africa at the industry level. This study makes use of regression analyses to estimate these returns. Research costs and output figures have, therefore, had to be estimated for the total industry. As recorded in the chapter reviewing agricultural research in South Africa, research has been the responsibility of the state and therefore recordings of project costs were under the bureaucratic control of state administrations. The cost-recording responsibilities have changed over the years. With these changes, the style of recording costs has also changed and resulted in no consistent system of research costs. Consistency is required in the data collection process to avoid problems that could be associated with changing definitions of R and D expenditures (Ravenscraft and Scherer, 1982).

This chapter describes the statistical model used in the analysis, the financial documents available for review and the type of data available. There is an outline of the methodology used for obtaining the final data series. The data series are given in tabulated form. The last part of this chapter describes the analysis and the results thereof with the policy recommendations that can be concluded from the analysis.

6.2 The Model

The general supply function of an agricultural product can be expressed as

$$Yi = \S(Pi, Pj, W, Rk, I, T,) \quad (18)$$

Where Yi is the quantity of output good *i*, *P*i is the price of output *i* , *Pj* is the price vector of competing outputs Rk is the price vector of inputs, I is the institutional constraints, infrastructure etc., T is the state of technology and W is the weather. A price vector of competing crops was included as the opportunity cost of a crop is considered in the planting decision. The major competing crops of deciduous fruit in South Africa are vegetables and grapes. On the input side labour, fertilizer and machinery were considered as the major input costs. The weather and R and D expenditures are included to capture shifts in the supply curve. For the purposes of this study a risk factor was not included.

The initial model used to estimate the supply function of deciduous fruit was:

$$\ln Yd = \S(\ln Pd, \ln Pg, \ln Pv, \ln Pm, \ln Pp, \ln Pf, \ln W, \ln RD) \quad (19)$$

Where Yd is an output index of deciduous fruit, Pd is a price index of deciduous fruit, Pg a price index of grapes, Pv a price index of vegetables, Pp a price index of packaging materials, Pm a price index of machinery, Pf a price index of fertilizer, W a weather index and, RD are the research and development expenditures. This model is very general and was fitted to obtain the effect of most influences and avoid any biases. A second order polynomial lag model was estimated with zero end constraints. Due to the lagged effects associated with R and D expenditure, an appropriate model is required to capture the lagged structure of R and D. Ordinary least squares may be ineffective as:

(1) the length of the time series may be short and, therefore, the model may lack sufficient degrees of freedom,
(2) the error term will usually be serially correlated and,

(3) multicollinearity is likely to be severe(Greene, 1993).

To capture the lag effectively it is necessary to impose some structure on the lag distribution. A popular approach is to use the polynomial distributed lag (Almon, 1965 cited by Greene 1993). This model is based on the assumption that the true distribution of lag coefficients can be approximated by a polynomial of low order. Industry output was used as the dependent variable as the purpose of the study was to estimate the effect that R and D had on the variation of the industry output. Ordinary Least Squares regressions were run using the TSP version 4.2A program. Various lag lengths were tested and significant relationships between R and D and output were found when R and D was lagged for seven, twelve and eighteen years. Models that tested lag lengths for R and D other than seven, twelve and eighteen years produced t statistics that suggested that R and D did not significantly contribute to fluctuations in deciduous fruit production. They were therefore discarded as this study concentrated on capturing the effect of R and D on deciduous fruit output. The rates of return were calculated as follows:

$$\alpha_i = \frac{\frac{\Delta Q}{\Delta RD}}{\frac{Q}{RD}} = \frac{\Delta Q}{\Delta RD} * (\frac{RD}{Q}) \qquad (20)$$

$$\text{P*MPP} = \alpha_I \, (\frac{MeanQ}{MeanRD}) * MeanP = \text{VMP} \qquad (21)$$

The IRR is calculated by setting r = 0,

$$\text{where n is the lag length } \sum_{i=1}^{n} \frac{VMPt-1}{(1+r)^i} - 1 = 0 \qquad (22)$$

Where the mean P and mean Q are the average of the price series and output series for 1978 to 1994 and n is the number of lags.

6.3 Data Collection

Due to the way in which funding of agricultural research in South Africa has changed over the years, the recording mechanism has changed markedly in the process. Much of this documented data has been lost, or simply not retained, as it was the policy certain institutions that financial data was no longer stored from after the period covered by the documents. This section describes the financial documents that were examined in an attempt to estimate the cost of research and the final methods that were adopted to estimate the cost of research at Infruitec, Unifruco Research Services and the University of Stellenbosch.

The first sources of budgeted information analysed were government expenditure estimates (listed in *Estimates of the expenditure to be defrayed from State Revenue account*). In these statements, total costs for personnel, administration, stores and livestock, equipment, land and buildings, and professional and special services were recorded under one heading, for all publicly funded research institutions. Another cost labelled "programme structure", which is more specific to commodities, is also given. It is uncertain what this estimates. Referring to programme structure, it is specific to the individual research institutions but not specific nor comprehensive enough to base a cost for deciduous fruit. Furthermore, considering that Infruitec covers more research than merely deciduous fruit, it is not possible to determine expenditures on research in deciduous fruit from these papers. "Appropriation reports" for the Fruit and Fruit Technology Institute were also analysed. The same method of recording costs as mentioned above was found and therefore the same problem. Attempts were made to estimate the cost of research in deciduous fruit from these papers and there was a noticeable lack of compliance between the two sources.

Financial statements at Infruitec were also analysed and here there was not enough clarity separating deciduous fruit types from the other fruit types researched at the Fruit and Fruit Technology Research Institute as it was then. The same problems were encountered as before: costs were too broadly described and were not specific enough to base feasible assumptions on. These reports were only available from 1985/86 to 1988/89. It was policy at the institute to discard financial reports after ten years.

As this is the extent of available information at the project level for the years prior to 1993 it was decided that the cost of research will be estimated on a project basis by using annual reports. The annual reports for the National Fruit and Fruit Technology Institute from 1972 to 1991 were used to record all projects for these years. Individual projects during the period 1972 -1991 have had their values estimated by department managers, based on costs from year end financial statements from 1994 -1997. These statements specify all direct and indirect institutional costs attributed to each project.

Projects, and their costs, which were of specific benefit to the dried and canned fruit industry, were not included in these calculations. The financial data describing these benefits are the property of private commercial firms and, therefore, confidential.

