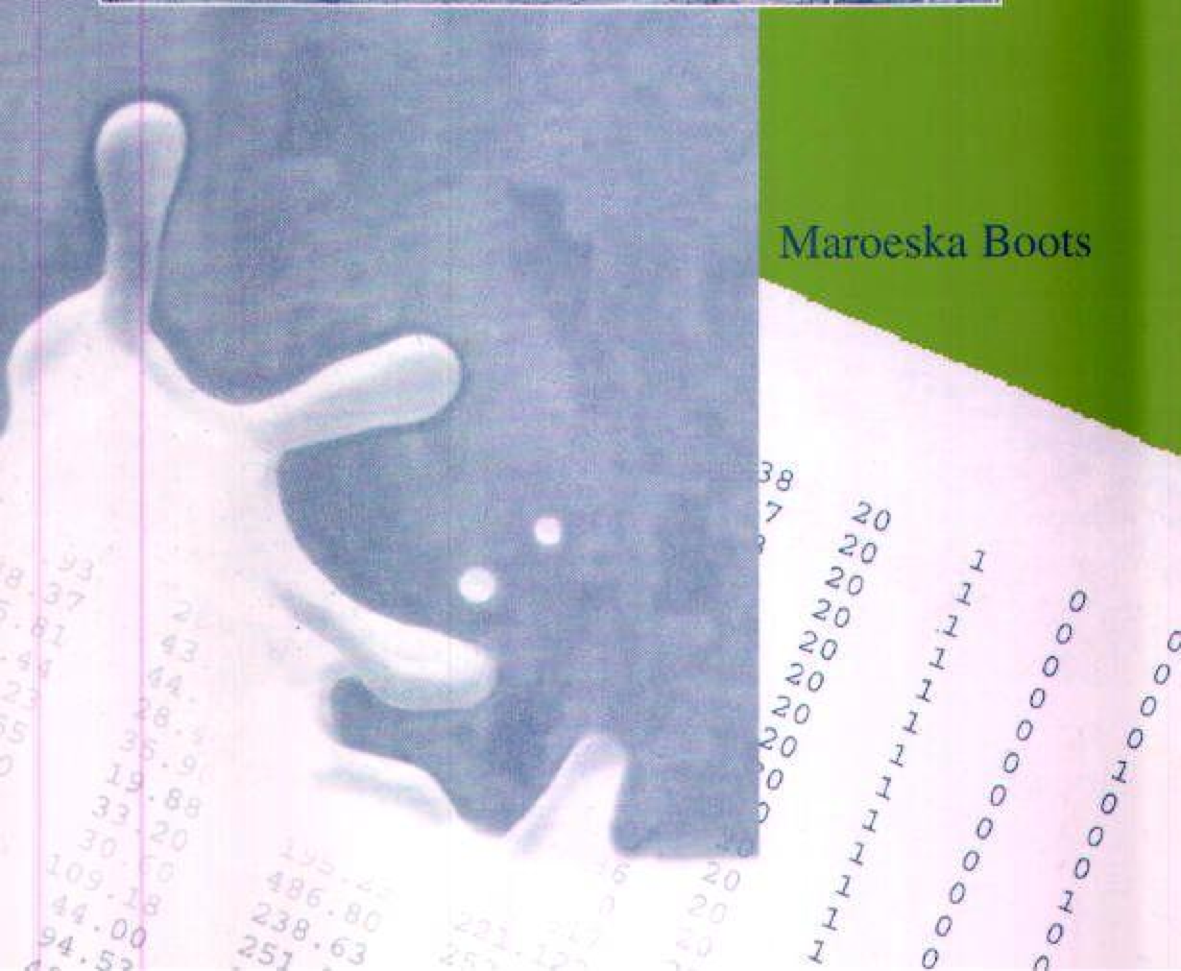
MICRO-ECONOMIC ANALYSIS OF ALTERNATIVE POLICIES FOR DUTCH DAIRY FARMING

Maroeska Boots



STELLINGEN

1. De genormaliseerde kwadratische functie vorm is niet geschikt voor simulatie doeleinden, omdat alle veranderingen ten gevolge van een verandering van de geselecteerde input-output combinatie in de simulatie worden geabsorbeerd door de numeraire.
   Dit proefschrift.

2. Het systeem van melkquota heeft een belangrijke bijdrage geleverd aan de oplossing van het mestprobleem in Nederland doordat het aantal melkkoeien drastisch is afgenomen. De veestapel en het mestoverschot zullen nog verder dalen door de ingevoerde overschotheffingen op fosfaat en de geplande implementatie van de nitraatrichtlijn.
   C. van Bruchem en H. Rutten, 1988. Landbouw-economisch bericht 1988. p.71. / Dit proefschrift.

3. De Agenda 2000 hervorming heeft op termijn negatieve inkomensgevolgen voor de Nederlandse melkveehouderij. Afhankelijk van de prijs binnen het A-quotum, zou het inkomen van de boer in een twee prijzen systeem gegarandeerd zijn. Bovendien zou het beslag dat een twee prijzen systeem legt op het overheidsbudget lager zijn omdat prijssteun, exportsubsidies en inkomenscompensaties lager zijn.
   Dit proefschrift.

4. Quotum handel via een nieuw op te richten quotumbeurs leidt niet tot een economisch efficiëntere handel en heeft geen drukkend effect op de prijzen van melkquota.
   Dit proefschrift.

5. Het kleine velden beleid voor aardgaswinning druist in tegen het economisch principe dat het aardgas eerst daar wordt gewonnen waar dat het goedkoopste kan. Het heeft echter wel als resultaat dat Nederland nog steeds relatief goedkoop aardgas kan exploiteren.

6. Being explicit about one's assumptions is the difference between a scientist and a politician.
   J.P.C. Kleijnen en W. van Groenendaal, 1992. Simulation - A statistical perspective.

7. Wie thuis blijft ziet het de hele dag regenen, buiten loop je tussen de buien door.
   John Jansen van Galen, 1997. Wandelingen - Nederland in vier seizoenen. p.53.

8. Het voltooien van een proefschrift is geen kunst. Je zult het boekje doorgaans niet in een museum aantreffen, hoogstens in een vergeten la of stoffige boekenkast.

9. De uitdrukking 'Oost West thuis best' krijgt een heel nieuwe dimensie wanneer je weer bij je ouders gaat inwonen, zeker als je pas getrouwd bent.

Proefschrift van Maroeska Boots
Micro-economic analysis of alternative policies for Dutch dairy farming
Wageningen, 13 december 1999

MICRO-ECONOMIC ANALYSIS OF ALTERNATIVE POLICIES FOR DUTCH DAIRY FARMING

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MICRO-ECONOMIC ANALYSIS OF ALTERNATIVE POLICIES FOR DUTCH DAIRY FARMING

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Proefschrift
ter verkrijging van de graad van doctor
op gezag van de rector magnificus
van Wageningen Universiteit,
dr. C.M. Karssen,
in het openbaar te verdedigen
op maandag 13 december 1999
des namiddags te 13.30 uur in de Aula.

Omslag ontwerp: Piet Kostense, Duotone

Druk: Grafisch Bedrijf Ponsen & Looijen BV, Wageningen

ISBN 90-5808-146-X

VOORWOORD

1999 is voor mij een bijzonder jaar geworden, en dat heeft niks te maken met de overgang naar het volgende millennium. Het is het jaar waarin ik met de liefde van mijn leven ben getrouwd. Daarnaast heb ik (eindelijk) een punt kunnen zetten achter dit proefschrift, wat toch wel een soort fin de siècle gevoel geeft. Het markeert in ieder geval het einde van een tijdperk in mijn leven.

Het mag echter duidelijk zijn dat ik gedurende dit 'tijdperk' veel steun heb gehad van anderen. Ten eerste zijn dat natuurlijk mijn collega's bij de Leerstoelgroep Algemene Economie en Plattelandsbeleid. Geert Thijssen heeft mij (waarschijnlijk onbewust) tijdens mijn afstudeertijd op het ingeslagen onderzoekspad gezet. Arie Oskam, Jack Peerlings en Alfons Oude Lansink hebben mij vervolgens verder gestuurd en richting gegeven. Wilbert Houweling zorgde dat de juiste computers en software aanwezig waren en kwam altijd met praktische oplossingen voor mijn vragen en problemen op computer gebied. Tenslotte, kunnen Rien Komen en Coos Gardebroek niet ongenoemd blijven. Met Rien als kamergenoot en 'promovendus-in-hetzelfde-schuitje' heb ik alle proefschrift perikelen kunnen afreageren en veel gelachen. Coos heeft mij gewezen op een fout in de schattingen, die ik over het hoofd heb gezien.

Ten tweede had ik dit werk niet kunnen doen zonder de uiterst gedetailleerde dataset die het LEI-DLO aan de Leerstoelgroep ter beschikking stelt. Ik besef dat we, in vergelijking met andere onderzoeksgroepen, bevoorrecht zijn met deze dataset. Ten derde heb ik mijn werk kunnen presenteren op verschillende internationale congressen door de financiële ondersteuning van het Fonds Landbouw Export Bureau en bood de reisbeurs van NWO mij de mogelijkheid om drie maanden in de Verenigde Staten te wonen en werken. Spiro Stefanou en andere medewerkers en studenten van PennState University zijn mij daarbij zeer behulpzaam geweest.

Maroeska Boots

Wageningen, oktober 1999

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Chapter 1 INTRODUCTION

1.1 Motivation

Within agriculture, dairy farming is an important industry, with considerable political and economic significance in the Netherlands. The importance of an industry is usually measured as the contribution of the industry to national (or total agricultural) income, employment, balance of trade, land use, and both positive and negative external effects (Stolwijk and Veenendaal, 1995). In terms of gross value added and employment, dairy farming is the largest agricultural industry in the Netherlands (Peerlings and Komen, 1998). Milk and related beef production account for almost one-third of total agricultural production. About 28 per cent of all agricultural farms in 1998 were dairy farms and a majority of these are characterised as highly specialised (LEI-DLO and CBS, 1999 table 21-a).

A large part of the Dutch farmland area is used in milk production, determining the landscape and the image of agriculture in the Netherlands. In a policy proposal from the dairy farmers' organisation the importance of putting cows out to pasture is emphasised (LTO Nederland, 1998). Hence, the link between milk production and land, i.e. producing fodder at the farm instead of purchasing it, is to be maintained. In addition, nature management and nature production by dairy farming and the care for the countryside are important issues, also within the European Union (EU) (European Commission DG VI, 1998). Therefore, the claim on farmland by dairy farms is justified. The positive valuation of landscape is an external effect of dairy farming. However, the sector also causes negative external effects. Nutrient losses and the emission of ammonia from animal manure cause problems. Moreover, the dairy sector is a substantial polluter of the environment because of the excessive use of fertiliser (Ministry of Agriculture, 1995).

Production and income formation in dairy farming is highly policy driven. In 1995, the net producer subsidy equivalent (PSE) of EU dairy farming amounted to 61 per cent or 189 ECU per thousand kg of milk (OECD, 1996). A support system in the form of border protection, intervention buying and export subsidies apply to dairy products in the EU. Moreover, production is rationed through milk quotas enforced by a super levy. Recently, the European Commission reached agreement on dairy policy reform, known as Agenda 2000. The framework of the common market organisation and the quota regime for dairy are to be maintained. However, support prices have to decrease and the resulting loss of income will be compensated by direct payments (Agra Europe, 1999). Besides the European regulations, the dairy sector faces domestic agricultural and environmental policies. For example, in the Netherlands, a body of manure regulations have been developed to curb manure and nutrient surplus problems (e.g. Ministry of Agriculture, 1995). In 1998 an accounting system for nutrient flows at the farm has been introduced.

Hence, the dairy sector is increasingly restricted by environmental and agricultural policies. Despite the liberal trade and free market tendencies (e.g. the General Agreement on Tariffs and Trade (GATT) and agreements of the World Trade Organisation (WTO)), farmers face an augmenting number of regulations, obligations and constraints, which are often very detailed in nature and oriented at the farm level. These detailed policies are made possible by increased opportunities for individual administration, observation and processing of data. For example, Dutch milk quotas are based on farmers' historical reference production. Detailed accounts of milk production and quality are kept. Over and under quota production and super levy payments are administrated, usually via dairies that purchase the milk from farmers.

In the Netherlands, the most frustrating policy subjects observed by dairy farmers were revealed in a study by Frouws et al. (1996). Especially, dairy farmers perceive various parts of Dutch manure policy (proposals) as problematic and hard to adjust to. The level of manure and ammonia problems often depend on local conditions, such as farm location and soil type, but also on farm management. Farmers are not satisfied with general solutions and they ask to account for local circumstances and for more freedom to find solutions. Besides, due to for example, weather conditions or market fluctuations, they find it difficult to produce exactly at the farms' available milk quota. Therefore, more flexibility with respect to the regulations (for example, using the average of quota over and under production over three years) is requested (Frouws et al., 1996 p.8-18).

To put it briefly, in choices made at the farm, detailed policies play an important role. Farmers constantly face minor and major policy changes, causing farm-specific uncertainties and adjustments in production.

1.2 Purpose and method

The main focus area of this thesis is individual behaviour of dairy farmers in response to policy changes and the consequences at the aggregate dairy farming level. This thesis aims to quantify the effects of specific policy changes on production decisions (e.g. regarding the input of animal feed and land) and profit of individual Dutch dairy farms. The micro effects, that is, the reaction of individual farmers to policy changes, are emphasised. However, results are mainly evaluated at the aggregate level of the whole sector.

Dairy farmers face a broad range of policies that affect their production. In this thesis, first the main policy issues will be identified. The policies analysed focus on three areas. The first deals with alternatives for current dairy policy, such as the abolition of the quota system. The second policy issue focuses on trade in milk quotas. Finally, manure policy in the Netherlands is handled. In these fields policy changes are to be expected or recently introduced.

In order to serve the main purpose, an empirical economic model of the production behaviour of dairy farming will be developed and elaborated, which can be applied to determine effects of policy changes. It is assumed that farmers react differently on policy changes, especially when policies become increasingly farm-specific. Therefore, a micro-economic approach is used. "A distinctive feature of such models is the close connection between economic theory and empirical implementation. Economic theory is often formulated in terms of individual decision making units." (Thijssen, 1989 p.viii). The basic theoretical assumption is that dairy farmers maximise profits in the short run, while facing technical and market restrictions. When farm-level effects of policy changes are determined, they can be aggregated in order to resolve the effects for the dairy sector.

Milk production is relatively easy to model because some fundamental assumptions of economic theory are fulfilled. Milk is a homogeneous output, produced by many, and mostly specialised, farmers. Dairy farmers are price-takers in the input and output markets. The availability of a rich panel data source, provided by LEI-DLO, allows us to identify dairy farmers' behaviour at the micro level and check the theoretical assumptions. Consequently, the econometric techniques to analyse panel data are used (Judge et al., 1988). Moreover, the data set provides weight factors in order to upscale the results for individual farms to the sector level.

The empirical model in this thesis builds on earlier modelling work. Thijssen (1992) developed micro-economic models for analysing the determinants of dairy production. He compared several assumptions. For example, should we use the primal or dual approach and are intercepts treated as fixed or random effects? Apart from milk, dairy farming produces other outputs, such as beef and calves. Therefore, the theory on multi-output production and the joint use of inputs has to be used (Shumway, Pope and Nash, 1984; Chambers and Just, 1989). Moreover, from an applied economist's point of view, dairy farming is an interesting sector to study because milk production is quota constrained. Moschini (1988) used an output-constrained profit function for the Canadian agricultural sector. Helming, Oskam, and Thijssen (1993) used the theoretical model of Moschini to incorporate supply constraints on milk production into their analytical framework. Finally, the models developed by Oude Lansink (1997) for Dutch arable farming aimed to analyse policy changes at the farm level.

Following the conclusions of the previous studies, in this thesis the static dual approach (Chambers, 1988; Shumway, 1995) is adopted, using a flexible functional form specification for the profit function. Micro level demand and supply equations are derived and a fixed-effects model is used, which assumes equal functional forms across farmers, however with different intercepts. The analysis relies on a strong empirical orientation, hence technical details of policy changes should explicitly be incorporated (Oude Lansink and Peerlings, 1997).

The purpose to assess individual farm effects and the choice for a micro-economic model demarcate the analysis in this thesis. Implications of policy changes for consumers, other agricultural industries and the government are not explicitly determined. Hence, conclusions with respect to social welfare effects, overall environmental effects and the results for imports and exports (including export subsidies) are not given. Moreover, the analysis is restricted to Dutch dairy farming, therefore dairy farming in other countries and the effects for the EU budget are not studied. Finally, a typical short-run method is applied. As a result, long-run dynamics, such as the impact of investments or major changes in production technologies, are not incorporated here.

1.3 Overview

This thesis consists of seven chapters, starting with this introduction. The chapters have originally been written as stand-alone papers, e.g. for submission to journals. Therefore, some overlap between the chapters, in particular in data and model description and in presenting the estimation results, is inevitable.

Chapter 2 describes the current policies faced by dairy farms. A distinction is made between EU policies, such as the Common Agricultural Policy with respect to dairy and the milk quota system, and typical Dutch policies, especially manure policy. Problems with respect to current policies are discussed and (expected) policy changes relevant to dairy farming are reported. Then, the research topics for the thesis are derived. Hence, the survey serves as background for the research and delineates the research questions of the thesis. The basic micro-economic model for analysing production and profit of dairy farms that are subject to milk quotas is developed in chapter 3. The decisions behind model choices are explained and some alternative specifications and estimations are reported. Moreover, the data that is used throughout the thesis, as well as estimation results are discussed.

