A parametric approach was used in this study to analyse milk production and supply systems based on farm level production cost data from a cross-section of dairy farms in South Africa for the 1997/1998 production year. Both single equation and system estimation techniques were applied to Normalised Quadratic, Normalised Translog and standard Translog specifications of the profit and derived output supply and input demand functions. Estimated functions were evaluated for adherence to structural properties. Results showed that convexity of the profit function in all prices holds in South African milk production. Uncompensated and compensated price elasticities of supply and demand were calculated. The results indicated that milk production and livestock trading activities are complements in the production activities of the observed multi-input, multi-output dairy farms. Both activities were intensive in the use of purchased and self-produced feed inputs, with a higher intensity in purchased feed use. The variable inputs are gross complements in the long-run and net substitutes in the short term. The long-term expansion effects overshadow short-term substitution between inputs.

The data provided details on input use, output and input prices and herd structures. However, the sample was too small, for a cross-sectional sample, to allow for a high degree disaggregation in inputs. Consequently, aggregate price and quantity indices had to be constructed for some variables.

The results from this study suggest that dairy producers in South Africa are rational profit maximisers who use resources efficiently to the point where the marginal returns are zero. They allocate bought and self-produced feed components as substitutes in the short-run but treat both inputs as complements in the long-run. The intensity of purchased feed use is higher than that of self-produced feed use. This has implications for the animal feed sector in terms of confirming dairy farmers' preferences for scientifically formulated feed components. It also suggests increased pressure on the international competition for already limited natural animal protein sources (fish meal, bone meal, etc.).

Milk supply shows an inclination to contract over time. This study's results suggest that increased milk prices will not stimulate expansion of the industry. Very useful information can be obtained if similar analysis is conducted for different production regions (given the high geographic diversity) and different groups of producers (based on technology preferences or size of operations) to establish what effects input and output price changes might have on short and long term production dynamics.

Supply analysis, as it was performed here, provides testable hypotheses about producer behaviour, and a basis from which supply and demand elasticities for dairy products can be computed for policy simulation and analysis, thus enabling the dairy sector to be proactive in its response to international and local economic stimuli.
# TABLE OF CONTENTS

## CHAPTER 1: INTRODUCTION

1.1 MOTIVATION AND OBJECTIVES OF THE STUDY .............................................. 1  
1.1.1 Objectives of the study ............................................................................. 2  
1.2 OVERVIEW OF THE SOUTH AFRICAN DAIRY SECTOR .................................... 3  
1.2.1 Organisational structures in the industry .................................................. 3  
1.2.2 Relative size and dispersion in the sector .................................................. 4  
1.2.3 Collection cost and production density ...................................................... 5  
1.2.4 Domestic production .................................................................................. 6  
1.2.5 Linkages with other sectors of the economy .............................................. 7  
1.3 AVAILABLE DATA ........................................................................................ 9  
1.4 OUTLINE OF THE STUDY ............................................................................. 10

## CHAPTER 2: LITERATURE STUDY

2.1 SUPPLY ANALYSIS DEFINED ........................................................................ 11  
2.2 THE PURPOSE OF SUPPLY ANALYSIS .......................................................... 11  
2.3 APPROACHES TO SUPPLY ANALYSIS ......................................................... 12  
2.3.1 Normative Approaches ............................................................................ 12  
2.3.2 Positive Approaches ................................................................................ 13  
2.3.2.1 The Primal Approach .......................................................................... 15  
2.3.2.2 The Dual Approach ............................................................................. 17  
2.3.2.2.1 The Profit Function ......................................................................... 18  
2.4 FUNCTIONAL FORMS ................................................................................ 21  
2.5 APPROACHES TO SPECIFICATION AND ESTIMATION OF SUPPLY MODELS 23  
2.6 INTERPRETING MEASURES OF EFFICIENCY .............................................. 27  
2.7 EXAMPLES OF MILK SUPPLY RESPONSE STUDIES .................................. 28