Documents recording the cost of research conducted at the University of Stellenbosch were pursued, but there was no known record. Students carry out the research at the university and the cost of maintaining these projects has been included in the overhead projects of the departments and is impossible to identify. The cost of research has, therefore, been estimated by assuming that all research conducted at the university was completed as either Doctoral projects or M.Sc.Agric projects.

A Doctorate takes three years to complete and the estimated cost of the three-year project is R222 000 in 1997 terms. This figure is reached by means of the following calculations and estimates. According to the department head, the government funds the Department nine subsidy units per doctorate; each subsidy unit is worth R12 000; the Foundation for Research Development (FRD) supports each student at R18 000 per annum, and the University Department gives R10 000 per annum; the estimated overhead cost for each project is R10 000 per annum.

The cost of an M.Sc.Agric is estimated at R135 000 over two years. This figure is made up of the following costs: an M.Sc.Agric student earns the Department five subsidy units at R12 000 per unit; the Department supports each student at R10 000 per annum, and the FRD gives R15 000 per annum; overheads are also estimated at R10 000 per annum. When allocating these costs per annum it was assumed that all doctorates took three years and an M.Sc.Agric two years to complete. The total cost of the project would then be spread evenly over the time it took for project completion.

Unifruco Research Services (URS) have also contributed significantly to research in deciduous fruit. Until 30 September 1997, when URS split into Hortec and Unifruco's commercial research services URS funded projects at Infruitec and supplied funds to the University of Stellenbosch. The recordings of funds allocated to the University and Infruitec are covered by the methods used to estimate costs at these institutes. Therefore, the cost of research carried out at URS has been summed as all the costs they allocate to their own research laboratories. These figures were supplied by the financial manager at URS.

The weather data were collected from unpublished data recording average rainfalls for different areas of South Africa. The sum of these averages for the areas where deciduous fruit is grown was used as the weather series. The price of substitute crops; grapes and vegetables, are price indexes from the same source. The data for machinery indexes and labour price indexes were taken from unpublished data and "South African Statistics". These series were incomplete in these sources and the balance of the data was taken from the abstract of agricultural statistics. The price of packing materials is an index of the price of wool sacks, grain bags, cartons and box wood. The price of fertiliser is a combined index of the price of ammonium sulphate, urea, super phosphate, potassium chloride, potassium sulphate, and mixtures.

Data Manipulations

There was no consistency with regard to the form in which the series were recorded, whether real or nominal. The data were, therefore, manipulated so that all series were expressed in common terms to estimate the correlation between the data series. The research and development data were estimated in real terms. Apart from expressing the series in real terms, manipulations of data were required to iron out cross effects that would be caused by price movements that are the result of quality and quantity adjustments. The following manipulations were required:

All data series were expressed in real 1990 terms. However, all the series collected from the Abstract of Agricultural Statistics were initially expressed in 1997 terms and were deflated using the PPI (1990=100) from the abstract. The cost of R and D was

estimated in real 1997 terms and then deflated using the index to 1990 terms. *Output* is an index of deciduous fruit production, the *price of deciduous fruit* is a combined index of deciduous fruit prices calculated using values of deciduous fruit production from the Abstract of Agricultural Statistics as follows:

$$\text{Price series} = \sum \frac{categoryprice * categoryquantity}{\sum categoryprices * categoryquantities} categoryprices \qquad (23)$$

$$\text{Value of crop} = \sum all(prices * quantities) \qquad \mathbf{(24)}$$

$$\text{Output series} = \frac{valueofcrop}{priceseries} \qquad \mathbf{(25)}$$

The 'category' refers to the channel through which the fruit was sold such as the export and fresh market. The price series calculated above was used as the independent variable and the industry price and the output series was used as the dependent variable.

Data Series.

Table 6.1 and table 6.2 show the actual data that was used in the analysis. All values are expressed in 1997 terms.

Table 6.1: Data Series Used in the Analysis.

Year	Nominal fruit price (R/t)	Real Fruit price series (R/t)	Output series (t)	Grape Prices index	Vegetable production index
1971	752.86	7682.30	70432.79	76.57	11.2
1972	1180.54	11351.35	60673.02	82.52	14.1
1973	1029.85	9033.77	67399.88	102.39	18.7
1974	1216.45	9578.37	83091.02	127.14	19.3
1975	1082.47	7517.13	81903.23	141.68	25.0
1976	1381.97	8637.33	69366.87	161.56	23.3
1977	1711.07	9612.76	75293.94	158.17	24.2
1978	1670.09	8434.80	73769.89	183.27	24.3
1979	1861.89	8312.00	82673.44	194.63	34.0
1980	1658.38	6503.45	80126.91	211.72	38.0
1981	2319.37	7889.02	101846.91	245.49	39.4
1982	1859.63	5518.19	91216.73	239.67	42.8
1983	2464.94	6521.00	99794.52	272.03	54.4
1984	3529.05	8362.69	85525.92	327.57	43.8
1985	4637.67	9445.36	103816.38	372.76	49.5
1986	4291.88	7374.36	119683.62	406.02	62.2
1987	5059.10	7483.87	102583.15	516.59	83.8
1988	6230.15	8176.05	105109.09	531.68	88.1
1989	8874.54	10153.93	105910.35	691.75	71.7
1990	9156.77	9156.77	112711.71	752.24	100.0
1991	9540.53	8274.53	123239.18	829.01	100.2
1992	7702.49	5866.33	114436.63	923.62	125.6
1993	10059.54	6980.94	123580.04	1132.97	97.4
1994	10708.18	6820.50	124618.16	1194.42	117.0

Table 6.2: Data Series Used in the Analysis.