In chapter 4 the issues of milk quota trade efficiency and resulting quota prices are addressed. Although the Dutch quota market is known as fairly liberal, there still exist some distortions in quota trade, resulting in efficiency losses for dairy farming. Distortions are caused by the minimum and maximum thresholds that can be traded according to the regulations. Costs related to transaction services by a middleman or a notary are less visible. Both types of trade distortions will be simulated. The effects of alternative EU dairy policy changes are assessed in chapter 5. The theoretical model is extended to allow for a two-tier milk price system. Further complication is introduced by simulating a two-tier system in which milk quota trade occurs. Quota abolition and the agreed price cuts for dairy products of Agenda 2000 are relatively easy to simulate, because only milk quantities or prices are affected. In chapter 6, the core issues are land demand and the introduction of phosphate surplus taxes. The model is adapted in order to simulate an imperfect market for farmland. Additionally, phosphate surplus taxes per farm are calculated and incorporated in the model in such a way that the surplus tax to be paid depends on the amount of farmland and the input of livestock. Farmers may avoid paying the tax by adjusting livestock or land input. Finally, in chapter 7 the various policy simulations and their effects for dairy farming are discussed. The model is evaluated on its theoretical and practical applications and final conclusions are drawn.

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Chapter 2 POLICY ISSUES FOR THE DAIRY SECTOR

2.1 Introduction

Dairy farming faces constantly changing circumstances regarding production techniques, policies and relative prices. In this thesis the short-term, policy-driven adjustments in dairy production play a central role. Therefore, the basics of policy relevant to dairy farming, as well as the issues at stake in this policy, should be clear. Hence, this chapter provides the reader with background information regarding dairy policy and it focuses on some topics that are currently in discussion. These topics are translated into three research objectives, which will subsequently be analysed further in the thesis. The level of detail of the policy descriptions in this chapter is determined by the research objectives.

Since the completion of a single market with common prices for dairy products in 1968, dairy policy in the Netherlands has been mainly directed by the Common Agricultural Policy (CAP) of the EU. A major shift in dairy policy came into force in 1984 with the introduction of milk quotas. There is quite some descriptive-analytic literature with respect to the formation and further development of the CAP (European Commission, 1997b; Tracy, 1997 and 1989; Harris, Swinbank, and Wilkinson, 1983; De Hoogh and Silvis, 1994), and the implementation and impact of milk quotas in the EU and the Netherlands (Burrell, 1989a; Krijger, 1991; Oskam and Speijers, 1992). More recently, further reform of dairy policy was proposed in Agenda 2000 (European Commission, 1997a; European Commission DG VI, 1998; Tracy, 1997; Agra Europe, 1998) and finally agreed in March 1999 (Agra Europe, 1999a). Two of the research objectives of this thesis are derived from this branch of literature and focus on the various alternatives for the current milk quota system and the efficiency of milk quota trade. In addition, Dutch manure policies (Ministry of Agriculture, 1995; Ministry of Agriculture, 1997b) have an increasing impact on dairy farming, especially since the introduction of prohibitive taxes on nutrient surpluses. Consequently, the third research objective focuses on the effects of these taxes.

The chapter proceeds with a description of EU policy relevant to dairy farming. Possible future developments in dairy policy are looked at from an EU perspective. The next section focuses on milk quota trade, from a mainly Dutch perspective. In addition, an overview of relevant Dutch manure policy is given. Each of these descriptions leads to a definition of the research topic that will be elaborated in separate chapters in the thesis. This chapter ends with a résumé and a brief discussion of the basic modelling requirements.

2.2 EU dairy policy

In this section, the basics of dairy policy in the EU, i.e. market support and the milk quota system, are described. Then, the different reasons and options for reforming this policy are given. Finally, the research topic for chapter 5 is defined.

2.2.1 Market support

In 1968, a full system with common pricing arrangements came into force for dairy in the EU (Commission of the European Communities, 1968), with important adjustments made in 1992 (1992 CAP reform) and 1995 (GATT). The main establishment of the common market organisation for dairy was the introduction of a *target price* for milk. The target price is a purely administrative instrument, which represents the average price that milk producers should be able to obtain for milk, containing 3.7 per cent fat, sold to dairies. The target price is determined in annual negotiations and applies for the marketing year, which runs from the beginning of July to the end of June the following year[1]. The target price is supported through a system of intervention buying, import tariffs, export subsidies and disposal measures.

Products covered by intervention are butter and skimmed milk powder (SMP). Butter represents the fat component of milk, whereas SMP represents the protein component. These products account for more milk than other dairy products, they are residual outlets for milk and are easily storable. Through purchases of butter and SMP offered for intervention, prices of other dairy products are also supported (Harris, Swinbank, and Wilkinson, 1983).

[1] Until 1996 the marketing year (milk year) ran from April to March. The reference period for milk quotas is still running from April to March.

Intervention purchases by public intervention agencies provide a floor in the market. This floor is set by *intervention prices*. The intervention price is derived from the target price, taking account of manufacturers' margins and yield factors (i.e. the amount of milk required to produce 1 kg of butter or SMP). Since 1987, buying-in of butter and SMP may be suspended if the quantities offered exceed certain limits. Thus, access to intervention is restricted, and the resulting effective support price for butter is only 90 per cent of the intervention price. Besides public intervention, aids are given for private storage of butter, cream, SMP and certain cheeses in order to balance seasonal variations in production. Stocks of butter and SMP have drastically decreased since 1987 (European Commission, 1997b). Table 2.1 gives an overview of institutional prices and intervention stocks in the EU.

Table 2.1: Target prices, intervention prices, community stocks and expenditure on dairy.

	1973/74	1977/78	1983/84	1987/88	1993/94	1997/98
Target price of milk (3.7% fc, gld/100 kg)[a]	42.08	59.04	74.97	75.23	69.13	68.84
Intervention price (gld/100 kg)[a]:						
Butter	605.44	785.85	978.13	846.36	743.59	722.93
SMP	220.16	320.16	409.01	470.31	451.47	452.70
Community stocks (1000 t)[b]:						
Butter	294.7	148.4	340.0	1175.0	196.0	
SMP	55.9	884.8	648.0	756.8	30.7	
EAGGF Guarantee expenditure on dairy[c]:						
Million ECU	1497.0	2545.0	4396.1	5182.3	5211.2	3738.0
Percentage of total	39.2	41.4	27.6	22.4	15.0	8.9

[a] Source: LEI-DLO and CBS, several years, tables 73-a and 73-b. Target prices and intervention prices are those that apply during the majority of the production year. [b] Source: European Commission, several years, table 4.20.6.3. 1973 and 1977 EU-9, 1983 and 1987 EU-10, 1993 EU-12. [c] Source: European Commission, several years. 1973/74=1973 etc.

In order to protect the EU internal dairy market, trade protection provisions at the border are established. When the GATT Uruguay Round Agreement (URA) came into force in July 1995, the system of variable import levies and threshold prices (i.e. minimum import prices) for certain pilot products was abolished. Variable import levies were replaced by fixed *tariffs* for specified dairy products. Under the GATT URA, existing import concessions with third countries were transformed into *"current access"* quotas with reduced or nil rates of tariffs. In addition, the EU offered *"minimum access"* import quotas with reduced tariffs to foreign importers. The sum of both types of access quota should count for the equivalent of 3 per cent of 1986-1988 internal consumption in 1995, rising to 5 per cent by the end of 2000 (Tracy, 1997 p.74). In addition, when world prices are lower than EU market prices, *export subsidies* (refunds) are paid to exporters of dairy products to enable them to compete on world markets. Export subsidies are also reduced under the GATT URA.

Since the achievement of a single market for dairy products, production surpluses have been present. Initially, the common market organisation was suited for ensuring a satisfactory income for milk producers, but not for balancing supply and demand for milk and dairy products at the same time (Harris, Swinbank and Wilkinson, 1983 p.96). With mounting surpluses and related budget costs, the EU sought for measures to increase the demand for dairy products and reduce supplies. Special disposal measures for butter and SMP are provided for. Butter and butterfat can be sold at reduced prices to the ice cream and baking industry and other food processors, to non-profit organisations, the armed forces, to recipients of welfare benefits or as concentrated cooking butter. Liquid skimmed milk and SMP are used in animal feed and casein production. A school milk programme provides for distribution in schools at reduced prices (European Commission, 1997b; Tracy, 1997 p.30).

Until the introduction of the milk quota system in 1984, the most important measures aiming to reduce milk supply included conversion schemes, co-responsibility levies and a guarantee threshold system. Conversion schemes[2] have been introduced in order to stimulate dairy farmers to convert to beef or sheep production or to go out of production altogether (Krijger, 1991 p.11). The system of co-responsibility levies forced farmers to contribute to the costs of disposing of production surpluses. In 1982 the EU established a guarantee threshold system for milk deliveries to dairy processors. The threshold was based on milk deliveries in 1981 plus a percentage to account for the growth in dairy consumption. Neither the co-responsibility levy nor the guarantee threshold was

[2] Also known as SLOM, which is the Dutch abbreviation for the slaughter and conversion schemes for the dairy cow herd.

able to re-establish the equilibrium between dairy production and consumption[3] (European Commission, 1997b; Krijger, 1991; Oskam et al., 1988 p.14).

2.2.2 Milk quotas

In order to control milk production and the agricultural budget, quotas on milk deliveries were implemented in the EU in April 1984. The milk quota system in the EU is based on a number of regulations (after a complete revision in 1992, see Commission of the European Communities, 1992 and Commission of the European Communities, 1993), which provide a framework for member states to organise their national quota system. Thus, within the framework, member states are, to some extent, free to arrange their quota system. Therefore, the rules and the effects of the milk quota system differ considerably between countries (Krijger, 1991 p.8).

The quota system provides for a limited quantity of milk to be produced (in 1995/96, 115 million tonnes for the EU-15). Production in excess of the quota is charged with a so-called *super levy*. Since 1992/93 the levy is fixed at 115 per cent of the target price of milk[4]. National guaranteed quantities (*reference quantities*) for deliveries to dairy processors (*delivery quota*) and for selling milk and dairy products directly to consumers (*direct sales quota*) were shared out[5]. Within the national quota it is possible to apply for quota exchanges from direct sales to deliveries to dairies. Individual farmers may also apply for the temporary or permanent *exchange* between direct sales quota and delivery quota, provided that he owns both types of quota.

By producing milk with higher fat levels, farmers could raise the price received for their milk and circumvent their quota. This resulted in increased milk deliveries and butter production and excessive intervention stocks, imposing a further pressure on the EU budget. Therefore, differences in the quality of milk (i.e. *fat content*) are accounted for in the regulations. Since 1986 reference quantities for the fat content of the milk deliveries are fixed for individual producers. If fat content of milk deliveries deviates from the

[3] The guarantee threshold system was replaced by the milk quota system in 1984, co-responsibility levies were abolished in 1993.
[4] Before 1992, the super levy for direct sales quota was lower than for delivery quota.
[5] Most of the milk produced is delivered to dairies, e.g. in 1994 93.5% of production was delivered to dairies in the EU-12.

producers' representative fat content in the reference period (1985/86), milk deliveries are increased or decreased by 0.18 per cent per 0.1 gram of additional or lower fat per kg of milk.

EU members were given the option of distributing their national quotas either to individual producers (*formula A*) or to purchasers of milk (i.e. dairy processors - *formula B*). In case of over-quota production, depending on the formula chosen, the individual farmer or the dairy processor had to pay the levy. Since 1993/94, there is no distinction made anymore; the purchasers (dairies) are liable for the levy, which they deduct from the price of milk paid to producers who owe the levy. Initially, the levy under formula A was lower than under formula B (75 per cent and 100 per cent of the target price of milk respectively). From 1987/88 both levies are fixed at the same rate (100 per cent, and since 1992/93 115 per cent).

At the end of the first reference year (1984/85) it was decided that, on a national basis, under-quota production could be used to offset over-quota production. If formula B was applied, this mechanism of *equalisation* was already possible at the level of the dairy processor. The problem with equalisation is that the individual farmer is uncertain about his exact amount of quota and the super levy in case of over-quota production, because the consequences also depend on the behaviour of other farmers (Oskam et al., 1988).

Initially, the national guaranteed quantity for most member states was equal to the guarantee threshold in 1983/84 (milk deliveries in 1981 plus one per cent). In the first quota year, 1984/85, the guaranteed quantity was increased by circa one per cent as a transitional provision. Table 2.2 shows that the reference quantities for deliveries to dairies in the EU-10 for the milk year 1984/85 were fixed at 99.524 million tonnes. Additionally, a Community reserve of 0.393 million tonnes was created[6]. Direct sale quota was fixed at 3.761 million tonnes. In subsequent years, quotas were reduced further and voluntary

[6] The Community reserve was created to facilitate the application of the milk quota system in those member states where difficulties occurred. The reserve was increased several times in order to take into account the social needs of certain member states and also the special situation of certain producers. In 1993 the Community reserve was abolished and the quantities divided between the member states.

cessation schemes were introduced in order to encourage farmers to discontinue production[7].

Table 2.2: EU milk quotas (1000 tonnes).

Year[a]	Delivery quota						Cons. quota	Total quota
	Guarantee	Suspended[b]	Reserve[c]			Available		
			EU	SLOM	+1%			
1984/85	99524		393	0	0	99917	3761	103678
1985/86	99079		393	0	0	99472	3334	102806
1986/87	103989		393	0	0	104382	3824	108206
1987/88	102096	3778	443	0	0	98761	3531	102292
1988/89	101059	5396	443	0	0	96106	3520	99625
1989/90	100209	4518	443	502	1040	97677	3520	101196
1990/91	100559	4679	443	502	1040	97865	3370	101234
1991/92	106658	4986	443	600	1040	103755	3126	106881
1992/93	101672		443	600	1040	103755	3097	106852
1993/94						106498	2548	109046
1994/95						107062	1984	109046
1995/96						115381	2070	117451
1996/97						115577	1915	117493
1997/98						115904	1593	117496

Source: European Commission, 1997b table 12. Source for figures in 1997/98: Agra Focus, 1998c p.47.
[a] 1984/85-1990/91: EU-10 (as from 1986/87 incl. Spain), 1991/92-1994/95 EU-12, 1995/96-1997/98 EU-15.
[b] In order to reduce production further, quotas were temporarily suspended by 4% in 1987/88, 5.5% in 1988/89 and 4.5% in the following three years. Farmers were compensated for this (10 ECU/100 kg in 1987/88 and 1988/89, 8 ECU in 1989/90, 7 ECU in 1990/91, and 6 ECU in 1991/92). Member states could supplement these compensations to a certain limit from their own budget. In 1992/93 the temporary suspension became permanent. [c] The Community reserve was initially allocated to Ireland (303), Luxembourg (25) and Northern Ireland (65) and from 1987/88 also to Spain (50). Part of the reserve was allocated to SLOM producers in several countries. Additionally, 1% was allocated as a result of the reduced temporary suspension from 5.5% to 4.5%.

In most countries, the distribution of reference quantities to individual producers and purchasers of milk was based on historical (1983) deliveries (or purchases) minus a necessary reduction in order to achieve the national guaranteed quantity and to create a

[7] Quota reductions in 1987/88 (2%) and 1988/89 (1%) were to be reached by a Community cessation scheme. Farmers participating in the cessation scheme received a buy-out premium; 6 ECU/100 kg of milk during seven years. Member states could adjust the buy-out premium under certain conditions.

national reserve (European Commission, 1997b). After the 1992 CAP reform, quotas are based on quantities at the end of the reference year 1992/93. The development of milk quotas in the EU is shown in Table 2.2.

2.2.3 Reasons to reform dairy policy

It is widely acknowledged that dairy policy in the EU should be revised. Besides the increased attention to consumer and social interests, such as food safety, environment, natural landscape, animal welfare, and rural development, there are four important reasons for policy reform (see also Tracy, 1997 p.96-100). First, imbalances between the production and consumption of milk and dairy products and the budgetary constraint of the EU make it difficult to maintain current policy. Second, dairy policy should be compatible with the WTO (World Trade Organisation) agreements (Agra Europe, 1996). Third, the enlargement of the EU with Central- and East European countries (CEECs) somewhere after 2000 will put pressure on the milk price and the export budget in the EU. Finally, the current milk quota system is often viewed as an obstacle for structural adjustments and productivity growth in the EU dairy sector. Support prices are too high in relation to both the level of production and the level of productivity.

Dairy policy has not substantially changed in the decade after the introduction of the quota system. However, the implementation of the GATT URA by the EU in 1995 affected the CAP fundamentally. The most important elements regarding dairy in the URA are (Tracy, 1997 p.74):

- A reduction of export subsidies by 36 per cent, combined with a 21 per cent reduction in the volume of subsidised export. For butter and SPM these reductions are compared with the reference period 1986-1990, for cheese and other dairy products the period 1991-1992 applies as reference. Reductions should be made in six annual steps;
- Tariffication: conversion of variable import levies into fixed tariffs and reduction of the average tariff by 36 per cent as compared with the average rate in 1986-1988 (tariff equivalent). The 36 per cent reduction applies to each dairy product, except SMP, for which the reduction percentage is 20. The reductions have to be realised in six annual steps;
- Current and minimum market access provisions.

For dairy products, the EU commitments regarding exports, import tariffs and access quotas are shown in Tables 2.3, 2.4 and 2.5. For butter and SMP, the export constraints can easily be met. As a result of disposing of large parts of the intervention stocks of these products, export volumes were substantial in the reference period 1986-1990. The EU-15 exports of butter and butteroil and SMP have to reduce to 399 and 272 thousand tonnes respectively. However, total exports of butter and SMP in 1994 were 154 and 138 thousand tonnes (European Commission, 1996). Hence, the URA effectively allows the EU to increase subsidised exports of butter and SMP (Swinbank, 1996). Despite the use of the favourable reference period 1991-1992 for cheese, export volumes of cheese still have to decline substantially (Swinbank, 1996).

Table 2.3: EU import tariff rates.

	Reference price (ECU/t.)		Import tariff (ECU/t.)		Reduction (%)
	External	Internal	Base (tariff equivalent)	Final after six years	Over six years
Butter	943	3905	2962	1896	36
SMP	685	2170	1485	1188	20

Source: Tracy, 1997 table 6.3.

Table 2.4: Current and minimum access quotas for the EU-15.