## CHAPTER 3: METHODOLOGY

3.1 DEFINITION OF "MILK PRODUCTION" .......................................................... 31  
3.2 CHOOSING BETWEEN A PRIMAL OR DUAL PARAMETRIC APPROACH ........ 31  
3.2.1 Profit maximisation or Cost minimisation .................................................. 32  
3.3 THE THEORETICAL MODEL ....................................................................... 32  
3.4 ECONOMETRIC SPECIFICATION ................................................................ 35  
3.4.1 Choice of Functional Form ...................................................................... 35  
3.4.1.1 The Normalised Quadratic profit function ........................................... 35  
3.4.1.2 The Translog profit function ................................................................. 36  
3.5 METHODS OF ECONOMETRIC ESTIMATION ............................................ 38  
3.5.1 Single equation, system- or full information estimation procedures ........ 38  
3.5.2 Single equation and system estimation techniques .................................... 39  
3.6 A NOTE ON PRICE VARIABILITY IN CROSS-SECTIONAL STUDIES .......... 41  
3.7 HYPOTHESISED RELEVANT VARIABLES ................................................. 42  
3.7.1 Selection of variables for the empirical analysis ...................................... 42  
3.7.2 Transformation of variables ..................................................................... 43  
3.8 SPECIFICATION OF THE EMPirical MODEL ............................................. 45  
3.8.1 Input demand and output supply equations for the Normalised Quadratic model 45  
3.8.2 Share equation specification for the Translog model ................................ 45  
3.9 TESTING THE PROPERTIES OF THE PROFIT FUNCTION ......................... 46  
3.9.1 Non-negativity ........................................................................................ 47  
3.9.2 Monotonicity .......................................................................................... 47  
3.9.3 Convexity ............................................................................................... 47
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Number</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1: Number of milk producers per province (1997) and milk production per province (1994) in South Africa.</td>
<td>5</td>
</tr>
<tr>
<td>Table 2: International comparison of milk production per km² per day</td>
<td>6</td>
</tr>
<tr>
<td>Table 3: Value of inputs purchased by dairy farmers in 1998.</td>
<td>8</td>
</tr>
<tr>
<td>Table 4: Estimated values of fixed investments on dairy farms, at 1998 prices.</td>
<td>8</td>
</tr>
<tr>
<td>Table 5: Base model system variables</td>
<td>44</td>
</tr>
<tr>
<td>Table 6: NQ Profit function estimated with OLS and HETCOV</td>
<td>50</td>
</tr>
<tr>
<td>Table 7: NQ Milk Supply function estimated with OLS and HETCOV</td>
<td>52</td>
</tr>
<tr>
<td>Table 8: NQ Purchased Feed Demand function estimated with OLS and HETCOV</td>
<td>54</td>
</tr>
<tr>
<td>Table 9: NQ Self Produced Feed Demand function estimated with OLS and HETCOV</td>
<td>55</td>
</tr>
<tr>
<td>Table 10: NQ Profit System estimated trough Iterative Seemingly Unrelated Regression method</td>
<td>59</td>
</tr>
<tr>
<td>Table 11: Modified NQ supply system</td>
<td>61</td>
</tr>
<tr>
<td>Table 12: Marshallian elasticities calculated from the different estimation results</td>
<td>63</td>
</tr>
<tr>
<td>Table 13: Translog Profit function estimated through OLS with HETCOV</td>
<td>66</td>
</tr>
<tr>
<td>Table 14: Translog Milk Share function estimated through OLS with HETCOV</td>
<td>68</td>
</tr>
<tr>
<td>Table 15: Translog Purchased Feed Share function estimated through OLS with HETCOV</td>
<td>69</td>
</tr>
<tr>
<td>Table 16: Translog Self Produced Feed Share function estimated through OLS with HETCOV</td>
<td>71</td>
</tr>
<tr>
<td>Table 17: Translog Trade Income Share function estimated through OLS with HETCOV</td>
<td>72</td>
</tr>
<tr>
<td>Table 18: Translog Profit System estimated with the Iterative Seemingly Unrelated Regression method</td>
<td>74</td>
</tr>
<tr>
<td>Table 19: Modified Normalised Translog profit system</td>
<td>76</td>
</tr>
<tr>
<td>Table 20: Results of Wald Coefficient tests for homogeneity in the translog profit system</td>
<td>80</td>
</tr>
<tr>
<td>Table 21: Elasticities calculated from the various estimation results for the Translog specification.</td>
<td>81</td>
</tr>
<tr>
<td>Number</td>
<td>Figure</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Figure 1</td>
<td>Normalised Quadratic Profit - result of OLS</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Normalised Quadratic - quantity of milk supplied</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Normalised Quadratic - quantity of purchased feed utilised</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Observed versus fitted quantities of self-produced feed (Normalised Quadratic)</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Actual and fitted normalised profit, and actual milk, purchased and produced feed quantities</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Fitted and actual normalised profit, and fitted milk, purchased and produced feed quantities</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Estimated levels of milk production, input use and associated estimated normalised profit</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Actual and fitted values of profit from the OLS estimation of the translog profit function</td>
</tr>
<tr>
<td>Figure 9</td>
<td>The actual and fitted shares of milk in restricted profit – OLS results</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Actual and fitted purchased feed shares derived from the OLS single equation estimations.</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Actual and fitted self-produced feed shares resulting from OLS single equation estimation.</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Actual and fitted values of trade income shares in restricted profit (OLS).</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Comparing the Normalised Quadratic and Normalised Translog profit with actual profit levels</td>
</tr>
</tbody>
</table>
ACKNOWLEDGMENTS

The author wishes to thank the Milk Producer Organisation (in particular Mr. Coetzee) for availing the data for this study. Much appreciation goes to Professor Chris Blignaut\(^1\) for his continuing efforts to obtain useful data and for his support. Professor Rashid Hassan\(^2\) has been tremendously helpful in supervising the work and providing constructive criticism. Dr Alison Burrell\(^3\) provided useful guidance during the initial phases of the written part of the work – her inputs are much appreciated. Thanks are also due to Dr Roelf Jongeneel\(^4\) for his patience and willingness to listen and help with technical issues regarding this study.

To my family (especially my parents) and Gustav for their support and faith in me and to friends (especially Nicola and Adèle), for their empathy, I am deeply indebted and very grateful.

I serve a great, big, wonderful God who has shown His faithfulness to me – to Him be all the praise!

Psalm 121 verses 1, 2, 7 and 8:

"I lift my eyes to the hills – where does my help come from? My help comes from the Lord, the maker of heaven and earth. The Lord will keep you from all harm – He will watch over your life; The Lord will watch over your coming and going both now and evermore."

\(^1\) Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, Pretoria, South Africa
\(^2\) Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, Pretoria, South Africa
\(^3\) Department of General Agricultural Economics, Wageningen Agricultural University, Wageningen, the Netherlands
\(^4\) Department of General Agricultural Economics, Wageningen Agricultural University, Wageningen, the Netherlands