Year	Fertiliser price index	Packaging Price index	Weather Index	Producer Price Index	Labour Price Index	Machinery Price Index	R and D series(R).
1971	8.1	11.0	198.45	9.8	8.55	6.057	5331720
1972	8.8	11.9	182.20	10.4	8.86	6.611	7433910
1973	9.5	12.4	194.68	11.4	10.23	7.268	7000577
1974	10.8	13.4	314.67	12.7	12.28	8.215	6728535
1975	15.1	16.5	243.39	14.4	14.38	10.167	6243858
1976	16.2	17.9	330.48	16.0	17.05	12.030	5622891
1977	18.1	19.5	340.24	17.8	21.02	13.443	6830418
1978	21.2	21.7	186.10	19.8	21.31	15.539	6975580
1979	24.1	24.3	218.77	22.4	24.04	17.359	7507301
1980	28.2	27.8	256.65	25.5	28.32	19.625	7287678
1981	30	32.3	324.34	29.4	35.36	22.218	6543055
1982	33.2	35.8	250.10	33.7	39.82	26.398	8804180
1983	37.8	38.4	283.15	37.8	47.09	30.179	8254449
1984	41.1	41.0	289.65	42.2	47.82	34.176	8908482
1985	54.8	43.5	352.46	49.1	50.63	42.434	8564127
1986	63.2	56.3	254.19	58.2	58.88	54.179	9074881
1987	62.9	64.9	254.62	67.6	63.34	64.325	7795580
1988	77.9	77.1	231.94	76.2	75.69	74.263	8021656
1989	93.2	86.9	273.71	87.4	87.82	90.125	8926367
1990	100.0	100.0	253.53	100.0	100.0	100.000	10428195
1991	110.4	105.7	282.22	115.3	102.85	107.158	9999723
1992	109.3	111.1	236.09	131.3	118.26	114.115	19176652
1993	118.2	122.6	285.21	144.1	127.92	128.789	25588303
1994	131.4	134	224.79	157	139.89	141.876	32852256

6.4 The Output Models

The variation in industry output is explained using changes in the price of deciduous fruit, cost of the crop considered, input prices and research and development expenditures. The variables were the most economically logical variables that could be used. In other studies where the internal rates of return have been estimated similar variables were used. The regressions were initially run using all 11 variables that were thought to have an effect on industry output. Dependent variables that produced the weakest statistical relationships were dropped individually until all the variables used had statistically significant relationships. Logarithms of the data series were used to eliminate any doubt regarding the symmetry of the data. Polynomial lags were used to test the time-delayed relationships between the variables and these lags produced highly statistically significant relationships.

Polynomial lags were used to estimate lag lengths from no lag up to a twenty two year lag. It is not feasible to attempt estimating a longer lag as there are insufficient degrees of freedom for the statistical model to be reliable. The following models appeared to be reliable due to their superior t, F, and Durbin-Watson statistics, Schwarz Bayes Information Criteria, Log Likelihood of function and adjusted R squared for the respective lagged years.

In each section below the output of the critical statistics of the analyses is provided in the form of a table and figure as produced by the time Series Processor Programme.

Seven Year R and D Lag Model

The critical statistics of the model are shown in Table 6.3 and Figure 6.1 below:

Table 6.3: Seven Year R and D lag model.

Variable	Coefficient	S.e.	t – stat
C	4.61643	3.34483	1.3801
LRPOUT(-2)	0.22687	0.09869	2.2986
LRPGRP(-4)	-0.49008	0.17910	-2.7362
LRD	0.04099	0.00978	4.1886
LRD(-1)	0.07028	0.01677	4.1886
LRD(-2)	0.08785	0.02097	4.1886
LRD(-3)	0.09370	0.02237	4.1886
LRD(-4)	0.08785	0.02097	4.1886
LRD(-5)	0.07028	0.01677	4.1886
LRD(-6)	0.04099	0.00978	4.1886
W	0.00127	0.00411	3.1021

Adjusted R-squared	= 0.856016
Durbin-Watson statistic	= 2.56117
F-statistic (zero slopes)	= 24.7808
Schwarz Bayes. Info. Crit.	= -5.10408
Log of likelihood function	= 26.3458

Figure 6.1: Summary of critical statistics for seven year R and D lag model.

The adjusted R squared suggests that 95 percent of the variation in deciduous fruit production can be explained by the variation in the independent variables. The F statistic (24.78) strongly proposes that the null hypothesis that the independent variables do not influence deciduous fruit production, be rejected. The size of the Schwarz Criteria and log of likelihood function statistics both indicate that the lag length is significant and reliable. Both these statistics provide a guide for the validity of lag lengths.

The t-statistics in the model suggest that the variables are significant at the 95 percent confidence level. The model indicates that there is a two-year lag between a price movement in deciduous fruit and the time that it takes for industry output to respond, and that this relationship is positive. The model suggests that for every one percent increase in the deciduous fruit price, the industry output increases by 0.22 percent. There is a four year lag between a response in the industry output and the change in grape price, and a one percent increase in grape price will decrease deciduous fruit production by 0.49 percent. The spread of the effects of Research and Development are illustrated by the coefficient of the lags in Table 6.3. Research and Development expenditures affect industry output positively the same year as the investment and its benefits are felt over a six-year period with the maximum benefit of the research felt in the fourth year after the research investment. The coefficient of the lag (LRD(-1) etc) illustrates the spread of the polynomial lag of the Research and Development investment and shows how the effects of a research investment are felt. The model suggests that research has a continually increasing and positive effect on industry output until four years after the investment. From the fourth year after the investment the effect of the Research and Development investment begins to diminish until the seventh year after the investment. After the seventh year the effect of the investment is no longer felt. Weather has a significant affect on industry output and the effect is felt the same year as the change in weather. The marginal internal rates of return to research expenditures are calculated using the coefficients of lagged research expenditure on output. Converting the output into a value, and discounting the benefits to allow for the lag between outlays and results gives a marginal internal rate of return of 380 percent (section 6.2). This suggests for every R100 increased investment in research industry output will increase by R380.

Eleven year R and D Lag Model.

The critical statistics of this model are shown in Table 6.4 and Figure 6.3

Table 6.4: Eleven-year R and D Lag Model

Variable/lag of R and D	Coefficient	S.e.	t stats
Constant	-16.70900	3.13600	-5.3290
LPd(-2)	0.386448	0.06094	6.3408
LPm	-0.784748	0.20315	-3.8620
LPf	1.123940	0.20963	5.3614
LRD	0.048191	0.00562	8.5636
LRD-1	0.088350	0.01031	8.5636
LRD-2	0.120478	0.01407	8.5636
LRD-3	0.144574	0.01688	8.5636
LRD-4	0.160637	0.01876	8.5636
LRD-5	0.168669	0.01969	8.5636
LRD-6	0.168669	0.01969	8.5636
LRD-7	0.160637	0.01876	8.5636
LRD-8	0.144574	0.01688	8.5636
LRD-9	0.120478	0.01407	8.5636
LRD-10	0.088350	0.01031	8.5636
LRD-11	0.048191	0.00562	8.5636

Adjusted R-squared	= 0.928902
Durbin-Watson statistic	= 2.26269
F-statistic (zero slopes)	= 40.1954
Schwarz Bayes. Info. Crit.	= -6.42144
Log of likelihood function	= 29.7055

Figure 6.2: Summary of Critical Model Statistics for Eleven Year R and D Lag Model.