	Current access quota (tonnes)		Minimum access quota (tonnes)	
	Beneficiary country	Quantity	Initial quantity	Final quantity
Butter	New Zealand	76667	0	10000
Skimmed milk powder	-	-	40401	68000
Cheese for processing	Australia, New Zealand	4500	-	-
Cheddar cheese	Australia, Canada, New Zealand	14250	-	-
Cheese and curd	-	-	15273	83400

Source: Tracy, 1997 tables 6.4 and 6.5.

While the effects of the URA for dairy products are not severe in the short run, in the longer run the commitments may cause serious problems for the EU. In future WTO-agreements it is likely that the new path of tariffication and reductions in subsidised exports and export subsidies will be continued. Moreover, the problems related to GATT and WTO commitments become more serious with the future enlargement of the EU.

Table 2.5: Initial and final commitments regarding subsidised exports in the EU-15.

	Limits on export subsidy expenditures (million ECU)				Export quantity limits (1000 tonnes)			
	Base	1995	2000	Reduction	Base	1995	2000	Reduction
Butter and butteroil	1481.0	1392.1	947.8	-36%	505.5	487.8	399.3	-21%
SMP	430.9	406.2	275.8	-36%	344.9	335.0	272.5	-21%
Cheese	533.9	594.1	341.7	-36%	406.7	426.5	321.3	-21%
Other milk products	1090.1	1024.7	697.7	-36%	1212.8	1185.4	958.1	-21%

Source: European Commission, 1997b table 10.

In 1998 negotiations started between the EU and several CEECs[8] to facilitate the integration of the CEECs into the common market organisation. Although enlargement would mean new market opportunities and trade expansion for EU businesses, there are quite some problems expected if the existing CAP regulations are applied to the acceding countries. The main difficulties arise from the difference in agricultural prices between the EU and CEECs; dairy prices in the CEECs are significantly lower[9]. The increasing production capacity, especially at high support prices, will boost dairy surpluses. EU budget costs of market support (support prices, border protection, intervention, quotas, direct payments etc.) would increase and keeping within the WTO constraints would become difficult.

Because dairy market support applies to the constrained production allowances (quotas), the high support prices have been incorporated into the value of milk quotas and other fixed assets, such as farmland. It allows some smaller, less efficient farmers to remain in the sector (delay of exit) and creates an entry barrier for new farmers. Producers wishing to increase their quota and young entrants face problems with respect to acquiring finance to buy (additional) quota. Therefore, the competitiveness of the sector and structural change towards larger and more efficient farms are obstructed.

[8] The first group of candidates for future membership of the EU comprise of Poland, Slovenia, the Czech Republic, Hungary, Estonia, and Cyprus. The other countries involved are Romania, Lithuania, Latvia, Slovakia, and Bulgaria.

[9] For example, compare the differences in PSE for milk between the EU and some CEECs in 1997: EU 54%, Poland 9%, Czech Republic 28%, Hungary 30% (Agra Focus, 1998b p.34).

2.2.4 Options for dairy policy reform

Within the EU, alternative systems, which combine lower support prices and more flexibility for the farmer regarding the production level, are examined. The discussion focuses on how farm prices should be brought in line with world market levels, whether and how farmers should be compensated for price reductions, and to what extent quota levels should be adjusted (European Commission, 1997a; Agra Europe, 1996).

A two-tier price system is one of the options (with advocates particularly in France and Denmark). Similar to the sugar regime, in a two-tier milk price system, A-milk is produced within the market support measures and farmers are allowed to produce additional B-milk at the lower world market price. The advantage of the two-tier system is that it would enable to export without export subsidies, a prerequisite given the GATT URA, while maintaining a high level of support for dairy farmers. However, there are high monitoring and administration costs involved (Agra Europe, 1996) and it is questionable if the WTO would accept the two-tier price system because it could be considered as unfair competition. Price support to A-milk increases the overall (A- and B-milk) average revenue of milk production (cross-subsidisation). Therefore, a two-tier system would lead to increasing exports to the world market and could offset the export reductions agreed in the GATT URA.

A radical option to reform focuses on the immediate elimination of milk quotas facilitated by a substantial price reduction to near world market levels (supported by Denmark, Sweden and the UK, see Agra Focus, 1998a p.7). Reducing prices gradually will also permit quotas to be phased out. Farmers could then be compensated for their income losses by direct payments, incurring increased budgetary expenditure (Tracy, 1997 p.99). However, it is questionable if the value of the quota assets, which is substantial in some countries, should also be compensated. Moreover, financial positions of dairy farmers reduce considerably because quotas are often used as collateral.

The European Commission's options for dairy policy reform are reflected in Agenda 2000, published in 1997, with adjustments made in 1998 (European Commission DG VI, 1998) and finally agreed in March 1999 (Agra Europe, 1999a). In the view of the Commission, extreme measures (e.g. quota abolition or drastic price cuts) are not necessary because severe market imbalances are not expected for dairy products in the near future. Furthermore, the Commission rejects the two-tier system because of the disadvantages mentioned above. Hence, the framework of the common market organisation and the quota regime for dairy are to be maintained.

The latest reform agreement includes a 15 per cent cut in the intervention prices for butter and SMP over the period 2005/06-2007/08 in order to improve competitiveness of EU dairy farming[10]. As a result, the possibilities to sell milk and dairy products are broadened. Therefore, a 2.4 per cent increase in total EU milk quotas until 2007/08 is assumed to be justified. A compensation for the price decrease is given on a flat rate basis per tonne of quota held in the previous year. The compensating premium is divided into a statutory EU element of 17.24 euro per tonne (from 2007 onwards) and a national element of 7.63 euro per tonne (from 2008 onwards)[11]. The latter element allows member states to allocate part of the premium as they see fit (not necessarily per tonne, but e.g. per hectare). CAP aid payments can therefore be better targeted e.g. to extensive producers or disadvantaged areas.

It is questionable if the Agenda 2000 agreement meets the needs of the new trade round. The elimination of export subsidies is not ensured and compensatory payments are not production-neutral. Therefore, the Agenda 2000 agreement is not WTO-compatible. Tracy emphasises that provisions for gradually phasing-out the compensatory payments and putting limits per farm on these payments are lacking. Moreover, the enlargement issues are not explicitly considered (Tracy, 1997 p.103; Agra Europe, 1999b). Another point of critique focuses on the price reductions, which are claimed not to be large enough. If the EU have to open its markets further in the next WTO-round (more import, less export) and if EU prices are better than world market prices, the EU market will be flooded with dairy imports. Price cuts of 25 (Boerderij, 1998) and 30 (Agra Focus, 1998a p.7) per cent have been discussed.

[10] The price reduction is greater than earlier announced (10 per cent reduction), because milk producers will benefit from the maintenance of the subsidy for silage cereals and EU milk quotas will increase by 2.4 per cent. The reduction in prices has to be established in three equal steps of 5 per cent each year.

[11] The development of the Dutch average compensation in euro/tonne is as follows:

	2005	2006	2007	2008
Premium:				
EU element	5.75	11.49	17.24	17.24
National element	1.92	3.82	5.74	7.63

The national element for the Netherlands is calculated by taking the countries' total envelope and dividing it by the milk quota in 1998/99 plus the 1.5 per cent quota increase (Agra Europe, 1999a p.EP/7).

2.2.5 Research topic

Because the Agenda 2000 agreement is just recently issued, detailed analysis of their effects are not available. Therefore, in this thesis, the effects of the agreement of the European Commission for dairy farms will be analysed. The two-tier system and quota abolition continuously return in debates on dairy policy reform, and have therefore been subject of study before.

Oskam et al. (1988) compared a number of alternatives for the milk quota system in the EU. One of the alternatives was abolition of quota combined with a milk price reduction. Another dealt with a two-tier quota system in which producers received a higher (supplemented) price for 80 per cent of the quota level at that time. For the other 20 per cent farmers received a lower (levied) price. The effects of the alternatives were determined for the aggregate level for the period 1988-1997. Quota abolition resulted in increased milk production of almost 19 per cent over the analysed period (23 per cent higher than with quotas), while dairy farming income would be 30 per cent lower (Oskam et al., 1988 p.90). In a linear programming approach, Berentsen, Giesen and Renkema (1997) assessed the effects of a two price system for a typically Dutch dairy farm. A theoretical and empirical analysis of the European quota regime for sugar is conducted by Bureau et al. (1997). The sugar quota regime is a three-tier system, with differentiated supported prices for A- and B-quota. For C-sugar producers receive the world market price. Especially, the welfare gains of introducing quota mobility across borders of EU member states are incorporated in their analysis.

Despite these investigations, the effects of a two-tier system and abolishing quotas, for individual Dutch dairy farms are unknown. These effects, together with those of the latest dairy reform agreement are determined in chapter 5. In contrast to the aggregate analysis of Oskam et al. (1988) and the mathematical programming analysis of a specific farm of Berentsen, Giesen and Renkema (1997), in this thesis we use a micro-econometric approach like Bureau et al. (1997) (although they empirically applied it to the regional level). Individual farm response to a two-tier system and to different world market prices of milk can be analysed and the interaction (e.g. quota trade) between farmers is explicitly taken into account. Where Bureau et al. (1997) applied their analytical framework to the existing sugar quota system, in this thesis it is applied to a hypothetical two-tier milk quota system.

2.3 Milk quota trade

In this section, a brief report of the Dutch milk quota regulations is given and the general regulations regarding quota trade and the interpretation thereof by the Netherlands are described. Then, the situation on the Dutch quota market and some policy issues regarding quota trade are described. Finally, the research topic, which will be elaborated in chapter 4, is defined.

2.3.1 Quota transfer regulations

The Dutch regulations with respect to the milk quota scheme and quota transfers are based in the 'Regeling Superheffing 1993' (Productschap voor Zuivel, 1998). Initially, quotas were distributed to individual producers (formula A). From 1988/89, quotas were distributed to dairy processors (formula B). In 1984/85 the guaranteed quantity of milk deliveries to dairy processors was equal to 12052 thousand tonnes. The guaranteed quantity for direct sale for consumption was 145 thousand tonnes (Krijger, 1991). In 1985/86, the Netherlands used the provision to exchange an amount of 50 thousand tonnes permanently from direct sales to delivery quota. Permanent and temporary exchanges between both types of quota have occurred frequently in the Netherlands.

Table 2.6 shows the development of delivery quotas in the Netherlands. In the initial four quota years there was an over allocation of quotas to the producers, which was mainly the result of additional quota allotments to farmers in specific situations (e.g. farmers who invested a lot just before milk quotas were introduced). With the introduction of the B formula in 1988/89 and the related quota reduction (see Table 2.7) the over allocation disappeared. The over-quota delivery in the beginning is reversed since 1987/88. This is the result of the higher super levy (100 per cent instead of 75 per cent), the quota reduction of 6 per cent and the tightened regulations with respect to the fat content of deliveries (Krijger, 1991 p.54). However, each year, milk deliveries corrected for the fat content of the milk remain higher than the national quota, causing a liability for the Netherlands to pay super levy.

Table 2.6: Development of Dutch delivery quota (1000 tonnes and percentage of available quantity).

Year	Available quantity[a]	Allotted quantity		Milk deliveries		Milk deliveries corrected for fat content	
	1000 t	1000 t	%	1000 t	%	1000 t	%
1983	11929	-	-	-	-	-	-
1984/85	12053	12173	101.0	12195	101.2	na.	na.
1985/86	11984	12158	101.5	12258	102.3	na.	na.
1986/87	11986	12177	101.6	12180	101.6	12267	102.3
1987/88	11266	11397	101.2	11223	99.6	11398	101.2
1988/89	10964	10942	99.8	11030	100.6	11213	102.3
1989/90	11124	11104	99.8	10921	98.2	11215	100.8
1990/91	11127	11112	99.9	10846	97.5	11208	100.7
1991/92	10882	10871	99.9	10542	96.9	10928	100.4
1992/93	11003	10996	99.9	10675	97.0	11070	100.6
1993/94	10983	10908	99.3	10579	96.3	11011	100.3
1994/95	10982	10960	99.8	10658	97.0	11032	100.5
1995/96	10986	10970	99.9	10749	97.8	11080	100.9
1996/97	10988	10977	100.0	10706	97.4	11070	100.7
1997/98	10989	10980	99.9	10697	97.3	11024	100.3

Source: LEI-DLO and CBS, several years, table 53-b. [a] National available quantity, including reductions, suspensions, addition to community reserve, SLOM provisions and exchange between delivery and direct sales quota. na. = not available.

Table 2.7: General quota reductions (percentage of quota in previous year and cumulative percentage of deliveries in 1983) at the Dutch farm level.

Year	Quota reductions[a]		Cumulative quota reductions
	%	Remarks	%
1984/85	8.65	6.6% to achieve the national reference quantity; 2.05% to create national reserve.	8.65
1985/86	1.00	Expired transitional provision for the first quota year.	9.56
1986/87	-	-	9.56
1987/88	6.00	2% permanent EU reduction; 4% temporary EU suspension.	14.99
1988/89	3.95	1% permanent EU reduction; 1.5% temporary EU suspention;1.45% national reduction to offset the over allocation in previous years. It was no longer possible to equalise the over allocation with the total under-quota production at the farm level, because of the shift to the B formula.	18.35
1989/90	-1.09	From the Community reserve; 1% (neutral) shift from temporary suspension to permanent reduction.	17.46
1990/91	-	-	17.46
1991/92	2.39	2.16% reduction in order to increase the Community reserve; 0.23% national reduction.	19.43
1992/93	-1.10	Temporary quota increase, because of 4 extra days (4/365=1.1%) as a result of a system-switch from 52 weeks to 12 months.	18.54
1993/94	0.82	Because of the 12 months-system, there is one extra day (1/364=0.27%), hence, the quota increase in 1993/94 compared with 1991/92 is 0.27%. The temporary 1.1% increase from 1992/93 lapsed, therefore quota decrease with a factor 0.9918 (=1.0027/1.011) in 1993/94 compared with the previous quota year, which is 0.82%. An additional EU quota increase of 0.6% was added to the national reserve in the Netherlands.	19.21
1994/95	-0.53	From national reserve.	18.78
1995/96	-	-	18.78
1996/97	-	-	18.78
1997/98	-	-	18.78

Sources: Krijger, 1991, table 2.2.; Productschap voor Zuivel, several years. [a] Negative percentages indicate quota increases. Individual reductions and increases are not included here.

In the first quota year, about 54500 producers (Krijger, 1991 p.48) received quotas according to their deliveries in 1983 minus 8.65 per cent. A reduction of 6.6 per cent of 1983 deliveries was necessary to achieve the guaranteed quantity and an additional 2.05 per cent was used to create a national reserve. Table 2.7 shows that, in subsequent years, quotas have been reduced, and occasionally increased, several times for different reasons.

One of the most discussed subjects regarding the milk quota system is quota transferability. Should quota trade be possible, and if so, how should it be organised? From an economic point of view, the possibility to transfer quotas is important in the allocation of milk quota to the most efficient producers (Cox, 1987). However, from a political or social point of view, (free) quota trade might be undesirable. For example, if quotas and dairy farming disappear from certain regions, leaving an "empty" country side.

Oskam and Speijers (1992) distinguish three types of quota transfers: i) sales of quota i.e. permanent transfers of ownership rights, ii) lease of quota i.e. temporary transfer of user rights, and iii) administrative redistribution of quotas. In order to decrease the rigidity on production structure imposed by the quota system, the EU has allowed the transfer of quotas within national borders[12]. Member states are free to implement quota trade rules at their own discretion. National differences regarding quota trade are therefore substantial (see Table 2.8). For example, in France, the government administratively redistributes quotas that are released from farms that cease production, whereas in the UK and the Netherlands a relatively liberal market for quotas exists (van Dijk, 1995). Moreover, quota trade rules have changed continuously since the introduction of the quota scheme.

In general, milk quotas are attached to the land and cannot be freely traded[13]. If the whole farm is being transferred, reference quantities are transferred to the new owner. If only part of the farm is being transferred, an amount of quotas proportional to the number of hectares (or another objective criteria) used in milk production will be transferred. The latter rule is widely used by farmers (especially in the UK and the Netherlands) to transfer quota permanently via a temporary lease of land, thus circumventing the link between quota and land. In the Netherlands, a maximum of twenty thousand kg per hectare can be transferred and a minimum of twenty thousand kg has to be transferred per transaction (with exceptions possible). Land transferred with quota must be used for milk production

[12] In some member states, e.g. the UK and Germany, quota transfer is only allowed within specified regions. From 1993, regional quota transfer boundaries are abolished in the UK.
[13] Tying quota to land had to prevent i) the concentration of milk production in a few regions and on a smaller area, and ii) quota from becoming an object of investment, which would bring about uncertainty for farmers (Oskam and Speijers, 1992; van Dijk, 1995).

at least one year before and one year after the transaction. Thus, milk quota transfers are tied to land, although in practice only for at least one year.

In 1987/88, member states were given the option of introducing one-year leasing of quotas, following the practices in the UK where quota leasing became possible in 1986. This was to meet demands for a more flexible quota trade system. Leasing is used as a management tool to absorb expected over-quota production. In addition, if quotas are tied to land, leasing increases quota mobility[14] and lowers the financial barriers to transfer (Oskam and Speijers, 1992). Lease is limited to one-year contracts, which have to be concluded before a (by member states) specified date before 31 December[15] of the effective reference period. Leasing of quotas has been permitted since 1989/90 in the Netherlands[16]. A lease contract has to deal with at least ten thousand kg of milk (exceptions possible). A maximum lease-in of 75 thousand kg per farm applies per reference year. Moreover, in order to prevent speculation, a farmer cannot take quota on lease and put quota out to lease in the same period.

Quotas accompanying the transfer of small amounts of land may be added to the national reserve. It is also optional to add a part of every transfer to the national reserve by introducing a siphon or deduction percentage on each quota transfer. In accordance with the policy of restructuring milk production, the government may buy quotas from farmers who withdraw from milk production (cessation scheme). These amounts of milk will then be added to the national reserve. The national reserve is used to administratively redistribute quotas to remaining and new farmers who follow specified requirements, e.g. farmers in less-developed regions, small farmers and new entrants. Implemented cessation and restructuring schemes have had varying successes in member states. It depended mainly on the presence of a quota market and prices paid on the market, but also on relative profitability of milk production and alternatives for outgoing producers.

[14] In general quota lease is separated from the lease of land, except in Denmark, where quota lease is linked to land.
[15] This date applies for all quota transfers in the Netherlands since 1994.
[16] At first, lease was only allowed between farmers who delivered to the same dairy, in 1993 this restriction was abolished.

Table 2.8: Overview of the main quota transfer regulations in different EU member states in 1995.

	Belgium	Denmark	France	Germany	Netherlands	UK
Sale	Max. 20000 kg/ha. Max. distance 30 km. Only within the region.	Strictly linked to land and producer. Max. 10000 kg/ha. Max. distance 10 km.	Strictly linked to land. Quota is not supposed to have any value, though land with quota is more expensive than land without quota.	Max. 12000 kg/ha. Since 1993 no link to land for transfers within Landesbezirk.	Max. 20000 kg/ha, though circumvented by one-year lease of land.	Linked to land, though circumvented.
Lease	Max. 60000 kg/year. Max. distance 30 km. Only within the region. Leasing out is limited to twice in a lifetime.	Linked to land. Max. distance 25 km.	No	Since 1990/91.	Since 1989/90. Max. 75000 kg/year. Min. per contract 10000 kg.	Since 1986. Only between farmers supplying the same dairy.
Siphon	10% if quota of purchaser stays below 520000 l, 90% if this limit or max. distance is exceeded.	1989-1992: 33% of all transfers (incl. lease)	No	Since 1990/91: 30% if quota of purchaser exceeds 350000 kg	No	No
Cessation scheme	Varying successes	Success is declining	Successful	Varying successes	Not successful	Not successful

Source: van Dijk, 1995.

The cessation schemes were not successful in the Netherlands, because prices paid in the quota market were higher and milk production in general was (and still is) more profitable than alternative agricultural businesses. About 2.1 per cent of the total reference quantity in 1984/85 was released in the period 1984/85 to 1988/89 via both national and Community cessation schemes (Dillen and Tollens, 1990; Krijger, 1991).

2.3.2 Quota values and activities in the quota market

The mere introduction of the milk quota system caused milk quotas to acquire value for producers, although some countries (i.e. France and Denmark) have forcefully tried to repress quota prices. Theoretically, the maximum quota price equals the capitalised super levy, whereas the levy rate equals the maximum lease price (Oskam and Speijers, 1992). Since the super levy is higher than the milk price, the theoretical maximum quota price is determined by the milk price. The theoretical minimum quota price is equal to the compensation that can be received by taking part in the cessation scheme of the government (De Boer and Krijger, 1989). In general, marginal cost and revenue of milk production determine quota prices. Costs are mainly affected by feed prices, while revenues are affected by the milk price (Oskam and Speijers, 1992). Additionally, institutional arrangements, such as tax regulations (e.g. provisions for the depreciation of quota expenditures) and quota transfer regulations (e.g. limits on the transferred quantities) affect quota prices. In this respect, the economic consequences can be quite different from one member state to another.

Relative quota values (i.e. efficiency of production) between farmers determine the decision to purchase quota. However, capital constraints faced by milk producers, imperfections in credit markets, the level of risk aversion and growth dynamics of the family business (e.g. the availability of family labour or a successor) also affect the purchase decision (Burrell, 1989b).

In the Netherlands, a market in milk quotas soon developed after the introduction of the quota regime. Table 2.9 shows the transferred quantities and the average prices of milk quota transfers. During the first years it was only possible to obtain additional quota via permanent land transfers. The quantity of quota transferred with land increased from about 0.4 per cent of the national reference quantity in 1984/85 to 5.4 per cent in 1997/98. There was a heavy demand for quotas, so quota prices increased rapidly. Important reasons for the increased quota values in the first years are: a) the reduced prices for feedstuff and the increased yields per cow, b) the quota reductions, causing an over-capacity of farm buildings and land, c) farmers got used to the quota system and assumed it would continue to exist for the time being, and d) the reduced interest rate (van Bruchem and Rutten, 1988). Essentially, the high quota values indicate the economic well being of the Dutch dairy sector (van Bruchem and Rutten, 1988).

Table 2.9: Milk quota transfers and quota prices in the Netherlands.

	Number of quota holders[a]	Total quota of quota held[a]	Quota transferred with whole farm[a]	Quota transferred with land (excl. whole farm)[a]	Purchasing price[b]	Average fat content[c]	Purchasing price	Quota leased[a]	Lease price[d]
		tonnes	tonnes	tonnes	gld/kg, 1% fat	%	gld/kg, real fat content	tonnes	gld/kg
1984/85	54500	na.	47713		-	4.13	-	-	-
1985/86	na.	na.	88650		-	4.17	-	-	-
1986/87	na.	na.	179031		0.26	4.27	1.11	-	-
1987/88	49000	na.	256989		0.48	4.31	2.07	-	-
1988/89	na.	na.	367796		0.72	4.30	3.10	-	-
1989/90	47097	11188575	na.		0.86	4.32	3.72	124871	0.38
1990/91	46506	11194135	na.	na.	1.07	4.37	4.68	210570	0.41
1991/92	46120	10970523	na.	na.	1.10	4.43	4.87	297546	0.40
1992/93	45083	11092024	253770	270982	1.12	4.41	4.94	401950	0.40
1993/94	43928	11000691	263675	231882	1.11	4.46	4.95	473727	na.
1994/95	42205	11052891	341600	254331	0.94	4.43	4.16	577607	na.
1995/96	41008	11057242	267945	259172	0.90	4.40	3.96	577455	0.36
1996/97	39865	11063164	302018	282046	0.87	4.44	3.86	600608	0.45
1997/98	38558	11065622	284998	309637	0.83	(4.41)	3.66	619740	0.35

[a] Source: COS statistics, several years. Figures for 1984/85 to 1988/89 are from Krijger, 1991 p.48 and p.43. na. is not available. [b] Source: Hoekman, 1998. Prices are averages over the calendar year, so 1986/87=1986 etc. [c] Source: LEI-DLO, several years. Also for the calendar year. [d] Sources: 1989/90 to 1992/93 van Zwambagt (1992); 1995/96 Loman, 1995 p.35; 1996/97 Hoekman, 1996 p.67; 1997/98 Siemes, 1997 p.71. Lease prices are estimated averages for the calendar year, i.e. 1997/98=1997 etc.

Table 2.9 also shows that fewer quota holders own more or less the same amount of total quota each year, indicating that Dutch dairy farms are becoming larger. Most of the quota sold comes from small and medium sized farms that cease milk production. Table

2.10 gives an indication of the size of the farms that trade quota in 1997/98. Almost 60 per cent of the quota that was sold with land (not the whole farm) originates from farms with up to 300 thousand kg of quota. About 40 per cent of the quota selling farms have quota holdings smaller than 100 thousand kg. Quota is often purchased by larger and specialised dairy farms; farms in the size class 200-750 thousand kg quota buy about 60 per cent of quota transferred with land. Purchases per quota buyer amount to 39 thousand kg on average, while an average of 106 thousand kg is sold. When the whole farm is involved in the quota transfer, the averages are much higher; 323 thousand kg for purchases and 312 thousand kg for sales.

The introduction of leasing gave an additional impulse to the development of the quota market. At the start, leasing seemed to oust quota transfers with land, because the latter amount decreased substantially in 1989/90. Thereafter however the amount of quotas transferred with land stabilised more or less and then increased again (van Bruchem, 1992 p.81). The quantity of milk quota leases increased from 1.1 per cent of the total reference quantity owned by quota holders in 1989/90 to 5.6 per cent of total quota in 1997/98. The jump in quota transfers in 1994/95 is mainly the result of extending the period in which contracts should be closed. For permanent quota transfers the closing date was changed from 31 October to 31 December, for lease contracts from 31 July to 31 December. Usually, the demand for quota and quota prices rise at the end of the calendar year because contracts have to be established then in order to be effective for the running reference year.

Note that the number of quota holders is not the same as the number of dairy farms. Two or more quota holders may represent one dairy farm, for example, a partnership of father and son. At the start of the quota regime, there were more dairy farms than there were quota holders, because some farms were not awarded milk quotas. At the moment there are more quota holders, because quota holders may lease-out quota while they are not registered as dairy farms. There is a remarkable number of quota holders who own just a small amount of quota, indicating that these quota holders see their quota as a valuable asset (van Bruchem and Terluin, 1994 p.105). Table 2.10 shows that 43 per cent of the lessors own less than 100 thousand kg of quota, and most of them lease-out their entire quota. About 80 per cent of the quantity of temporarily transferred quotas originates from farms with less than 300 thousand kg of quota and is leased-in by farms with 100-500 thousand kg. On average, lessors lease-out 73 thousand kg, while lessees lease-in 40 thousand kg.

Apart from the buyers/lessees and sellers/lessors involved, there are also intermediaries operating in the quota market, such as brokers, middlemen and traders. In addition, large dairy processors and some compound-feed companies are active on the Dutch quota market as intermediaries. Intermediaries are important in matching quota demand and supply and some of them take-over part of the price risk (i.e. uncertainty about the level of quota prices at the end of the reference year) faced by dairy farmers (Pennings, 1998).

Table 2.10: Activities in the Dutch quota market in 1997/98 per quota size class in the previous year (percentages of total).

Quota class	Quota transfers with whole farm				Other quota transfers with land				Temporary quota transfers			
(tonnes)	Buying		Selling		Buying		Selling		Lease-in		Lease-out	
	h.	q.	h.	q.	h.	q.	h.	q.	h.	q.	h.	q.
0	89.3	90.1	0.8	0.7	4.8	13.5	1.3	1.4	3.2	3.3	1.4	1.4
< 100	5.6	5.5	10.2	1.8	3.8	4.2	38.0	14.3	6.9	5.3	42.0	27.0
100-199	1.4	1.1	19.6	9.9	9.0	7.6	24.2	22.3	19.7	19.0	24.6	34.6
200-299	1.5	1.1	22.3	17.9	16.6	12.8	13.9	19.9	22.4	23.5	11.7	17.3
300-399	0.2	0.2	20.2	22.3	23.3	17.8	9.0	15.0	20.5	20.9	8.2	8.8
400-499	0.9	0.6	14.0	20.1	18.0	14.7	4.7	8.2	13.0	12.9	5.1	4.3
500-749	0.5	0.8	9.7	17.9	18.3	18.0	5.2	9.5	11.1	11.4	5.2	4.5
> 750	0.7	0.6	3.2	9.5	6.2	11.4	3.6	9.4	3.1	3.6	1.7	2.2
Total	100	100	100	100	100	100	100	100	100	100	100	100
Absolute	882	285	913	285	8042	310	2920	310	15314	620	8487	620

Source: COS statistics, several years. h. = number of quota holders; q. = total quantity of quota. Absolute total quantities transferred are given in million kg. Farmers with no quota (quota class 0) in the previous year can sell or lease-out quota because they have also bought quota in the same year.

2.3.3 Quota trade issues

There are three, interrelated issues of possible concern regarding the liberal Dutch quota market. First, Dutch quota prices are often perceived as too high. High quota prices cause rising cost of obtaining additonal quota (especially for young farmers) which endangers both the structure and the competitive position of the Dutch dairy sector. At the farm level the costs (including interest and depreciation costs) of aquiring quota have increased and may be reduced by increasing production. However, only a limited amount of quota is available (Ministry of Agriculture, 1998). Note, that quota prices may decrease as a result of the price cuts agreed by the European Commission in Agenda 2000. Second, the possibility to lease is believed to hamper the permanent transfer of quota, hence slowing down structural changes. Farmers willing to cease production gain from putting quota out to lease and delay the decision to stop farming (Ministry of Agriculture, 1998). Third, it is sometimes argued that farmers face an undesirable price risk, because of fluctuating prices in the spot market for milk quota sales and leases (Pennings, 1998 p.239-246).

A number of alternatives have been suggested for the reorganisation of quota trade, in order to solve the assumed problems. First, a centralised spot market, according to the model of the quota exchange in Ontario and Quebec (Canada), could replace both existing decentralised permanent and temporary quota trade[17]. In such a system, farmers must state what volume they wish to sell at what minimum price, or how much they want to buy at what maximum price. Based on these offers, a market clearing price is calculated. Transfers are effectuated at this price. If the bid to sell (buy) is above (below) this price there is no sale (purchase). Since the beginning of 1998, a milk quota exchange is effective in Denmark. The Canadian experience with a quota exchange indicates that there is less shortage of quotas and prices are tempered. Moreover, transparency of the market is enhanced, because demand and supply are centralised at a specified date (van Dijk, 1995; Oskam and Speijers, 1992). However, if the current quota market in the Netherlands is already efficient and transparent, a centralised quota exchange would not have much effect.

A second alternative for the organisation of permanent quota transfers is reducing each quota transfer by a siphon. Belgium and Germany are currently operating a siphon on quota transfers. In Belgium the siphon aims to limit farm sizes and stimulate new established producers (van Dijk, 1995 p.31). In Germany, the siphon also had to encourage farmers to sell their quota to the state in order to correct the over-allocation of quotas (van Dijk, 1995 p.20). The theoretical and empirical effects of a siphon on the transfer of quotas have been studied by Burrell (1989b), Daatselaar and Rijk (1994) and by Guyomard, Herrard, and Mahé (1995). In general, less quota will be traded as a result of a siphon. The

[17] In the Canadian system quota rental is prohibited and separate auction markets exist for trade in used and unused quota, see e.g. Chen and Meilke, 1998.

effect on quota prices depends on the elasticities of quota demand and supply (e.g. Chen and Meilke, 1998). However, quota that is "creamed off" is usually administratively reallocated by the government (for example to young farmers or proportionally to all dairy farmers) and therefore costs of acquiring quota are expected to be lower than without a siphon. Because the government usually lacks information about farm level efficiency, the government uses other criteria to reallocate quota (e.g. equity). As a result the efficiency of dairy farming worsens.

Third, putting limits to the production per hectare or the number of cows per hectare may also reduce quota prices. In this system only extensive farms are allowed to purchase quota (up to the specified limit). The demand for quota and quota prices are expected to decrease. However, the demand for farmland and land prices possibly increase. Fourth, quota lease may be restricted to a pure management tool, i.e. permit lease only for 'last minute' adjustments in production. As a result, demand and supply for permanent quota transfers increase. However, de Hoog (1998) concludes that abolition or restriction of the current quota lease system will not be effective. Finally, in order to increase the transparency of the quota market and to reduce the price risk that farmers possibly face, Pennings (1998) studied the possibilities for a futures market for milk quotas.

2.3.4 Research topic

Despite the various options for reorganising quota trade in the Netherlands, the question remains if current quota trade is efficiently organised. The high quota prices, the lease system, and price risks suggest that there are important inefficiencies involved in current quota trade. However, high quota prices and some price risk may be a common result of demand and supply in a fairly free market, wherein quotas are purchased by the most efficient farmers.

A number of authors have studied quota trade efficiencies, either theoretically or empirically. Burrell (1989b) and Cox (1987) focus on the theoretical efficiency gains of free quota trade. For the case of tobacco in the U.S., the distribution of economic rents between owners and renters of marketable production quotas is analysed by Babcock and Foster (1992). Other literature deals with the welfare effects of transfer restrictions. Rucker, Thurman and Sumner (1995) determine the impact of geographical trade restrictions, while Guyomard, Herrard and Mahé (1995) model a tax in the form of a siphon on French milk quotas exchanges.

The economic inefficiency of current milk quota distribution and efficiency losses that result from distortions in quota trade are the subjects in chapter 4. Theoretical insights from previous studies are used to quantify the effects of quota trade distortions that are specific for the Netherlands, such as quantitative trade restrictions and costs for transaction services. Again, a micro-level approach is used, so each farm is identified either as a quota buyer or quota seller (or indifferent to buying and selling). Gains from quota trade and losses from distortions in quota trade are quantified at the farm level and aggregated to the total dairy sector.

2.4 Manure policy

In this section, the current manure regulations in the Netherlands are described. Furthermore, the possibilities for dairy farms to adapt to the new regulations are discussed. Finally, the research topic for chapter 6 is defined.

2.4.1 Manure problems and early policy

Application of excessive amounts of phosphate (P_2O_5) and nitrogen (N), contained in animal waste (manure) and chemical fertiliser, cause eutrophication of the soil and surface and ground water. Eutrophication of surface water poses a threat to the ecosystem, while increasing amounts of nitrate in ground water endangers its use for drinking water. Table 2.11 shows that dairy farming accounted for almost 65 per cent of manure production in 1996. However, only about 6 per cent of the Dutch manure surplus problem is caused by dairy farming. Because dairy farms are mainly self-supporting in producing fodder, they can sustainably apply manure on their own land. Apart from the direct contamination of soil and water, the emission of ammonia from stables and spreading manure contribute to acidification. About 50 per cent of the emission of ammonia (NH_3) caused by agricultural sectors originates from dairy farming (see also Ministry of Agriculture, 1995). Ammonia emission depends on the type of housing, type of manure storage, manure application methods and grazing.

Table 2.11: Manure production, manure surplus at the farm (million tonnes and million kg N, P, and K) and emission of ammonia (million kg NH_3) in 1996.

	Total agriculture	Dairy cattle	Dairy cattle in % of total
Production (million kg):			
Nitrogen N	636.2	354.5	56
Phosphorus P	84.1	38.1	45
Potassium K	511.5	333.0	65
Quantity (million tonnes)	79.9	51.5	64
Surplus at farm (million kg):			
Nitrogen N	199.0	7.8	4
Phosphorus P	34.7	0.9	3
Potassium K	112.7	7.3	6
Quantity (million tonnes)	18.4	1.1	6
Ammonia emission (million kg NH_3) from:			
Stables	83.7	35.4	42
Storage	4.0	1.5	38
Grazing	14.6	12.4	85
Spreading	25.2	12.5	50
Total	127.5	61.8	48

Source: Brouwer, Baltussen and Daatselaar, 1997 p.162-163.