The adjusted R squared suggests that 93 percent of the variation in deciduous fruit production can be explained by the variation in the independent variables. The F

statistic (40.195) strongly suggests that the null hypothesis, that the independent variables do not influence deciduous fruit production, be rejected. The size of the Schwarz Criteria and log of likelihood function statistics both indicate that the lag length is significant and reliable. These statistics provide a guide for the validity of lag lengths.

The lowest t-statistic is 3.86289 which indicates that all coefficients are significant at the 99 percent confidence level. The model shows that there is a two-year lag between a price movement in deciduous fruit and the time that it takes for industry output to respond, and that this relationship is positive. The model suggests that a one percent increase in industry prices may increase output by 0.38 percent with a two year lag. Machinery and fertiliser price affects production within the same year, a one percent increase in machinery price usually decreases output by 0.78 percent similarly whereas a one percent increase in fertiliser price is usually associated with a 1.12 percent increase in industry output. The coefficients of the lags illustrate how the benefits of Research and Development expenditures are felt in the industry. Table 6.4 shows the Research and Development investment has an immediate impact on the industry. The positive coefficient to LRD illustrates this point. In Table 6.2 the coefficients of the lags (LRD(-1) etc) show the spread of the polynomial illustrating that the benefits of the Research and Development have a maximum impact five to six years after the research and development investment. From the sixth year after the investment the benefits are felt less and less until they are no longer felt from twelve years after the investment. The marginal internal rates of return to research expenditures are calculated using the coefficients of lagged research expenditure on output. Converting the output into a value, and discounting the benefits to allow for the long lag between outlays and results gives a marginal internal rate of return of 249 percent. This figures suggests that for every R100 increased in Research and Development, industry output increases by R249.

The Eighteen Year R and D Lag Model

The critical statistics for the model that found an eighteen year lag between the research investment and output is shown below in Table 6.5 and Figure 6.5.

Table 6.5: Eighteen Year R and D Lag Model.

Var-iable	Coefficient	s.e.	T. Stat
Constant	0.30	0.180	1.73
LPd(-2)	0.37	0.091	4.099
LPd/Pg(-3)	0.15	0.083	1.83
LPm(-6)	-0.25	0.237	-1.06
LRD	0.46	0.14	3.382
Time	0.014	0.005	2.58

Adjusted R-Squared	= 0.95
D-W Statistic	= 2.28
F-Statistic	= 110.54
Shwarz Bayes Information Criteria	= -4.93
Log-Likelihood	= 41.52

Figure 6.3: Summary of Critical Statistics for Eighteen Year R and D Lag Model.

The adjusted R squared indicates that 95 percent of the variation in deciduous fruit production can be explained by the variation in the dependent variables. The Durbin - Watson statistic (2.28) finds the model is free of autocorrelation. The F statistic (110.54) strongly suggests that the null hypothesis, that the independent variables do not influence deciduous fruit production, be rejected. The size of the Schwarz Criteria and log of likelihood function statistics both indicate that the lag length for research expenditures is significant and reliable.

The model indicates that there is a two year lag between a price movement in deciduous fruit and the time that it takes for industry output to respond, and that this

relationship is positive and significant at 90 percent confidence level. The model suggests that a one percent increase in industry prices will increase output by 0.37 percent after two years. The relative price of deciduous fruit to grape prices also has a significant effect on industry output. A one percent increase in the relative price results in a 0.15 percent increase in output after three years. The price of packing material affects output after a period of six years. A one percent increase in the price of packing material will decrease industry output by 0.25 percent. Research and Development expenditures affect industry output positively within the same year of the investment and the benefits are felt over an eighteen year period with the maximum effect after eight to nine years. The marginal internal rates of return to research expenditures are calculated using the coefficients of lagged research expenditure on output. The effect of a one percent increase in research expenditures is a 0.46 percent increase in output. Converting the output into a value, and discounting the benefits to allow for the long lag between outlays and results gives a marginal internal rate of return of 78 percent.

Figure 6.4 illustrates the distribution of the polynomial lag where it can be seen that maximum effect of the research investment is felt after eight to nine years.

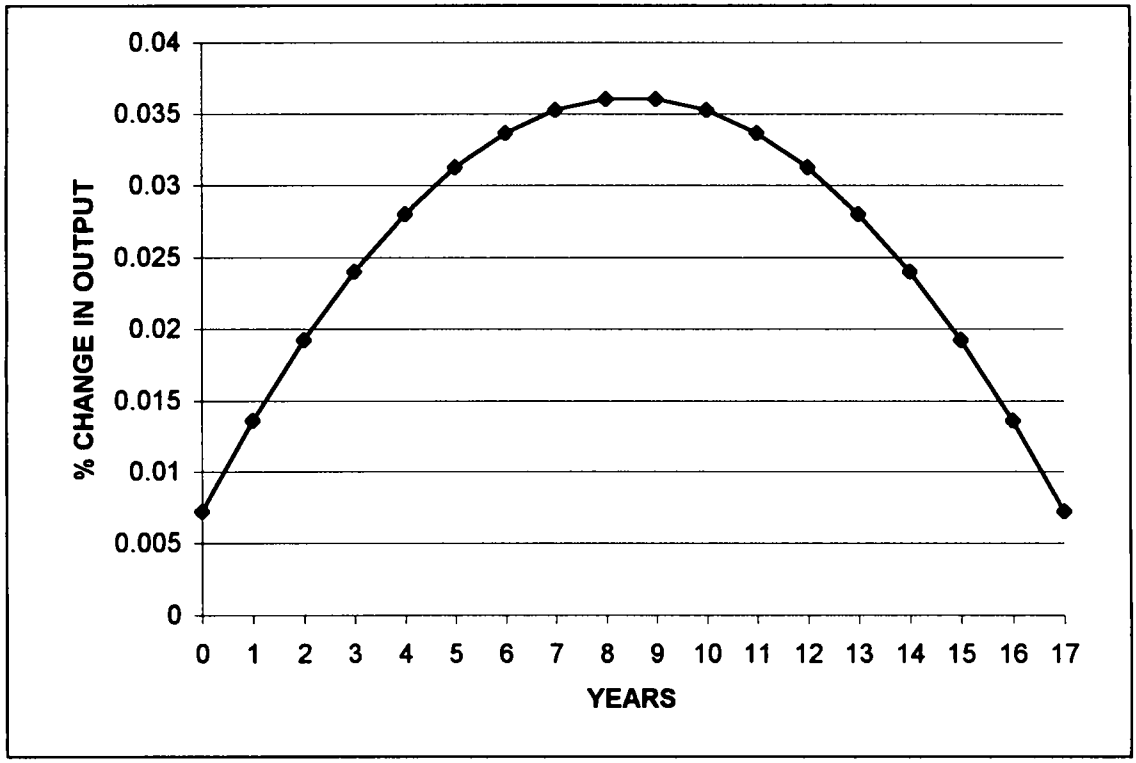


Figure 6.4: The Effect of R and D on Output with a 18 Year Lag.

6.5 Conclusion

Statistically all three models are good fits. The seven-year lag model is the weakest as far as adjusted R-squared, Durbin Watson statistic, F-statistic, the Schwarz Bayes information Criteria and Loglikelihood are concerned, but it has significant t statistics and, despite being worse than the other models is, as a statistical model, a very good fit. A seven-year lag between R and D and output can be seen as short and IRR of 380 percent is very suspect. A two-year lag between own price and output is consistent with the rest of the models. A two-year lag is suspect as fruit bearing trees take four years before they start bearing and a response to price changes should take that long. A farmer will see a season out before he replants his orchard, so that, a price change should logically have a five-year lag. As fruit prices change, farmers may invest more resources in crops that will be more financially rewarding, hence a two-year lag may be plausible. The four-year lag between change in grape price and industry output is short for a normal explanation. A similar explanation is offered for the two-year lag between industry price and own price and may be the most appropriate explanation.

This is the only model where the weather was noted as having a significant effect and the positive relationship with no time lag is as expected.

The twelve-year lag model has superior t statistics at higher confidence levels, which suggests that the variables used are more appropriate for the purposes of this study. Besides the t statistics the size of all the critical statistics suggest very good models. It is logical to assume that output, machinery and fertiliser prices would affect production as well as investment in research and development, and a positive relationship between the price and output of deciduous fruit would be expected. The deciduous fruit industry makes intensive use of machinery so that a negative relationship between price of machinery and output would also be expected. However, a positive relationship between fertiliser price and output is not anticipated. The use of fertiliser should increase output but, as the price increases its use would drop at the same time lowering output. Machinery and fertiliser are essential to production and a price inelastic response with these commodities is expected. Their use, therefore, should not have changed much over the years. Therefore, a significant statistical relationship between these variables, and the output is surprising. The sizes of the coefficients that these variables obtain in the model are a point of concern. They suggest that changes in the prices of these commodities have a strong influence on output. The positive relationship between research and development expenditures and output is as expected. The size of the coefficients and significant T statistics suggest a very significant relationship between R and D and output.

Considering the eighteen-year lag model, the only common variables that are significant are the own product price and the R and D series. Packaging material is found to be significant at a six-year lag. A six-year lag with packaging material has no logical defence as packaging equipment is a variable input of which new stocks are brought annually. The relationship between a ratio of fruit price to grape price can be expected although the three-year lag is suspect. The only plausible explanation has to follow the same line as the two-year lag with own price. In this model, the lag is also two years between own price and the time it takes to affect industry output, the same defence for this short time lag is offered again.

Other similar studies, reviews of which can be found in Ruttan (1982) and Bottomley and Thirtle (1988), have rates of returns ranging between negative rates of return and positive 148 percent, whereas this study estimates three rates of return ranging from 380 percent to 78 percent. Bottomley and Thirtle's report acts as an update of Ruttan's work and most of the studies they describe have returns below 20 percent. Bottomley and Thirtle review more modern studies than Ruttan and this study could be expected to produce similar results to these. The logic that the older studies conducted measure returns to industries where the industries may have been in the growth stages and research was having a greater impact than would be expected in a mature industry. The data used in this study cover the period of 1972 -1994 when the South African deciduous fruit industry was a mature industry, hence the comparison between this work and the more modern studies.

The deciduous fruit industry had an extremely effective communication system through the DFB, and growers' associations representing the apple and pear and stone fruit producers. The cost of maintaining research in deciduous fruit in 1994 was more than R20 million and, considering that the effect of this has been regressed against an output of about R6 billion the model may be expected to produce the coefficients that it has. As the industry has been operating in a controlled environment with the effective communication system mentioned above, research needs would rapidly have been taken care over of, information of the new technology dispersed efficiently and the respective technology adopted swiftly. Most of the research benefits would then have been captured within the industry without the losses associated with public good and free rider problems. These benefits would, therefore, be captured by the analysis. If the results of this analysis are to be believed, then that explanation must be used to explain the unusually large returns.

The lags also need to be defended. It is quite plausible, due to the broad nature of research that has been conducted at Infruitec, that research benefits can have seven, twelve and eighteen year lags. Much of the work is managerial or technique producing research. These projects are annual and investigate the seasonal needs of fruit trees, and their effect could explain the seven-year lag. The twelve and eighteen-year lags can be explained by breeding and evaluation and other longer-term projects, as these may take from anything up to 16 years to complete, or the release of a new

cultivar. The three different models produced could suggest that the benefits of research and development may be better captured by a polynomial of a higher order than that used. It is possible that the spread of benefits may better be illustrated by a curve with two or three turning points, rather than just one. However, this study attempted only to estimate a single rate of return to research and development.

A point about the models produced in the analysis that raises interest is the inverse relation between the internal rate of return and the lag estimated. This illustrates that the lag length is critical in estimating an unbiased internal rate of return. The longer lags estimated in this study have produced more realistic rates of return, however the critical statistics produced by the analyses suggest that the models estimating the shorter lag lengths are better models and more academically reliable. Therefore, when estimating an unbiased IRR a balance that will satisfy statistical and economic logic must be found to ensure a plausible scenario is created. If the IRR's produced in this study were accurate there would have been an undoubtedly huge increase in research expenditure, which did not happen. As this is the first study of it's kind for the industry this huge increase may not have occurred as those involved were unaware of the how huge the benefits of research and attributed industry growth to other factors. More plausibly, though, is that the internal rates of return produced in this study are so large as a result of the industry growing at a similar rate as the research structures that supported it. This is especially true for the years covered by the data used in the analysis.