Manure policies have been in effect in the Netherlands since 1984. In several steps, various regulations were introduced and tightened. At first, the law aimed to prevent further expansion of the numbers of pigs, chickens and cows. In 1987, the production of manure was restricted by phosphate based manure production rights (quotas) and application standards for phosphate were enacted. Total manure production from all animal sources up to 125 kg phosphate per hectare of land was allowed. Farmers producing more manure need additional animal based manure production rights. Each farmer received a reference quota based on an inventory of animal numbers and standards for the manure production for each animal category. Moreover, the area of farmland was assessed. The difference between the reference quota and the acreage based phosphate rights was used to make a distinction between manure surplus farms and manure deficit farms (i.e. farms with a manure production larger or smaller than 125 kg phosphate per hectare).

Manure production in excess of the 125 kg standard was charged with a small levy[18]. Funds raised by the levy were used to stimulate technical solutions to the manure problem, such as lower levels of minerals in animal feed, distribution of manure from surplus areas to non-surplus areas, industrial processing of manure into dry granular fertiliser, and export of manure. In addition, the handling of manure is regulated. The general rules include i) a ban on the application of manure on farmland during the period September-January, ii) the obligation to use pre-described application techniques, and iii) a compulsion to cover manure deposits.

Table 2.12: Development of P, N and NH_3 emission by the agricultural sector (million kg).

	1985	1990	1995	1996
Emission of P to soil	87	71	63	60
Emission of N to soil	527	426	509	473
Emission of NH_3	239	220	141	138

Source: Silvis and van Bruchem, 1998 p.100.

Table 2.12 shows how the emissions of different nutrients to the environment have developed since the introduction of manure policy in the Netherlands. The emission of phosphorus from the agricultural sector declined by about 30 per cent, while ammonia emission decreased by 42 per cent (although controversy exists about this figure, see Silvis and van Bruchem, 1998 p.103). The emission of nitrogen clearly decreased initially, however since the beginning of the 1990s it increased again. Especially the declining stock of cattle caused by the milk quota regulations, the lower contents of phosphorus in animal feed, and the awareness of farmers about the efficient use of fertiliser resulted in decreasing emission of nutrients. Unfavourable weather conditions and the obligation to apply manure under the surface of the soil caused nitrogen emissions to increase (Silvis and van Bruchem, 1998 p.100).

Despite the development of a whole body of regulations and some declining emissions, the Dutch manure policy has not been sufficiently effective in abating nutrient losses. Especially the pace at which emissions are reduced is too slow. Dietz (1992)

[18] The first 125 kg phosphate per hectare was free of charge, the next 75 kg was subject to a levy of 0.25 guilders per kg, and any quantity in excess of 200 kg was charged with a levy of 0.50 guilders per kg.

identified the main failures of the manure policy. The policy aimed at a gradual reduction in the use of manure, without reducing the size of the national herds. Besides, only the production and use of phosphate was regulated. Nitrogen was ignored, and the application of nutrients via chemical fertiliser was unrestricted. Moreover, the maximum application standards were set too high and some categories of animals were excluded from the regulations (e.g. horses) (Dietz, 1992). Therefore, a new framework for manure policy was outlined in 1995 in the 'Integrale notitie mest- en ammoniakbeleid' (Ministry of Agriculture, 1995). Effective regulations with respect to the amount of N and P_2O_5 that can be applied, the permitted applications method and the period during which it can be applied are retained. The emission of ammonia has to fall by 70 per cent in the period 2000-2005 compared with 1980. Therefore, animal housing has to fulfil specific requirements regarding ammonia emission (e.g. 'green-label' housing). Additionally, a new instrument, known as Minas (mineral registration system), is implemented to control manure surplus problems.

2.4.2 Manure regulations: Minas

From the beginning of 1998 on Minas has been effective. Phosphate and nitrogen flows have to be registered and acceptable losses of phosphate and nitrogen per hectare are fixed. Phosphate and nitrogen surpluses are taxed. The new policy makes a distinction between intensive and extensive farms. Intensive farmers with more than 2.5 GVE[19] per hectare are obliged to keep accounts of nitrogen and phosphate flows at their farm. Farmers may choose between a detailed registration of real flows or a registration based on standards. In the detailed registration, the farms' in- and outflow of minerals (phosphate and nitrogen) is based on the real mineral content in all inputs and outputs. The exact contents of phosphate and nitrogen in, for example, animal waste, feedstuff, chemical fertiliser and milk have to be determined. If the registration is based on standards, only the in- and outflow of minerals in animal waste and chemical fertiliser is recorded. Standards are provided by law (Ministry of Agriculture, 1997b).

The calculation of phosphate and nitrogen surpluses is based on the registrations (either detailed or standardised) in Minas. For political reasons, phosphate inflow from

[19] GVE is the Dutch abbreviation for standardised cattle unit, 1 GVE = 1 dairy cow.

chemical fertilisers can be deduced to determine the taxable mineral surpluses. Moreover, legally permitted losses of phosphate and nitrogen (i.e. application minus the amount taken up by the crops) can be deduced. In 1998, the permitted loss of phosphate is 40 kg per hectare. Permitted nitrogen losses are 300 kg per hectare of grassland and 175 kg per hectare of arable land. Table 2.13 shows that the permitted nutrient losses decrease in the following years. For intensive farms, the number of animals, rather than the area of farmland, determine ammonia emission. Therefore, a correction is made for ammonia losses per animal.

Table 2.13: Permitted phosphate and nitrogen losses per hectare.

	1998	2000	2002	2005	2008
Phosphate loss / ha	40	35	30	25	20
Nitrogen loss / ha of grassland	300	275	250	200	180
Nitrogen loss / ha of arable and waste land	175	150	125	110	100

Source: Ministry of Agriculture, 1997b.

Arable farming, horticulture and farms with 2.5 GVE or less per hectare, are not obliged to participate in Minas initially[20]. They only have to keep a simple registration of animal numbers and hectares. In addition, they have to keep accounts of the deliveries of manure and other organic fertilisers (volume and type of manure) on their farm. Nitrogen and nutrients in chemical fertilisers are not recorded. In 1998 and 1999, these farms are allowed to apply 120 kg phosphate per hectare on grassland, and 100 kg phosphate per hectare on arable land. In 2000 and 2001 these thresholds are 85 kg phosphate per hectare, and from 2002 onwards 80 kg. Farms have a phosphate surplus if the sum of their phosphate production, calculated as the number of animals times the phosphate standard per animal[21], and the deliveries of phosphate in manure (standards per type of manure) is higher than the total amount they are permitted to apply on their land. Note here that manure removed from the farm is not deducted from the surplus (Ministry of Agriculture,

[20] From 2000 all animal farms, and from 2002 all arable and horticulture farms have to participate in Minas.
[21] For example, the standard phosphate production per dairy cow is 41 kg per year, whereas standard nitrogen production is 161 kg per cow per year.

1997a). In the case of a surplus, the farm automatically participates in Minas based on standards.

Resulting surpluses will be taxed according to the rates in Table 2.14. For nitrogen surpluses the tax is 1.5 guilders per kg per hectare, for phosphate it is 10 guilders per kg per hectare. However, the first 10 kg per hectare of the phosphate surplus will be taxed a the rate of 2.5 guilders per kg per hectare in 1998 and 1999 (Ministry of Agriculture, 1997b).

Table 2.14: Mineral surplus taxes (guilders per kg of surplus).

	1998-1999	2000-2004	2005 onwards
Nitrogen	1.50	5.00	5.00
Phosphate	10.00	20.00	20.00
first 10 kg of the surplus	2.50	5.00	-
first 5 kg of the surplus	-	-	5.00

Source: Ministry of Agriculture, 1997b.

2.4.3 Consequences for dairy farming

Since the onset of manure policies in 1984, dairy farming was hardly restricted by the Dutch manure regulations. In the first period after 1984, the milk quota system contributed even more to the solution of the manure problems in the Netherlands than the manure policy itself (van Bruchem and Rutten, 1988 p.71). Due to the milk quota constraints, Dutch dairy farming has become less intensive. Dairy cow numbers decreased substantially, although this was partly offset by keeping more fattening animals and sheep. Furthermore, farmland acreage was under-utilised. Because of growing milk yields per cow and the availability of more or less the same area of farmland, the extensification process is expected to continue. The average specialised dairy farm held 2.46 GVE per hectare in 1997, and it is expected that it will decline to less than 2 GVE per hectare in 2015 (LTO Nederland, 1998 p.14). Anyway, it is the dairy sectors' own wish to further extensify production and prevent dairy farms from becoming industrialised units where dairy cows are kept inside year-round. Thus, the sector aims at the full dependence of milk production on land, because of the image building of dairy farming towards society and manure policy (LTO Nederland, 1998). Note that the propagation of grazing cows works against the goal of ammonia emission reduction.

On the basis of the situation in 1997, about half of the Dutch dairy farms are obliged to participate in Minas (Silvis and van Bruchem, 1998 p.101). However, there are large differences between farms. Somewhat more than half of the dairy farms in 1996 held less than 2.5 GVE per hectare, about 30 per cent held between 2.5 and 4 GVE per hectare. Another 15 per cent of dairy farms held even more than 4 GVE per hectare (LEI-DLO and CBS, 1997 table 41-d). If these intensive farms are not able to properly remove or avoid manure surpluses, the new manure policy may cause serious problems. In the case of an imminent surplus, the farmer has to weigh the transportation costs involved in removing manure from the farm and paying the surplus tax against each other. For individual farms it may be profitable to extensify their production by purchasing land, hence grow more feed on the farm, and prevent manure surpluses arising.

Obviously, interaction is expected between the manure surplus taxes on the one hand and the demand for farmland and milk quotas on the other (e.g. Luijt, 1994). If the manure regulations have a negative effect on farm profits, then the value of land and the demand for farmland will decrease. Differences in the value of land between farms induce land transfers. However, extending farmland acreage usually is difficult in the short-run, because there is no supply of land in the neighbourhood of the farm. Land supply is essentially rationed (Luijt, 1994). Of course, this is also affected by other measures such as the objective to create valuable wildlife and landscape conservation areas (Oskam and Slangen, 1998). More severe manure regulations might eventually constrain milk production, making milk quotas non-binding in the Netherlands. As a result, quota prices will decrease.

2.4.4 Research topic

Until the introduction of Minas, dairy farming in the Netherlands was hardly restricted by manure and nutrient policies. In addition, it may be clear from the above that the average dairy farm will probably not be constrained much by Minas (because of the 2.5 GVE limit). However, in the case of surpluses, individual farms are liable for surplus taxes, and the regulations become stricter in the future, thus restricting more dairy farms.

Economists generally propagate taxes (levies) as instruments to curb manure problems (see for example Dietz and Hoogervorst, 1991). Using a linear programming (LP) model, describing a typical dairy farm, Berentsen and Giesen (1997) (see also

Berentsen, Giesen and Renkema, 1997) calculated the possible effects of prohibitive levies on nitrogen and phosphate losses. As a result, land use on the farm shifted from growing silage maize to grass. However, the total area of land remained fixed. The interaction between different farms, e.g. on a market, are ignored in LP modelling. In an econometric study, nitrogen surplus levies for Dutch pig farms have been analysed by Fontein et al. (1994). They assume that farmers reduce livestock numbers in response to a levy. Polman and Thijssen (1996) use the concept of marginal abatement costs in order to take into account that farmers have several options to react to a nitrogen surplus levy. Oude Lansink and Peerlings (1997) introduced a nitrogen tax in their model of arable farms. Kleinhanss, Becker and Schleef (1997) simulate the impact of a fertilizer levy on agricultural production at the regional level of EU member states and at the farm level in Germany.

Despite the historical emphasis on phosphate in Dutch manure policies, phosphate surplus levies have not often been studied before in a micro-econometric context. In addition, empirical studies, which recognise the interaction between a surplus tax and the demand for farmland, are lacking. The effects of the new phosphate surplus taxes for individual dairy farms, especially in relation to the demand for farmland, will be studied in chapter 6. The effect of the surplus taxes on the demand for milk quotas is illustrated by the change in the shadow prices of quota.

2.5 Conclusion

The supply constraint, enforced by the milk quota regime, combined with the price support and border protection measures, play a central role in dairy policy. However, the EU seeks to readjust dairy policy. The alternative EU policies to be analysed in chapter 5 are a two-tier milk price system, quota abolition, and the Agenda 2000 agreement, which include price cuts and compensating premiums. Within the milk quota system, quota mobility and the organisation of quota trade have been debated constantly. In the Netherlands, milk quotas are traded in a fairly liberal quota market. The efficiency of milk quota trade and the effects of distortions in quota trade are analysed in chapter 4. Another policy issue of interest for Dutch dairy farms consists of the nutrient surplus taxes recently introduced. The effects of phosphate surplus taxes, especially in relation to the demand for farmland, are investigated in chapter 6.

In order to assess the impacts of the policies described, a model is developed. The model should be flexible in order to handle the diversity of policy changes defined here, implying that the model can be adapted to answer specific research questions. Obviously, the model should distinguish milk quotas and various inputs necessary for producing milk. Moreover, it should be possible to include farmland and manure surpluses. Since we are particularly interested in the policy effects for individual dairy farms, a micro-economic method is required, which recognises differences between farms. It is assumed that differences in the efficiency of milk production drive the adjustments to policy changes on the farm. Therefore, the production economics of dairy farming play a central role. The reaction of individual farms to policy changes will often come together in simulating a market (e.g. the quota market). In that way, interaction of individual behaviour is aggregated to the level of the dairy sector. Besides, the model accounts for regional differences in the Netherlands. Thus, effects can be aggregated to the level of the region or the total dairy industry.

The data, the choices regarding the basic model, and the estimations will be discussed in the next chapter. Specific extensions to the model that are required for simulating the defined policy issues are described in the respective chapters.

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Chapter 3 A MICRO-ECONOMIC MODEL FOR DAIRY FARMING UNDER QUOTAS

3.1 Introduction

In 1984 supply control regulations for dairy farming were implemented in the European Union (the European Community at the time) in response to overproduction and budgetary problems. In the Netherlands, milk production was effectively restricted to farm level quotas by a prohibitive levy on surplus production. Quotas have been allocated to producers on the basis of their milk output in 1983/84. In order to decrease the rigidity in production structures, milk quotas were made transferable. Initially, only the quota ownership rights were exchangeable, but since 1989, farmers are also allowed to exchange quota user rights through leasing.

Modelling quota constraints has received considerable attention in the agricultural economics literature. Moschini (1988) and Helming, Oskam and Thijssen (1993) provided a framework for modelling quotas, where the latter implicitly includes the regime switch in the empirical model. Fulginiti and Perrin (1993) showed the link between quota-constrained and unconstrained behaviour, while others focused on different aspects of quota trade (Cox, 1987; Babcock and Foster, 1992; Guyomard, Herrard and Mahé, 1995; Rucker, Thurman and Sumner, 1995).

Objectives of this chapter are a) to develop a theoretical framework for transferable and non-transferable output quota, b) to develop an empirical micro-model which can be used to simulated alternative dairy policies, and c) to describe the considerations behind choices we make about the model. In general, the objectives serve as a basis for further, continuating research of Dutch dairy farming. However, the latter objective is also an implicit reply to Elhorst's criticism on the "additional and practically-based decisions" of agricultural economists in implementing agricultural household models (Elhorst, 1996). Elhorst distinguishes choices related to data, model specification, prices and econometric methods. Several of these points will return in this chapter. Regarding the data, we will go into the choice of the research population, the stratified nature of the data and the related necessity of weighting. Regarding the model specification, this chapter deals with the short-term dimension, the treatment of cattle as a variable in the model, and the measurement of quasi-fixed inputs, especially buildings. Finally, regarding the econometric methods, this chapter focuses on the possibility of negative profits and the panel data nature which allows for fixed and random effects.

In order to make the choice for a particular model more explicit, three alternative models are compared with the central model in this study. The central model consists of the unweighted estimation of the symmetric normalised quadratic (SNQ), including fixed effects. The alternatives distinguished are the normalised quadratic (NQ), the SNQ including additional fixed effects, and the weighted estimation of the SNQ. The comparison between the SNQ and NQ relates to the functional form of the model (for a thorough study on functional forms see Oude Lansink and Thijssen, 1998). The other alternatives relate to the estimation procedure.

The next section presents the theoretical model for non-tradable and tradable production quotas, which is followed by a description of the empirical model. Then the data are given, the estimation procedure is explained and the estimation results are presented. This chapter ends with a discussion and conclusions.

3.2 Theoretical model

In this section a theoretical micro-economic model, which includes non-tradable and tradable production quotas, is developed. Assumptions made beforehand are that dairy farming is characterised by the joint production of multiple outputs using variable inputs and some inputs which are fixed in the short run (quasi-fixed inputs). The objective of the farmer is to maximise profit, while the level of prices and quasi-fixed inputs are given. Therefore, the short-term, dual profit function $\pi_h(\mathbf{v},\mathbf{z}_h)$ for farmer h is:

$$\pi_h(\mathbf{v},\mathbf{z}_h) = \max_{q_h}\{\mathbf{v}\mathbf{q}_h\} = \mathbf{v}\mathbf{q}_h^* \tag{3.1}$$

where $\mathbf{q}_h$ is a vector of netputs (if $q_{ih} > 0$, it is an output, whereas if $q_{ih} < 0$, it is an input) with corresponding netput prices $\mathbf{v}$. Quasi-fixed inputs are denoted by vector $\mathbf{z}_h$. It is assumed that the profit function is continuous and twice differentiable. Furthermore, profits are non-negative, non-decreasing in output prices and quasi-fixed inputs, non-increasing in input prices and convex and linear homogeneous in prices (Chambers, 1988).