Although the analysis produced statistically significant relationships, due to the abnormally large rates of return calculated, consideration must be given to the data used, the variables tested and the nature of the study. Doubt may be cast over the manipulations applied to the data described in chapter six. These were essential because as industry output grows there are price adjustments due to changes in industry supply. As the industry grows and innovation occurs there will be changes in the price and quality relationships of the fruit. The manipulations were necessary to eliminate any unusual variations in the data that may have arisen from these relationships so as to avoid any occurrence of cross relationships or ordinary least square violations. As can be seen from chapter six these manipulations were successful.

Obvious policy implications can be drawn from this study. The international deciduous fruit industry is a very large and interactive industry. The different industries are continuously comparing performances and techniques. Information flows rapidly between different countries and therefore, due to the similarities in growing conditions there are very strong spillover effects from research. These spillover effects could have had a significant magnifying effect on the results of this study and, therefore, when considering the results of this study much thought must be given to this fact. The abnormally large returns to research can therefore only act as a guideline to decision makers and not as a cut and dry indication of the value of the research investment. There are too many factors to consider that affect industry output in an industry the size of the South African deciduous fruit industry to attribute the growth to one specific element. But, even if the figures produced here are reviewed sceptically it can still be confidently concluded that the research investment is associated with very large returns and is a most worthwhile investment. An aspect of the study that must be remembered is the immediate returns to the research investment. In South Africa where government budgets are tight and the investments made watched and evaluated very carefully, an investment where the effects can be felt in the short run can only act as a positive political selling point and, therefore, make the research investment easier to market.

CHAPTER SEVEN
SUMMARY AND CONCLUSIONS

7.1 Summary

South Africa has experienced major political changes since the beginning of the 1990s, and in the process wide-ranging changes in the agricultural industry. In 1939 the Deciduous Fruit Board was formed and controlled marketing of deciduous fruit in South Africa was created. Since then the various responsibilities within the industry have shifted between different members of the industry. However, the deciduous fruit industry has been deregulated, and control decentralised from a single channel to a free market system. Producers are now able to sell their output in the domestic market and through exporters of their choice rather than having to export through Unifruco. In the process there have been many new entrants into the export industry. A new industry structure has evolved with a central non-statutory body acting as a pivot for the various ligaments of the industry. This body, The Deciduous Fruit Producers Trust, is funded by a non-statutory levy and co-ordinates finances and industry activities and is operated as a non-profit, farmer orientated organisation. All activities are based on farmer referendums. When comparing the history of the South African deciduous fruit industry to that of international decentralised industries the South African deciduous fruit industry has shown poor growth. However, the new freedom disposed on the farmers will allow them to invest more in increasing production and should result in a larger growth in industry output compared with the past.

Historically agricultural research in South Africa has been a function of the state. Since 1910 the state has attended to all research requirements of the agricultural industry. As political changes have occurred during the twentieth century so have research responsibilities shifted between different departments within South African agriculture. Initially there were departments that attended to the requirements of non-white farmers, but these efforts were short lived so fundamentally, state supported research in South Africa has concentrated solely on the needs of white commercial farmers. As control in the deciduous fruit industry has been decentralised the structure of research and research funding has changed. Until 1989 the industry was unable to contribute to state supported

research. In this year Unifruco started to make significant financial contributions to research, more specifically to Infruitec, which was the government body responsible for carrying out research on deciduous fruit. Unifruco also formed it's own research body, Unifruco Research Services. As control of the industry has been decentralised away from Unifruco, and state support for commercial research withdrawn, a new equitable structure of research has been called for. Unifruco has created a private commercial research body aimed at serving the needs of farmers that use their exporting services as well as providing professional services and information bulletins on a pay for basis. Unifruco Research Services has been converted to Hortec Limited that shall attend to farmer needs and shall be funded via on a non-statutory levy and essentially run by the farmers. This levy is co-ordinated by the financial arm of the above mentioned Deciduous Fruit Producers Trust. The government has specified that if the industry raise 30 percent of project costs it shall supply the other 70 percent to make up the balance of the costs. Hortec's main purpose is to raise these funds and allocate them appropriately across necessary research needs, from immediate short term research to long term strategic type research. The allocation of these funds across projects is by a project appraisal system by members of Hortec, but is essentially driven by farmer referendums. These funds are distributed across projects carried out at the South African plant Improvement organisation, Infruitec, University of Stellenbosch. Eighty percent of the funds collected are allocated to the fresh fruit industry with the balance being shared equally between the dried fruit industry and the processing industry.

The economics of research were examined. Due to the public good nature and spillover effects of research this is a complex issue detailed with many subjective arguments. There are no clear cut rules about whose responsibility the various research activities are. However, a rough guide used is that the more basic research is, the greater the need for public funding, but as research becomes more strategic and applied there is greater scope to appropriate returns from the research investment and, therefore, more scope for private funding of this research kind. In this case there is no need for public funding and private funding should be encouraged. However, it is essential that the economics of research are understood fully in the face of reduced government funding. Research is fundamental to the competitiveness and survival of the deciduous fruit industry and therefore vital that the most appropriate structure attending to research needs is developed. The appropriate institutional set-up is required to ensure that innovators will

receive the legal protection that shall enable them to appropriate returns from the research investment. A structure where a lack of co-ordination exists could be cause a vital loss of efficiency in research due to an unnecessary amount of duplication of research. On the other hand it is necessary to get the right mix to ensure there is competition within the research industry that will drive these players to be innovative and efficient so as to maximise social welfare.

Due to the political changes that have occurred in South Africa research aimed at benefiting white commercial farmers is becoming less of a priority to the government and funding for research slowly withdrawn. Therefore, a study of this kind is required to establish the economic worth of investing in research to provide those lobbying for government funds with something definitive on which to base facts. On an international scale there is a very long and extremely detailed history of studies where the economic rate of return to research has been estimated. There are essentially two main categories of research evaluation types: ex post and ex ante. This study employs the popular production function approach which makes use of ex post, historical data, to estimate the economic rate of return to research. The production function approach is the most appropriate for estimating returns to research on an industry level. The other, less popular, ex post method of estimating economic rates of return to research is the supply model approach. Ex ante evaluations are used to evaluate present or future projects of which the benefits have not yet been felt.

As agricultural research in South Africa has a history of state funding, government documents that recorded costs at research institutions were analysed. These were found to be either too vague or too many costs were mixed into one figure which made it too difficult to allocate costs specifically to deciduous fruit. Research reports dating back to 1972 found at Infruitec were used in conjunction with year end financial reports to base estimates on the cost of research at that institution for the period 1972 -1994. The cost of research at the University of Stellenbosch was based on student subsidies and scholarships and rough estimates of overhead costs. The financial director of that institution provided the data pertaining to the cost of research from Unifruco Research Services. Other data used was collected from the Abstract of Agricultural Statistics, unpublished government archives and "South African Statistics". Time series were constructed and all financial values were expressed in 1997 terms. The financial series

were then manipulated to iron out relationships that may have been developed due to cost, quality and price relationships that would exist in the production of fruit. These manipulations were seen as necessary to ensure that the statistical analysis would be free of any ordinary least square violations.

A time series regression analysis was performed on the data using the Time Series Processor programme. A second order polynomial lag was estimated with zero end constraints. This is viewed as an appropriate model to use to estimate a lag such as the lag that exists between when the research and development investment is made and when its effects are felt. Industry output was used as the dependent variable. The following were used as independent variables; price index of deciduous fruit, price index of grapes, price index of vegetables, price index of packaging materials, price index of machinery, price index of fertiliser and a weather index.

Significant statistical relationships were found when R&D was lagged with output, but only for seven-, twelve- and eighteen-year lags. These models were very good fits although the lag lengths produced different statistical relationships between the variables used. In the seven year lag model the following relationships and lags between industry output and the independent variables were established; a two year lag with the deciduous fruit price index; a four year lag with the grape price index; a seven year lag with R&D and an strong relationship with weather with no lag. All relationships were significant at the 99 percent confidence level. A polynomial distribution illustrated that maximum returns to the research investment were experienced after three to four years. In the twelve year lag model the following relationships and lags between industry output and the independent variables were established; a two year lag with the deciduous fruit price index; an immediate relationship with the machinery and fertiliser price indexes and a 12 year lag with R&D. All the relationships were significant at the 99 percent confidence level. A polynomial distribution illustrated that the maximum returns to the research investment were experienced at six years after the investment. In the eighteen year lag model the following relationships and lags were established; a two year lag with the deciduous fruit price index; a two year lag with a combined deciduous fruit price index and grape price index; a six year lag with a packaging material price index and an eighteen year lag with R&D. Only the relationships between the dependent variable and the deciduous fruit price index and R&D were statistically significant at the 99 percent

confidence level. A polynomial distribution illustrated that the maximum returns to the research investment were experienced after eight to nine years. For all of the models the effect of the research and development investment was felt with immediate effect after the research investment.

7.2 Conclusion

The political change experienced in South Africa since the early 1990's has been felt in almost every aspect of South African life and the deciduous fruit industry is no exception. Both the research industry that supports the deciduous fruit industry and the industry itself have undergone major changes. Change in these industries is not only required to meet new political agendas but also to bring the deciduous fruit industry in line with the needs of the competitive global industry in which it operates. The exposure to the global market political change has brought through the lifting of sanctions has opened many opportunities for farmers and should continue to create even more. The deregulation of the industry has and should continue to attract increased foreign investment. This increased foreign investment is likely to create a competitive environment between these investors and functions like packing and grading are more likely to be carried out by private firms offering to export farmers produce. Historically farmers have had capital locked in to resources to carry out these functions. As farmers will be able to alter their investment portfolios and move resources into increasing productivity they should be in a position to increase productivity and industry output. The arrival and inflow of foreign and new investors will hopefully create a competitive environment amongst the exporters, where new services and products are introduced to capture the market and further increase the value of this industry. The exposure to new markets that foreign investors are likely to bring will spread the destination markets of South African deciduous fruit further afield than was experienced under the single channel marketing system. Hopefully with the discovery of new markets will come the discovery of new potential products and trade partnerships. New partnerships between members of the South African deciduous fruit industry and those of foreign countries may lead to the discovery of competitive advantages not known now and the creation of more markets that will have a trickle down effect increasing job opportunities.

One of the most fundamental changes to occur in the research industry is the flexibility in the funding mechanisms introduced allowing participants in the industry to contribute to funds that have traditionally been supplied by the state. Farmers and other participants are now able to contribute financially with greater flexibility and ease than was possibel previously. Due to this ease and the co-ordinating structures that the Deciduous Fruit Producers Trust and Hortec shall offer there should be much greater interaction between researchers and the farmers than previously. Hopefully this will create and environment where more farmers participate actively in the decision-making processes involving research and development investments. Strategic issues should also be attended to in a manner that is more representative of the entire industry than under the previous regime where these were restricted to a smaller group. This increased interaction will hopefully build a synergy that will provide research and other services that will meet market demand more efficiently than in the past. This should at least maintain and possibly improve the present competitive position of the South African deciduous fruit industry. Despite these obvious advantages of increased farmer participation the industry must maintain some kind of control to ensure that research concentrating on the long term needs of the industry are attended to. Besides the above-mentioned increased investment from members within the industry a more modern and competitive type of research industry may attract investment from sources not traditionally associated with research. Members of the corporate sector may seek publicity and use the research industry as a tool for creating an image of conducting proactive investments in the community. Previously this was not permitted and was probably viewed as a very unattractive investment as research was bogged down with bureaucratic processes and lack of accountability.

The economics of research is a topic detailed with very complicated issues and few strict guidelines as to who provides what kind of research. There are an endless amount of externalities associated with research. The exact effect of externalities is often a very debatable issue. In many instances the provider of certain research or extension service my claim that others are able to free ride on the provision of such services. In these circumstances the situation can often arise that the parties, who are claimed to be the free riders, may rightfully claim that had the knowledge are service never been provided they would never have been otherwise effected. In many instances certain groups could justify the public provision of funds for research covering certain topics, while at the

same time opposing groups could argue that the benefits experienced from such investments are too specific to justify public moneys being used. Hence to ensure that market failure of the provision of research does not arise there an industry will require that an external or public body monitor this. However, it is evident that the planners involved in the deciduous fruit research industry in South Africa have paid attention to this matter in the way that Hortec has been established. This body should ensure that all types of research across the continuum of different research kinds are covered regardless of how long it may take for the benefits of the research investment to be felt. The continual reassessment of research activities is highlighted in the literature on this topic as a critical element to ensuring success of research projects and therefore required to ensure that the needs of the industry are being met and met appropriately. The re-organisation of the research structures in this industry has created new councils that have overlapping duties and requirements. This set-up should cause these councils to work together to obtain the desired results. Besides the benefit these councils should derive from this co-operation, a situation where the councils criticise each other when they neglect certain duties may also occur. The research duties performed should, therefore, be continually reassessed by the various councils and farmers and hence create an environment where the necessary reassessment of research is conducted. This continual reassessment can only act as a positive for the industry and help to keep the research topics covered to be timely and therefore maintain technological progress of the industry up to breadth with the rest of the international industry.