If the netput vector is partitioned into a single output q_{0h} (could also be a vector) and a vector of other netputs $\mathbf{q}_{ih}$, the profit maximisation problem is represented by:

$$\pi_h(\mathbf{v},\mathbf{z}_h) = \max_{q_{0h}}\{v_0 q_{0h} + g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)\} \tag{3.2}$$

$$g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h) = \max_{q_{ih}}\{\mathbf{v}_i \mathbf{q}_{ih}\} \tag{3.3}$$

Here, $g_h(\cdot)$ is the restricted profit function which is defined as the cost of producing q_{0h}. The properties of the restricted profit function are equivalent to those of the regular profit function in (3.1). However, it is possible that restricted profit is negative (Moschini, 1988).

Since both profit functions satisfy the derivative property (Hotelling's lemma) supply and demand equations for the netputs $\mathbf{q}^*_{ih}(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)$ are:

$$\frac{\partial \pi_h(\mathbf{v},\mathbf{z}_h)}{\partial \mathbf{v}_i} = \frac{\partial g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)}{\partial \mathbf{v}_i} = \mathbf{q}^*_{ih} \tag{3.4}$$

and the supply of $q^*_{0h}(\mathrm{v}_0, \mathbf{v}_i, \mathbf{z}_h)$ results from solving:

$$\begin{aligned} \frac{\partial \pi_h(\mathbf{v},\mathbf{z}_h)}{\partial v_0} &= q^*_{0h} + v_0 \frac{\partial q_{0h}}{\partial v_0} + \frac{\partial g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)}{\partial q_{0h}} \frac{\partial q_{0h}}{\partial v_0} = q^*_{0h} \\ &\Rightarrow v_0 + \frac{\partial g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)}{\partial q_{0h}} = 0 \end{aligned} \tag{3.5a}$$

or equivalently:

$$\frac{\partial \pi_h(\mathbf{v},\mathbf{z}_h)}{\partial q_{0h}} = v_0 + \frac{\partial g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)}{\partial q_{0h}} = 0 \tag{3.5b}$$

This condition states that the optimal output supply q^*_{0h} is found where the marginal cost of producing this output $(-\frac{\partial g_h(\cdot)}{\partial q_{0h}})$ equals its price. The economic value of the quasi-fixed inputs can also be revealed in this system:

$$\frac{\partial \pi_h(\mathbf{v},\mathbf{z})}{\partial \mathbf{z}_h} = \frac{\partial g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)}{\partial \mathbf{z}_h} = \mathbf{s}_h \tag{3.6}$$

Here, $\mathbf{s}_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)$ is the vector of shadow prices for the given quasi-fixed inputs $\mathbf{z}_h$. These shadow prices result in $\mathbf{z}_h$ being profit-maximising levels of quasi-fixed inputs.

3.2.1 Introducing quotas

When the supply of q_{0h} at the farm level is restricted by a production constraint at the level $\breve{q}_{0h}$, the partitioning of **q** proves to be helpful. The profit maximisation problem for every farm *h*, assuming given netput prices, becomes:

$$\pi_h(\mathbf{v},\mathbf{z}_h) = \max_{q_{0h}}\{v_0 q_{0h} + g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)\} \qquad s.t. \quad q_{0h} \le \breve{q}_{0h} \tag{3.7}$$

This constrained maximisation problem is restated as the Lagrangian:

$$L(\mathbf{v},\breve{q}_{0h},\mathbf{z}_h) = \{v_0 q_{0h} + g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h) - r_{0h}(q_{0h} - \breve{q}_{0h})\} \tag{3.8}$$

where $r_{0h} \geq 0$ is the Lagrange multiplier resulting from the quota constraint. It represents the extra profit of the farm when the constraint is relaxed by one unit. Therefore, it is also referred to as the shadow price of the constraint (Chiang, 1984 p.727). If the constraint is not binding r_{0h} must be zero.

The optimal supply and demand of unconstrained netputs $\mathbf{q}^*_{ih}$, are already solved implicitly by the restricted profit function $g(\cdot)$, see equation (3.4). The shadow prices for $\mathbf{z}_h$ are derived as in equation (3.6). In the following, the derivations of the unconstrained netputs and shadow prices of quasi-fixed inputs are not shown anymore. The Kuhn-Tucker conditions of the problem in equation (3.8) are:

$$\frac{\partial L(\mathbf{v},\breve{q}_{0h},\mathbf{z}_h)}{\partial q_{0h}} = v_0 + \frac{\partial g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)}{\partial q_{0h}} - r_{0h} = 0$$
$$\Rightarrow v_0 + \frac{\partial g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)}{\partial q_{0h}} = r_{0h} \tag{3.9a}$$

$$r_{0h}(\breve{q}_{0h} - q_{0h}) = 0 \tag{3.9b}$$

Equation (3.9a) is used to reveal the shadow price $r_{0h}(\mathbf{v}, q_{0h}, \mathbf{z}_h)$ of a given positive supply q_{0h}. This shadow price equals the difference between the market price, v_0, and the marginal costs of q_{0h} ($= -\frac{\partial g_h(\cdot)}{\partial q_{0h}}$). When the quota constraint is not restrictive (e.g. in the pre-quota period), r_{0h} will be zero.

Fulginiti and Perrin (1993) show that there exists a shadow price $\breve{r}_{0h}$ which would induce the farm to freely choose the output at the level $\breve{q}_{0h}$. Evaluated at shadow prices, constrained and unconstrained profit (equation (3.8) and (3.2) respectively) must be equal. The relationship can be characterised by stating that constrained profit equals unconstrained profit evaluated at the shadow price plus the quota rent: $v_0\breve{q}_{0h} + g_h(\cdot) = \breve{r}_{0h}\breve{q}_{0h} + g_h(\cdot) + \breve{q}_{0h}(v_0 - \breve{r}_{0h})$.

When quota trade is possible in a competitive quota market, the initial quota level at the farm is not binding anymore, instead the aggregate national quota is binding. If the rental price of quota is denoted by λ, the profit function becomes:

$$\pi_h(\mathbf{v}, \breve{q}_{0h}, \mathbf{z}_h, \lambda) = \max_{q_{0h}} \{v_0 q_{0h} + g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h) - \lambda(q_{0h} - \breve{q}_{0h})\} \tag{3.10}$$

The first order condition implies that the marginal cost of producing q_{0h} equals the difference between its market price and the rental price of quota:

$$\frac{\partial \pi_h(\mathbf{v}, \breve{q}_{0h}, \mathbf{z}_h, \lambda)}{\partial q_{0h}} = v_0 + \frac{\partial g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)}{\partial q_{0h}} - \lambda = 0 \tag{3.11}$$

This equation holds for all farms and v_0 and λ are equal across farms. Moreover, the sum of all q_{0h} over farms is given (the national quota level $\breve{Q}$). Therefore, both q^*_{0h} and λ^* are found where:

$$\frac{\partial g_h(\mathbf{v}_i, q_{0h}, \mathbf{z}_h)}{\partial q_{0h}} = \frac{\partial g_h(\mathbf{v}_i, q_{0f}, \mathbf{z}_f)}{\partial q_{0f}} \qquad h, f = 1,.., H \tag{3.12a}$$

$$\text{and } \sum_{h=1}^{H} q_{0h} = \breve{Q} \tag{3.12b}$$

This concludes the theoretical model for tradable quotas.

3.3 Empirical specification

In this section, the functional form for the empirical model of dairy farming under quotas is developed. Here, the symmetric normalised quadratic (SNQ) is chosen as the functional form (Oude Lansink and Thijssen, 1998). The SNQ allows for negative profits and it has a Hessian of constants, so that convexity in prices can be tested globally. In earlier versions of the model the normalised quadratic (NQ) was used (see Appendix 3.A). However, the NQ has two major disadvantages. First, it is well known that the estimates of the NQ are not invariant with respect to the choice of the numeraire (Diewert and Wales, 1987). Second, using the model for simulating purposes, the NQ imposes that a profit change at the national level is wholly due to a change in the numeraire netput. The other netputs remain at their initial levels. The SNQ is used to avoid these problems.

Consider a profit maximising dairy farmer who produces two outputs; milk (q_0), which is subject to supply constraints, and an aggregate of other output (q_1), using purchased feed (q_2), dairy cattle (q_3) and a composite of other inputs (q_4) as variable inputs. Output is produced given netput prices v_0 to v_4 and quasi-fixed inputs labour (z_1), land (z_2), buildings (z_3) and machinery (z_4). The model also includes a time trend (z_5) representing technology and a dummy (z_6) allowing for a change in technology due to the introduction of milk quotas in 1984. Furthermore, there are dummies (z_7 and z_8) included to distinguish between three regions. It is assumed that each farmer has access to the same production technology. Farm-specific features (e.g. the quality of land and management) are modelled using fixed effects. In a micro-economic study on Dutch dairy farms, Thijssen (1992) concluded that the fixed effects estimator is preferred to the random effects estimator, because the important assumption for the random effects estimator to be consistent, i.e. that the individual effects and the regressors are independent, is rejected by a Hausman test.

The symmetric normalised quadratic (SNQ) restricted profit function (see Kohli, 1993; Moschini, 1988) for each farm h and year t is here defined as:

$$\begin{aligned} g_{ht}(v_{it}, q_{0ht}, z_{kht}) = {} & \sum_{i=1}^{4} \alpha_{ih} v_{it} + \frac{1}{2} w^{-1} \sum_{i=1}^{4} \sum_{j=1}^{4} \alpha_{ij} v_{it} v_{jt} + \sum_{i=1}^{4} \zeta_i v_{it} q_{0ht} + \sum_{i=1}^{4} \sum_{k=1}^{8} \gamma_{ik} v_{it} z_{kht} + \\ & \frac{1}{2} w \rho q_{0ht} q_{0ht} + w \sum_{k=1}^{8} \mu_k z_{kht} q_{0ht} + \frac{1}{2} w \sum_{k=1}^{5} \sum_{n=1}^{5} \beta_{kn} z_{kht} z_{nht} + \\ & w \sum_{k=1}^{5} \sum_{n=6}^{8} \beta_{kn} z_{kht} z_{nht} \end{aligned} \tag{3.13}$$

The last term in the restricted profit function indicates that the cross-products of the dummies are not taken into account. Farm h's specific parameters are denoted by α_{ih}. Symmetry is maintained by requiring $\alpha_{ij}=\alpha_{ji}$ and $\beta_{kn}=\beta_{nk}$. Linear homogeneity in prices is imposed by the term $w = \sum_{l=1}^{4} \theta_l v_{lt}$, where θ_l are non-negative constants. In this study θ_l is the average share of netput l in total costs plus revenues, so they sum to unity. They can be interpreted as fixed weights for the price index w. In order to identify all parameters of the model, additional restrictions have to be imposed:

$$\sum_{j=1}^{4} \alpha_{ij} \bar{v}_j = 0 \qquad \forall i = 1,..,4 \tag{3.14}$$

where $\bar{v}_j$ is an arbitrary point of observation. In this study $\bar{v}_j$ equals the sample mean of price j ($\bar{v}_1$=1.04, $\bar{v}_2$=0.94, $\bar{v}_3$=1.04 and $\bar{v}_4$=0.98).

From the restricted profit function, the following netput equations (i=1,..,4) for each farm h are derived using Hotelling's lemma:

$$q_{iht} = \alpha_{ih} + w^{-1}\sum_{j=1}^{4}\alpha_{ij}v_{jt} - \frac{1}{2}\theta_i w^{-2}\sum_{l=1}^{4}\sum_{j=1}^{4}\alpha_{lj}v_{lt}v_{jt} + \zeta_i q_{0ht} + \sum_{k=1}^{8}\gamma_{ik}z_{kht} + \frac{1}{2}\theta_i \rho q_{0ht}q_{0ht} + \theta_i\sum_{k=1}^{8}\mu_k z_{kht}q_{0ht} + \frac{1}{2}\theta_i\sum_{k=1}^{5}\sum_{n=1}^{5}\beta_{kn}z_{kht}z_{nht} + \theta_i\sum_{k=1}^{5}\sum_{n=6}^{8}\beta_{kn}z_{kht}z_{nht} \tag{3.15}$$

Note that all netput equations have a farm-specific intercept. The model is completed by the milk supply function, which is only valid in the pre-quota period. The milk supply function does not include a farm-specific intercept (see later on for motivation):

$$q_{0ht} = -\frac{1}{\rho}\left[w^{-1}\left(\sum_{i=1}^{4}\zeta_i v_{it} + v_{0t}\right) + \sum_{k=1}^{8}\mu_k z_{kht}\right] \tag{3.16}$$

In the post-quota period, milk supply is exogenously given for the individual farm and the milk supply equation does not apply. In that case, the marginal cost of milk supply, that is, the price that would have given rise to producing at the quota level, is given by:

$$s_{0ht} = -\left[\sum_{i=1}^{4}\zeta_i v_{it} + w\left(\rho q_{0ht} + \sum_{k=1}^{8}\mu_k z_{kht}\right)\right] \tag{3.17}$$

The farm shadow price of milk quota, r_{ht}, equals v_{0t}-s_{0ht}. The shadow prices of the quasi-fixed inputs (k=1,..,5) are calculated as:

$$s_{kht} = \sum_{i=1}^{4}\gamma_{ik}v_{it} + w\left(\mu_k q_{0ht} + \sum_{n=1}^{8}\beta_{kn}z_{nht}\right) \tag{3.18}$$

3.4 Data

Data on Dutch dairy farms, that obtain 50 per cent or more of their total returns from milk production, are selected from a stratified sample of farms keeping accounts on behalf of the LEI-DLO farm accounting system. The panel contains 9365 observations on 1961 farms, covering the period 1973/74-1992/93. The farms usually remain in the panel for about five years, so the data set forms an incomplete (or unbalanced) panel.

In the model, one supply-constrained output, one unconstrained output, three variable inputs and four quasi-fixed inputs are distinguished. The constrained output is 'milk' which consists of milk revenues. The unconstrained or 'other output' is an aggregate of revenues from marketable crops, beef and veal, pigs, poultry and other farm revenues. The three variable inputs are 'purchased feed' for cattle, 'dairy cattle' and 'other input'. The first consists of the costs of compound feed, roughage and milk powder. Dairy cattle is measured as 4 per cent[1] of the dairy cattle stock at the farms' balance sheets. Dairy cattle is assumed to be a variable input since dairy cows are rather easily adjusted to optimal levels. Other input is a composite of costs of feed for animals other than dairy cattle, seeds, fertilisers, pesticides, contract work, veterinary services, fuel, energy, other cattle (again 4 per cent of stock value) and other variable inputs.

Quasi-fixed inputs are 'labour', 'land', 'buildings' and 'machinery'. Labour contains both family labour and hired labour, measured in hours. Earnings from family labour and hired labour are divided by their respective wage rates. The area of farmland is directly available in the data set and measured in hectares. Data on capital invested in buildings for tenant farms are incomplete (Elhorst, 1990 p.84). Therefore, simulated values for invested capital in tenant farmers' buildings are used. First, for owner-occupied farms, capital invested in buildings was regressed on the costs of buildings and size of the farm. Second, predicted values for capital invested in buildings for tenant farms were determined and used in later stages of estimation. Buildings and machinery are both measured as total invested capital at 1980/81 prices (stock value in the balance sheets). A 'trend' variable is included in the model to represent technology development. Furthermore, it is assumed that the soil type and regional location influence dairy farmer behaviour. Therefore, the farms are distinguished according to the region in which they operate. The regions are 'sandy soils', 'northern clay and peat', and 'western pastures' (see also van Dijk, Douma and van Vliet, 1995 p.16).

[1] This is the real discount rate, which is taken as an estimate for the yearly costs.

Table 3.1: Data and base simulation for the average specialised dairy farm in 1992/93. Simulated values between brackets (NQ) and [SNQ].

	Price[a] index	Dimension	Sandy soils	Northern clay	Western pastures	Total sector	
No. of farms			14517	6888	6110	27515	
			Quantity	Quantity	Quantity	Quantity	Shadow price (1992/93 guilders)
Milk output	1.17	Kilograms *1000	366.412	441.047	365.380	384.868	(0.330)
			-	-	-	-	[0.311]
Other output	1.05	Guilders *1000	84.121	72.112	72.243	78.477	
		(1980/81 prices)	(86.897)	(74.722)	(74.349)	(81.063)	-
			[87.603]	[75.379]	[75.114]	[81.769]	
Purchased feed	0.82	Guilders *1000	73.321	70.348	66.626	71.090	
		(1980/81 prices)	(70.315)	(71.108)	(65.491)	(69.442)	-
			[69.174]	[70.010]	[64.364]	[68.315]	
Dairy cattle	1.12	Guilders *1000	3.852	4.562	3.809	4.020	
		(1980/81 prices)	(3.839)	(4.555)	(3.788)	(4.007)	-
			[3.743]	[4.463]	[3.685]	[3.910]	
Other input	1.14	Guilders *1000	81.134	69.382	66.349	74.909	
		(1980/81 prices)	(81.581)	(72.111)	(66.968)	(75.965)	-
			[82.051]	[71.241]	[67.539]	[76.122]	
Profits	-	Guilders *1000	189.364	244.293	198.531	205.151	
			(194.255)	(243.311)	(200.994)	(208.032)	-
			[195.508]	[245.999]	[202.190]	[209.632]	
Labour	-	Hours	3 869	4 054	3 871	3 916	(4.717)
							[7.676]
Land	-	Hectares	28.738	37.790	29.244	31.117	(1 553)
							[1 629]
Buildings	-	Inventory value, guilders *1000	235.160	277.324	233.572	245.363	(0.015)
		(1980/81 prices)					[0.036]
Machinery	-	Inventory value, guilders *1000	195.540	211.498	184.619	197.110	(0.009)
		(1980/81 prices)					[0.086]

[a] 1980/81=1.

Implicit quantity indices were obtained as the ratio of values (revenues or costs) over price indices. Tornqvist price indices (see Thijssen, 1992) were calculated for the compound variables (other output, purchased feed and other input). The price indices vary over years but not over farms, implying that differences in the composition of a netput or quality differences are reflected in the quantity. The base year for the indices is 1980/81. Price and quantity indices for milk are standardised for a fat content of 3.7 per cent. Data on prices are obtained from the Agricultural Economics Research Institute (LEI-DLO) and Statistics Netherlands (CBS). The data for 1992/93 are presented in Table 3.1. In 1992/93 θ_1=0.323, θ_2=0.337, θ_3=0.022 and θ_4=0.317, hence $w = \sum_{l=1}^{4} \theta_l v_{lt}$ = 1.003 in 1992/93. Appendix 3.B shows the yearly averages of the data over the period 1973/74-1992/93.

3.5 Estimation procedure

The equations estimated are (3.15) and (3.16) with additional error terms. Every farm is assumed to have a different intercept reflecting differences in farm characteristics. This assumption is explicitly accounted for by a fixed effects model. The necessary transformation of the variables (the deviation of each observation from the average over time per farm) can also be applied to an incomplete panel like our data set, as long as a farm is present in the panel for at least two subsequent years (Thijssen, 1992). As a consequence the information on farms that are present in the panel only once is lost, affecting the representativeness of the data. The farm-specific intercepts of the netput equations (α_{ih}) appear as slope coefficients in the profit function. In order to avoid direct estimation of the farm-specific intercepts, the profit function is left out of the estimated system. The milk supply equation is assumed not to have a farm-specific effect, since consistent estimation requires the farm-specific effect to appear as a slope coefficient in the netput equations. These farm-specific effects do not leave when the fixed effects model is transformed to be estimated.

The structure of the estimated system, consisting of a pre-quota (1973/74-1983/84) and post-quota (1984/85-1992/93) period, is as follows:

$$\begin{Bmatrix} q_{it} = (1 - z_6)\{A\} \\ q_{is} = z_6\{B\} \\ q_0 = (1 - z_6)\{C\} + z_6 y_0 \end{Bmatrix}$$

where $z_6 = 0$ in the pre-quota period and $z_6 = 1$ in the post-quota period; q_{it} = endogenous netput i in pre-quota period (t=1973/74,..,1983/84); q_{is} = endogenous netput i in post-quota period (s=1984/85,..,1992/93); q_0 = endogenous milk supply; y_0= exogenous milk output; A = equation (3.15) with q_0 included; B = equation (3.15) with y_0 included; C = equation (3.16). The milk supply equation is only estimated in the period before the quota introduction, causing a difference in the number of observations across equations. The covariance matrix of residuals used in estimating the system is corrected for this difference in observations (Judge et al., 1988 p.462). In the pre-quota period, the quantity of milk can be related to the error term and an instrumental variable estimator must be applied. Endogenous variables are q_0, q_i (i=1,..,4), and all variables containing milk output ($q_0 q_0$, $z_k q_0$). All exogenous variables are used as instruments. Error terms may be correlated across equations. Therefore, non-linear 3SLS is an appropriate estimation technique (Judge et al., 1988 p.655). The 'proc model' procedure of the SAS/ETS software is used for estimating.

The farm-specific effects are calculated afterwards, using the parameter estimates (denoted by hats) and the averages over time per farm (denoted by bars). It is assumed that the average of the remainder disturbance per farm, that is the part of the error term which is not farm-specific, is zero (Baltagi, 1995):

$$\alpha_{ih} = \bar{q}_{ih.} + \frac{1}{2}\theta_i\left(\sum_{l=1}^{4}\theta_l\bar{v}_{l.}\right)^{-2}\sum_{i=1}^{4}\sum_{j=1}^{4}\hat{\alpha}_{ij}\bar{v}_{i.}\bar{v}_{j.} - \left\{\left(\sum_{l=1}^{4}\theta_l\bar{v}_{l.}\right)^{-1}\sum_{j=1}^{4}\hat{\alpha}_{ij}\bar{v}_{j.} + \hat{\zeta}_i\bar{q}_{0h.} + \sum_{k=1}^{8}\hat{\gamma}_{ik}\bar{z}_{kh.} + \frac{1}{2}\theta_i\hat{\rho}\bar{q}_{0h.}\bar{q}_{0h.} + \theta_i\sum_{k=1}^{8}\hat{\mu}_k\bar{z}_{kh.}\bar{q}_{0h.} + \frac{1}{2}\theta_i\sum_{k=1}^{5}\sum_{n=1}^{5}\hat{\beta}_{kn}\bar{z}_{kh.}\bar{z}_{nh.} + \theta_i\sum_{k=1}^{5}\sum_{n=6}^{8}\hat{\beta}_{kn}\bar{z}_{kh.}\bar{z}_{nh.}\right\} \qquad (3.19)^2$$

3.5.1 Fixed effects in the milk supply equation

In contrast with the earlier statement that consistent estimation of fixed effects in the milk supply equation is not possible, this problem is addressed here. In the following it is shown that it is possible to 'estimate' fixed effects also when they appear as slope coefficients in an equation in the estimation system. This solution is due to Oude Lansink (1997).

An additional term $w\varepsilon_h q_{0ht}$ is included at the right-hand side of equation (3.13):

$$g_{ht}(v_{it}, q_{0ht}, z_{kht}) = \sum_{i=1}^{4}\alpha_{ih}v_{it} + \frac{1}{2}w^{-1}\sum_{i=1}^{4}\sum_{j=1}^{4}\alpha_{ij}v_{it}v_{jt} + \sum_{i=1}^{4}\zeta_i v_{it}q_{0ht} + \sum_{i=1}^{4}\sum_{k=1}^{8}\gamma_{ik}v_{it}z_{kht} + w\varepsilon_h q_{0ht} + \frac{1}{2}w\rho q_{0ht}q_{0ht} + w\sum_{k=1}^{8}\mu_k z_{kht}q_{0ht} + \frac{1}{2}w\sum_{k=1}^{5}\sum_{n=1}^{5}\beta_{kn}z_{kht}z_{nht} + w\sum_{k=1}^{5}\sum_{n=6}^{8}\beta_{kn}z_{kht}z_{nht} \qquad (3.20)$$

Here, ε_h is a farm-specific parameter. It is easy to see that the additional term is highly correlated to the third term on the right-hand side of the same equation. In order to avoid singularity, an additional restriction (additional to equation (3.2)) has to be imposed:

$$\sum_{j=1}^{4}\zeta_j\bar{v}_j = 0 \quad \forall j = 1,..,4 \qquad (3.21)$$

[2] Note that the term $\sum_{k=1}^{8}\hat{\gamma}_{ik}z_{kh.}$ should have been the summation over k=1,..,6 only. The regional dummies z_7 and z_8 are time-invariant. Therefore, the deviations of these from the average over time per farm $(z_{kht} - z_{kh.})$ are zero and γ_{i7} and γ_{i8} cannot be estimated. However, we have failed to recognise this complication until recently. Moreover, due to errors in the data (for 13 farms the region changed during their presence in the panel) the deviations from the mean were not always zero. As a consequence parameters γ_{i7} and γ_{i8} have been estimated. Hausman and Taylor (1981) show how the coefficients of the time-invariant variables can be estimated.

This restriction should not contradict the assumptions for a normal milk supply function, i.e. ζ_2, ζ_3, ζ_4 and $\rho < 0$. As a result of including the extra term, there appear extra terms on the right-hand side of equations (3.15) and (3.16) as well:

$$q_{iht} = \alpha_{ih} + w^{-1}\sum_{j=1}^{4}\alpha_{ij}v_{jt} - \frac{1}{2}\theta_i w^{-2}\sum_{l=1}^{4}\sum_{j=1}^{4}\alpha_{lj}v_{lt}v_{jt} + \zeta_i q_{0ht} + \sum_{k=1}^{8}\gamma_{ik}z_{kht} + \frac{1}{2}\theta_i \rho q_{0ht}q_{0ht} + \theta_i\varepsilon_h q_{0ht} + \theta_i\sum_{k=1}^{8}\mu_k z_{kht}q_{0ht} + \frac{1}{2}\theta_i\sum_{k=1}^{5}\sum_{n=1}^{5}\beta_{kn}z_{kht}z_{nht} + \theta_i\sum_{k=1}^{5}\sum_{n=6}^{8}\beta_{kn}z_{kht}z_{nht} \tag{3.22}$$

$$q_{0ht} = -\frac{1}{\rho}\left[w^{-1}\left(\sum_{i=1}^{4}\zeta_i v_{it} + v_{0t}\right) + \varepsilon_h + \sum_{k=1}^{8}\mu_k z_{kht}\right] \tag{3.23}$$

The farm-specific effects ε_h do not leave equation (3.22) when the fixed effects model is transformed to be estimated (subtracting the average over time per farm from each observation). However, direct estimation of ε_h is avoided when the definition of ε_h is used, which follows from rewriting equation (3.23), and using the averages over time per farm (denoted by bars):

$$\varepsilon_h = -\left[\frac{\sum_{i=1}^{4}\zeta_i\bar{v}_{i.} + \bar{v}_{0.}}{\sum_{l=1}^{4}\theta_l\bar{v}_{l.}} + \rho\bar{q}_{0h.} + \sum_{k=1}^{8}\mu_k\bar{z}_{kh.}\right] \tag{3.24}$$

For estimation, this definition is included in equation (3.22), instead of ε_h. Because both s_{0ht} and ε_h are unknown in the post-quota period, ε is estimated as a parameter which is equal across farms in the post-quota period. Thus, ε_h is only relevant in the pre-quota period.

3.5.2 Weighted estimation

The data used in this study are selected from a stratified sample of farms. For each farm in each year a weight factor is given, denoting the number of farms in the population which are represented by the farm in the sample. The purpose of stratifying is to increase the reliability of the sample results. The reliability will only increase if there is a high correlation between the variables under research and the variables on which the stratification is based. Thus, the classification into strata may affect the level of the research variables. As a result, the important assumption that, given the explanatory variables, the expected error term will be zero, is not valid anymore. Therefore, the method of estimation may need a modification which accounts for the weight factors (Elhorst, 1988). The stratification of the LEI-DLO data used in this study is mainly based on farm type (eight classes) and farm size (four classes). The resulting strata are further stratified by the number of hectares, age of the farmer and region (Dijk, 1990).

Elhorst (1988) proposes a test to determine if there is a significant difference between the ordinary estimation method and the weighted estimation. The model $\mathbf{y} = \mathbf{Xb} + \mathbf{u}$ is taken as the null hypothesis, while the alternative model is $\mathbf{y} = \mathbf{Xb} + \mathbf{w}'\mathbf{Xc} + \mathbf{u}$, where $\mathbf{b}$ and $\mathbf{c}$ are vectors of parameters, $\mathbf{X}$ is the matrix of explanatory variables, $\mathbf{y}$ is the vector of explained variables, $\mathbf{w}$ is the vector of weight factors and $\mathbf{u}$ is the vector of error terms, with a zero expected value. Thus, the alternative model has twice as many parameters than the original model. Now, an F-test on $\mathbf{c}$=0 with an $F_{(K,N-2K)}$ distribution is performed. However, this method cannot be applied to our system of simultaneous equations, because the model becomes highly singular. Therefore, we only compare the unweighted and weighted estimation of the model, without testing.

The estimation of our central model does not account for the weights, because weighting only becomes important when we would like to say something about the average farm or the total sector, but not when estimating individual behaviour. Moreover, it is questionable if the variables on which the stratification is based are highly correlated with the variables in the model.

3.6 Results

In this section the estimation results, elasticities and shadow prices of the SNQ model are being discussed. Results for the alternative estimation procedures are also given. Differences between the results of the NQ and SNQ model are only mentioned if they are notable. The estimation results are reported in Table 3.2.

Table 3.2: Estimation results.

Parameter	NQ		SNQ		Parameter	NQ		SNQ	
	Estimate	t-ratio	Estimate	t-ratio		Estimate	t-ratio	Estimate	t-ratio
ε	-0.429	-17.85	-	-	γ_{43}	-	-	0.014	0.78
β_1	-3.0E-4	-0.14	-	-	γ_{44}	-	-	0.191	4.53
β_2	-0.152	-0.54	-	-	γ_{45}	-	-	-2.332	-2.69
β_3	0.047	2.11	-	-	γ_{46}	-	-	-4.926	-0.51
β_4	0.438	9.09	-	-	γ_{47}	-	-	1.662	0.14
β_5	-4.881	-4.62	-	-	γ_{48}	-	-	1.180	0.08
β_6	55.818	4.66	-	-	ρ	-0.005	-18.13	-0.009	-11.17
β_7	5.945	0.44	-	-	μ_1	2.7E-5	7.27	5.4E-5	6.70
β_8	0.218	0.01	-	-	μ_2	0.010	15.33	0.020	10.72
α_{11}	17.284	5.22	18.163	5.69	μ_3	0.001	16.13	0.003	10.61
α_{12}	7.340	3.67	2.382	1.24	μ_4	0.002	15.24	0.004	10.17
α_{13}	-0.097	-0.13	-1.662	-3.08	μ_5	0.003	2.03	0.007	2.22
α_{22}	11.393	4.87	2.619	1.32	μ_6	0.222	8.13	0.102	1.08
α_{23}	-0.450	-1.83	-0.453	-2.39	μ_7	0.024	2.39	0.038	2.00
α_{33}	1.308	2.14	1.752	3.96	μ_8	-0.069	-5.83	-0.108	-4.63
ζ_1	-0.101	-8.63	-0.247	-16.58	β_{11}	8.0E-7	1.85	5.2E-7	0.45
ζ_2	-0.493	-48.87	-0.678	-48.65	β_{12}	3.3E-6	0.08	2.3E-5	0.22
ζ_3	-0.026	-28.77	-0.035	-35.47	β_{13}	-4.9E-6	-1.49	-8.4E-6	-0.98
ζ_4	-	-	-0.179	-11.98	β_{14}	-6.2E-5	-8.54	-1.2E-4	-6.07
γ_{11}	0.003	7.11	0.004	2.20	β_{15}	0.001	3.59	0.001	2.07
γ_{12}	1.189	17.99	1.405	5.58	β_{16}	-0.005	-4.64	-0.005	-1.62
γ_{13}	0.033	8.31	0.059	3.07	β_{17}	-3.0E-4	-0.21	-0.001	-0.21
γ_{14}	0.085	8.59	0.292	6.75	β_{18}	-0.001	-0.85	-0.001	-0.20
γ_{15}	1.081	6.48	-0.976	-1.10	β_{22}	-0.044	-7.02	-0.085	-5.27
γ_{16}	-4.714	-5.44	-7.595	-0.77	β_{23}	-0.002	-3.83	-0.004	-2.99
γ_{17}	-1.420	-0.22	-0.972	-0.07	β_{24}	-0.002	-3.14	-0.006	-2.69
γ_{18}	-11.448	-1.58	-15.583	-0.97	β_{25}	-0.046	-2.50	-0.089	-1.85
γ_{21}	3.3E-4	0.92	0.002	0.97	β_{26}	0.031	0.18	1.277	2.59
γ_{22}	1.488	26.16	1.775	6.89	β_{27}	0.144	0.63	0.098	0.16
γ_{23}	-0.033	-9.81	-0.001	-0.04	β_{28}	0.307	1.00	0.045	0.06
γ_{24}	0.046	5.43	0.276	6.18	β_{33}	-3.4E-4	-7.42	-0.001	-5.75
γ_{25}	1.483	10.21	-0.785	-0.86	β_{34}	-0.001	-11.33	-0.002	-7.16
γ_{26}	-5.531	-7.40	-9.075	-0.88	β_{35}	0.006	3.41	0.007	1.57
γ_{27}	-2.517	-0.45	-1.730	-0.14	β_{36}	-0.108	-7.63	-0.102	-2.42
γ_{28}	2.769	0.45	-1.632	-0.10	β_{37}	-0.059	-4.20	-0.073	-1.97
γ_{31}	3.9E-5	1.22	1.3E-4	0.96	β_{38}	-0.011	-0.77	-0.021	-0.52
γ_{32}	0.023	4.49	0.035	2.10	β_{44}	-0.001	-6.39	-0.002	-5.14
γ_{33}	0.001	1.89	0.002	1.71	β_{45}	-0.012	-3.80	-0.004	-0.44
γ_{34}	0.003	4.00	0.017	5.70	β_{46}	-0.120	-5.25	-0.171	-2.69
γ_{35}	0.102	7.82	-0.046	-0.77	β_{47}	0.015	0.48	0.072	0.84
γ_{36}	-0.328	-4.92	-0.510	-0.76	β_{48}	0.120	3.06	0.265	2.56
γ_{37}	0.276	0.56	0.294	0.35	β_{55}	0.533	5.13	0.246	0.93
γ_{38}	0.254	0.47	-0.004	-0.00	β_{56}	-4.205	-4.26	1.385	0.55
γ_{41}	-	-	4.6E-4	0.24	β_{57}	-0.479	-0.94	-0.254	-0.19
γ_{42}	-	-	-0.860	-3.53	β_{58}	-0.919	-1.59	-1.221	-0.79
Observations	9 365								
Farms	1 961								
Period	1973/74-1992/93								

The t-ratios indicate that 49 per cent of the parameters in the SNQ model and 67 per cent of the parameters in the NQ model are significantly different from zero at the 5 per cent level. The Hessian matrix of prices is positive semi-definite, which is a necessary condition for farmers to be profit maximisers. Most parameter estimates related to regional dummies are not significant. Therefore, an F-test is used to test $H_0: \gamma_{i7}=\gamma_{i8}=\mu_7=\mu_8=\beta_{k7}=\beta_{k8}=0$ (i=1,..,4; k=1,..,5) against the alternative that at least one of these parameters is not equal to zero. The null hypothesis is rejected ($F_{(20,34662;\alpha=0.05)}=1.57<25.00$)[3]. Furthermore, the fixed effect model is tested on the assumption that all farms have the same intercepts in the netput equations; H_0: $\alpha_{ih}=\alpha_{if}$ for all h,f=1,..,H (i=1,..,4) against the alternative that at least one of the farms has a different intercept (note, that this is a rather broad way of testing). For each netput equation q_i and for the whole estimated system the null hypothesis is rejected ($F_{(1960,7384;\alpha=0.05)}=1<31.30$; 16.49; 19.02; 32.42 and $F_{(7840,34662;\alpha=0.05)}=1<9.18$)[4].