The literature on research evaluation is extremely extensive and consists of a massive variety of analysis styles as well as reviews on the economics involved in the organisation of research, extension and development. There are many statistical approaches available to analyse and evaluate research. A large proportion of the literature is dedicated to ex ante evaluation techniques designed to predict a stream of future benefits from proposed research projects. There is a mass of different techniques and approaches described on this matter and, therefore, whether the approach used in a specific analysis is the best is a very subjective topic. The balance of the analytical section of this literature is taken up by ex post analyses and is also very extensive and again exposed to subjectivity. Most of the analyses described detail explicit statistical analyses. The two most popular approaches used are the production function approach and supply models. In most cases the studies practice a direct application of statistical

procedures that analyse the costs of research, extension and development and the believed associated benefits and increases in industry output. The methods used to calibrate these costs and outputs vary from analysis to analysis and the actual techniques decided on are usually specific to the industry and respective institutional arrangements. The flexibility in the methods of data collection required causes the data collection technique used to be exposed to debate and scrutiny. Data collection is an extensive topic on which a large amount of literature is also available. Hence it would be unjustifiable to lay claim that the data used in the kind of analysis covered in this study is the best. Much of the data used in this study were based on educated estimates based on concrete material. A large amount of energy was invested in investigating records only to discover the information sought had not been recorded. Therefore, when reviewing a study of this nature consideration must be given to the fact that there will be a large variety in techniques used between various studies attempting to obtain very similar results. The data used was the best available, based on what was perceived to be the most accurate method of calibrating the costs of research, however, it is impossible to assess how accurate the data actually is.

The principal reason for this study is the analysis that is conducted and described in chapter six. The analysis produced three different models suggesting very significant statistical relationships between the investment in research and development and industry output. The models produced unusually high internal rates of return in comparison to other studies of its kind. The only consistencies between the three models are the relationships between industry output and own price, industry output and expenditure on research and development and the unusually short time period in which the benefits of the research investment are felt. The relationships between own price and industry output were as expected. A brief analysis of the production patterns of the deciduous fruit industry will provide evidence that this has occurred in South Africa in the past. That this is proved in the analysis suggests that, although the results may appear suspect, the only part of the analysis where the results could be compared to historical production proved to be reasonably accurate. Therefore, the analysis has respectable statistical grounding. But, as mentioned in chapter six the internal rates of return calculated are inconsistent with rates of return to modern studies of this kind. Therefore, these figures should be reviewed with caution and can in no way be used as an accurate guideline in policy decision making.

If the rates of return produced were an accurate assessment of the value of the research investment there would undoubtedly have been a far larger increase in investments in the research industry. This probably did not occur due to the uncertainty surrounding the value of the research investment as this is the first study of its kind and therefore the extent of the value of the research investment was not known until this study. The participants in the deciduous fruit industry invested in research facilities as they could afford to do so and hence the research structures that support the deciduous fruit industry have expanded at a similar rate as the industry itself. These similar growth patterns could have contributed to how significant the statistical relationships produced by the analysis were.

The international deciduous fruit industry is a very large and interactive industry and therefore, due to the similarities in growing conditions there is likely to be a dominant effect between international industries and their research. These spillover effects could have had a significant magnifying effect of these results and, therefore, when considering the results of this study much thought must be given to this fact. Therefore, reference needs to be made again to the fact that these returns to research can only act as a guideline to decision-makers.

The effect the efficient manner in which information was disseminated through the information channels in the centralised industry structure may have had on the abnormal rates of returns should be considered. The deregulation and decentralisation of control of the industry is a very necessary event to maintain the competitiveness of the industry, but the benefits of the effective communication network resulting from centralisation cannot be ignored. Therefore, a system that encourages a very large degree of interaction, but also maintains a structure that stimulates competition and enables those involved in the industry to maximise freedom of choice within obvious and necessary legal bounds must be encouraged.

However, despite the imperfections mentioned this study provides a valuable insight as to what return investments in research yield. Even if the results are viewed with extreme caution they still suggest that the research investment in deciduous fruit is extremely worthwhile. The analysis produced results that can be at least used as a marketing tool

for those seeking public funds to be used in research. Of critical importance is the short time period it took for the benefits of the research investment to be felt. These figures suggest that the benefits of the research investment be felt with in the same year as when the investment is made. In South Africa, like all countries, the accountability of public funds is extremely important. The political environment in South Africa is extremely volatile characterised with political supporters who are impatient and require quick results to comfort their political views. In such circumstances an investment where the benefits are felt quickly can more easily be used as a point for gaining political points. Therefore, the research investments described in this study with such a short time period between the initial investment and the time they appear to yield results must, therefore be a very attractive bargaining tool for policy makers.

Due to the history of state supported funding of South African agricultural research there has being a system of cost recording that has lent itself to a system where research costs can not be specified for individual fruit kinds, let alone individual projects. Therefore, collecting data for a study of this kind has been a complicated procedure and resulted in the data actually used in the analysis been estimates based on the best possible guidelines. Of vital importance for the success of South African research, in the context of limited public funds for research, is that research be easily and accurately evaluated. Therefore, strict guidelines should be followed so as to maximise the ease in which a study of this kind can be carried out. Before a research project commences it must have a defined set of objectives. These objectives should include a set financial budget within which the project costs should fall. The time to completion of the project, the time period within which the project shall yield results and where precisely the effects of the project will be felt must be explicitly defined. An imperative is that the precise benefits of the project are defined so that when attempting to estimate the financial benefits from research there are clear boundaries as to where the benefits lie. In this case few resources will be required to be spent on estimating the economic value of research and can instead be invested in improving the management and administration of research to the benefit of the whole country.

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