Table 3.3 presents the simulated conditional and unconditional elasticities for 1992/93. The elasticities are calculated for each farm in 1992/93 and their weighted average is presented here. The conditional elasticity (conditional on the quantity of milk supply) can be referred to as a short-term elasticity, whereas the unconditional elasticity is a kind of intermediate-term elasticity because milk supply is variable but the quasi-fixed inputs are still taken as given. The Le Chatelier-Samuelson principle is satisfied since, in absolute terms, the unconditional own price elasticity is larger than the conditional elasticity.

The first column of Table 3.3 gives the elasticities of milk supply. Because milk supply is subject to quotas, the elasticity of milk supply with respect to the market price of milk has no practical meaning (the elasticity conditional on the quantity of milk does not exist). Therefore, the elasticities of milk supply are calculated using the marginal costs of milk. Increasing netput prices result in decreased milk supply. Milk supply is increased by increasing the quantity of quasi-fixed inputs. Milk supply is inelastic.

[3] The number of restrictions is 20. The degrees of freedom are (N*G)+M-K-(H*G), where N is the total number of observations, G is the number of equations in which fixed effects are included, M is the number of observations in the pre-quota period, K is the number of parameters and H is the number of farms. Thus, the degrees of freedom equal (9365*4)+5127-81-(1961*4)=34662.

[4] The number of restrictions is 1960 for each netput equation and 4*1960=7840 for the whole system. The degrees of freedom are $N-K_i-H$=9365-19.67-1961=7384.33 for each netput equation and 34662 for the whole system.

Table 3.3: Conditional and unconditional price and quantity elasticities simulated for 1992/93 (weighted calculated mean) for NQ and SNQ.

		Milk	Other output		Purchased feed		Dairy cattle		Other input	
		U[a]	C[b]	U	C	U	C	U	C	U
With respect to prices:										
Milk	NQ	0.43	-	-0.12	-	0.71	-	0.66	-	0.09
	SNQ	0.26	-	-0.08	-	0.47	-	0.40	-	0.03
Other output	NQ	-0.08	0.20	0.22	-0.10	-0.24	0.02	-0.11	0.26	0.24
	SNQ	-0.04	0.26	0.27	-0.06	-0.13	0.44	0.38	0.28	0.27
Purchased feed	NQ	-0.32	0.07	0.16	-0.12	-0.64	0.08	-0.41	0.14	0.07
	SNQ	-0.20	0.04	0.10	-0.04	-0.41	0.10	-0.21	0.06	0.04
Dairy cattle	NQ	-0.02	-0.00	0.01	0.01	-0.03	-0.32	-0.36	0.01	0.01
	SNQ	-0.01	-0.02	-0.02	0.01	-0.02	-0.50	-0.52	-0.00	-0.00
Other input	NQ	-0.01	-0.26	-0.26	0.21	0.20	0.22	0.21	-0.40	-0.40
	SNQ	-0.00	-0.28	-0.28	0.09	0.09	-0.05	-0.06	-0.33	-0.33
With respect to quantities:										
Milk output	NQ	-	-0.29	-	1.65	-	1.53	-	0.22	-
	SNQ	-	-0.30	-	1.80	-	1.53	-	0.12	-
Labour	NQ	0.10	0.14	0.12	-0.02	0.14	-0.04	0.11	-0.05	-0.03
	SNQ	0.11	0.21	0.18	-0.11	0.08	-0.13	0.03	-0.03	-0.01
Land	NQ	0.29	0.46	0.37	-0.67	-0.20	-0.18	0.26	0.34	0.41
	SNQ	0.31	0.48	0.39	-0.75	-0.19	-0.21	0.26	0.41	0.44
Buildings	NQ	0.32	0.10	0.01	0.12	0.64	-0.03	0.45	0.01	0.08
	SNQ	0.31	0.11	0.02	0.08	0.65	-0.05	0.43	0.02	0.06
Machinery	NQ	0.44	0.21	0.08	-0.13	0.59	-0.15	0.52	0.36	0.46
	SNQ	0.43	0.10	-0.03	-0.05	0.73	0.02	0.68	0.14	0.19
Technology[c]	NQ	0.06	0.27	0.25	-0.43	-0.34	-0.51	-0.43	-0.47	-0.46
	SNQ	0.07	0.48	0.46	-0.67	-0.55	-0.79	-0.68	-0.15	-0.14

[a] Unconditional elasticity: milk supply is variable, although there are still quasi-fixed inputs. [b] Conditional elasticity: milk supply is fixed. [c] Annual percentage change in supply and demand due to technological change.

Looking at the conditional elasticities, milk and other output are substitutes at the farm level; also variable inputs are mainly substitutes, except for dairy cattle and other input in the SNQ model. Dairy cattle and purchased feed become complements if milk supply is variable. The elastic demand for purchased feed and dairy cattle with respect to the quantity of milk already indicates this reaction. Labour, land and machinery are substitutes for purchased feed input, indicating that the dairy farmer has a choice between buying feed or growing it on the farm. Labour and machinery become complements for purchased feed when the farmer has the possibility to adjust his level of milk supply (unconditional elasticities). For given milk quota, quasi-fixed inputs, except machinery in the SNQ model, are substitutes for dairy cattle, and they become complements when quotas can be reallocated. Land, buildings and machinery are complements for the composite category of other variable inputs; labour is a substitute. The elasticities with respect to the trend (last row of Table 3.3) indicate an annual technological efficiency progress.

For the farms in 1992/93, the estimates are used to simulate input demand, output supply, profits and shadow prices. The results of this base simulation are shown in Table 3.1. The simulated values for the input supply, output demand and profits are very similar to the data. The NQ model performs better than the SNQ model. Calculated shadow prices are given in Table 3.4. The quasi-fixed inputs are at their long-run equilibrium level if the shadow price equals the actual rental price (Segerson and Squires, 1993). The shadow price of labour is low compared to hourly earnings of hired farm labour, which was 27.40 guilders in 1992 (LEI-DLO and CBS, 1994). This well-known result in agriculture indicates either, that agricultural labour is satisfied with lower wages because they are attached to the farm, or official off-farm wages are higher than real off-farm earnings for farm labour (Elhorst, 1996). The average shadow price of agricultural land resembles the actual free rental price of 1700 guilders per hectare (Huntjens, 1996). The average calculated shadow price of milk quota is 39 cents per kilogram. The average lease price of quota in 1992/93 was 40 cents per kilogram of milk with an average of 4.4 per cent fat (LEI-DLO and CBS, 1994). So, for milk with 3.7 per cent fat (which is the standard in our model), the actual lease price was 34 cents per kilogram. The difference indicates an incentive to invest in quota.

The shadow prices of the quasi-fixed inputs are positively related to the quota level (μ_k>0, k=1,..,4), so a more restrictive quota regime lowers the profitability of additional units of quasi-fixed inputs. The estimates μ_k imply that larger amounts of quasi-fixed inputs on the farm result in higher shadow prices of quota. Moreover, the shadow price of quota is higher (μ_7) for farms on northern clay and lower (μ_8) for farms on western pastures, compared to farms on sandy soils with equal endowments of quasi-fixed inputs. Therefore, this model indicates a tendency to redistribute quotas from western pastures to northern clay and peat. Parameter estimates for β_{kn} (k,n=1,..,4), except β_{11} and β_{12}, indicate that larger amounts of labour, land, buildings or machinery result in lower shadow prices for any of these quasi-fixed inputs.

Table 3.4: Average[a] shadow prices in 1992/93 for milk quotas and quasi-fixed inputs (1992/93 guilders) for NQ and SNQ.

Variables	Dimension		Total sector	Sandy soils	Northern clay	Western pastures
Milk quotas	Kilogram	NQ	0.374	0.387	0.390	0.325
		SNQ	0.393	0.410	0.420	0.323
Labour	Hour	NQ	4.717	4.946	4.815	4.065
		SNQ	7.676	7.681	7.301	8.090
Land	Hectare	NQ	1 553	1 449	1 554	1 798
		SNQ	1 629	1 619	1 609	1 675
Buildings	Invested guilder of 1980/81	NQ	0.015	0.027	-0.020	0.025
		SNQ	0.036	0.049	0.001	0.045
Machinery	Invested guilder of 1980/81	NQ	0.009	-0.033	0.004	0.116
		SNQ	0.086	-0.000	0.087	0.288
Technology	Annual increase in profits	NQ	4 455	4 835	4 145	3 900
		SNQ	4 716	5 085	4 713	3 842

[a]Weighted calculated mean.

3.6.1 Fixed effects in the milk supply equation

The estimation results of the model including fixed effects in the milk supply equation are shown in Appendix 3.C. The t-ratios indicate that 48 per cent of the parameters are significantly different from zero. The parameter estimates for α_{ij}, ρ and μ_k (k=1,..,5) are of the same magnitude and sign as in the central SNQ model. The estimates for μ_6, μ_8 and most of the estimates for β_{nk} and γ_{ik} related to k=6 and k=8 switched signs. As a result of the restriction in equation (3.21) the estimate for ζ_1 has a positive sign, indicating that other output and milk have become complements. The estimates for ζ_2, ζ_3, ζ_4 and ρ correspond to the assumption for a normal milk supply function, i.e. they are smaller than zero. The estimate for the intercept of the milk supply equation ε, which is equal for all farms and valid for the post-quota period, is significant and matches the estimate in the NQ model (which is valid for the total sample period).

3.6.2 Weighted estimation

The results of the weighted estimation of the SNQ model are also shown in Appendix 3.C. The number of significant parameters is 43 per cent, which is less than in the other models. Only 6 of the parameter estimates have an other sign than in the central SNQ model. The magnitude of most of the estimates is the same.

3.7 Discussion and conclusions

In this chapter, a theoretical framework and an empirical micro-model for quota constrained dairy farming are developed. The model is applicable to simulate short-run effects of alternative dairy policies, see chapter 4 for an example. Elhorst (1996) indicated that, while building an empirical model, a lot of practically-based decisions are made, which are not always clearly described and argued by the researcher. Although, for the purpose of many articles, it is not necessary and even diverting to describe all those decisions, some of the consideration behind the model in this study are discussed here, as far as they have not yet been discussed in earlier sections. In the following we discuss the functional form, using weights, the research population, and fixed effects.

The empirical model consists of a system of simultaneous equations, which accounts for a regime switch through a difference in the number of observations across equations. Since estimating such a model, using an unbalanced panel data set, is complicated, the structure of the model is kept as simple as possible (keeping in mind also the applicability for policy simulations). Therefore, the NQ would have been preferred to the SNQ as a functional form. However, the NQ is not invariant with the numeraire and resulted in one-sided simulation effects, that is all variability is absorbed by the variable used as the numeraire.

The data used are selected from a stratified sample of farms, which gives an opportunity to obtain weighted estimators. However, the test which Elhorst (1988) suggests to determine the difference between weighted and unweighted estimation could not be applied to our model. Further research is needed in this respect. Therefore, the estimation of our central model does not account for the weights. Weight factors are only used in this thesis to present averages and totals and in the simulations. Estimation results of the weighted estimation are similar to the results of the unweighted estimation.

For the purpose of developing a model for simulating dairy policy, it is necessary to distinguish specialised dairy farms. In order to get as many observations as possible, the criteria used is 50 per cent of total returns coming from milk. As a consequence, a small part of total milk production (ca. 5 per cent in 1992/93) is not covered by the model. Furthermore, observations are lost due to the fixed effect transformation and substitution between milk and other specific agricultural products, cannot be handled by this model.

The available panel data set makes it possible to use fixed effects or random effects estimators. In this study the fixed effects model is used, because Thijssen (1992) showed that the random effects estimators are not consistent since individual effects and the regressors are not independent. Moreover, as argued before, the model is mainly used to make inferences about the behaviour of individual farms in the sample. In that case, fixed effects are more appropriate (Elhorst, 1996). A more complicated system, i.e. including additional fixed effects in the milk supply equation for the pre-quota period, was also estimated. However, given that the model will be used for simulating behaviour in the post-quota period (the most recent year, 1992/93, will be taken as the base year), they are relatively unimportant. Furthermore, the necessary restriction (equation (3.21)) forced milk and other output supply to become complements, which is counter-intuitive.

The central model presented in this chapter is a flexible tool to show short-term behaviour of individual Dutch dairy farms. The chapter showed some of the considerations a researcher has to make in constructing such a model. It is shown in next chapters that the model enables to simulate alternative policies, especially those dealing with tradability of quotas.

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Chapter 4 EFFICIENCY LOSS DUE TO DISTORTIONS IN DUTCH MILK QUOTA TRADE[1]

4.1 Introduction and background

In 1984 quotas on milk supply were introduced in response to overproduction and budgetary problems of the EU. In the Netherlands, milk production was effectively restricted to farm level quota by a prohibitive levy on surplus production. In order to decrease the rigidity on production structure, imposed by the quota system, exchange of milk quotas was allowed for. Initially quota exchange was limited to the exchange of ownership rights, but since 1989, farmers are also allowed to exchange user rights through leasing.

The exchange of quota ownership and user rights is subject to restrictions (Krijger, 1991). Milk quotas are tied to land, and a buyer of ownership rights is required to buy land or rent land for the period of at least one year. Moreover, a maximum of twenty thousand kilograms per hectare applies in the exchange of ownership rights. Suppliers of user rights are not allowed to lease-out less than ten thousand kilograms of milk; demanders may not lease more than 75 thousand kilograms. Exchange of both ownership and user rights incurs additional costs related to arranging and preparing the contract, for example costs for transaction services by an estate agent or notary. De Groot (1995) calculated the notary and estate agent costs as approximately two per cent of the milk quota price. Distortions like these result in efficiency losses for the dairy sector.

Modelling milk quota and quota mobility has received considerable attention in the agricultural economics literature. Moschini (1988) and Helming, Oskam and Thijssen (1993) provided a framework for modelling quotas while others (Burrell, 1989; Cox, 1987) focused on the efficiency gains of free tradability of quotas or analysed milk quota mobility in different countries (Oskam and Speijers, 1992). For the case of tobacco in the U.S., the distribution of economic rents between owners and renters of marketable production quotas is analysed by Babcock and Foster (1992). More recent literature deals

[1] This chapter has been published as: Boots, M., A. Oude Lansink and J. Peerlings (1997). Efficiency loss due to distortions in Dutch milk quota trade. *European Review of Agricultural Economics* 24: 31-46.

with the welfare effects of transfer restrictions. Rucker, Thurman and Sumner (1995) determine the impact of geographical trade restrictions using county level data, whereas Guyomard, Herard and Mahé (1995) model a tax on milk quota exchanges (siphon), using a cross-section of French dairy farms.

The contribution of this chapter is that it explicitly quantifies the costs of quantity restrictions and transfer costs in dairy quota exchange, for dairy farms in different regions in the Netherlands. The relevance of these results for policy makers is that these costs should outweigh the policy gains (e.g. protecting small farmers).

This chapter calculates the welfare costs of the existing quota trade distortions, using a simulation model that consists of equations estimated on panel data of specialised Dutch dairy farms. In the model there are two outputs: milk and other outputs; three variable inputs: purchased feed input, dairy cattle and other inputs; four fixed inputs: labour, land, buildings and machinery. All farms are allowed to have a different technology through farm specific and regional dummies. The next section elaborates on the econometric model, which is followed by a description of the data and a discussion of estimation results. The results of the estimation are used in a simulation model that calculates the short-term effects of the trade distortions for the farms in the panel. Simulation results are aggregated for farms in different regions and for the sector as a whole. The static model used does not enable us to distinguish explicitly between the exchange of ownership and user rights. Therefore the simplifying assumption is made that only the exchange in user rights takes place. Since the markets for user and ownership rights are closely related (Hubbard, 1992) this assumption is not very restrictive, given the purpose of this research. Simulations and simulation results are presented subsequently, followed by a summary and concluding comments.

4.2 Econometric model

In order to analyse the welfare effects of distortions in a system of tradable milk quotas, a model of output supply and input demand for dairy farmers is developed. It is assumed that the farmers' objective is the maximisation of short-run profit and that the farmer is a price-taker in all input and output markets. In the short run, volumes of fixed inputs and the state of technology are assumed to be fixed. The system of input demand and output supply is derived from a symmetric normalised quadratic (SNQ) restricted profit function. The SNQ was used because it allows for checking convexity in prices globally (a Hessian of constants) and because netputs are treated symmetrically (Kohli, 1993; Oude Lansink and Thijssen, 1998). Restricted profit is defined as the value of unconstrained outputs minus the value of inputs (Moschini, 1988). It is assumed that each farmer has access to the same production technology; farm-specific features (e.g. the quality of land and management) are modelled using fixed effects.

In the model, five netput quantities q_i (positive for outputs, negative for inputs) are distinguished with i=0 (milk output), 1 (other output), 2 (purchased feed input), 3 (dairy cattle) and 4 (other variable inputs). Netput price indices are $v_0,..,v_4$. Fixed inputs are z_k (k: 1=labour, 2=land, 3=buildings and 4=machinery). Furthermore, the model includes a trend z_5 representing technology and a dummy z_6 allowing for a change in technology due to the introduction of milk quota in 1984. Finally, dummies z_7 and z_8 are included to distinguish between three regions in which farms operate; sandy soils (z_7=z_8=0), northern clay and peat (z_7=1, z_8=0), and western pastures (z_7=0, z_8=1).

For each farm h and year t, the SNQ restricted profit function is written as:

$$\begin{aligned} g_{ht}(v_{it}, q_{0ht}, z_{kht}) = {} & \sum_{i=1}^{4} \alpha_{ih} v_{it} + \frac{1}{2} w^{-1} \sum_{i=1}^{4} \sum_{j=1}^{4} \alpha_{ij} v_{it} v_{jt} + \sum_{i=1}^{4} \zeta_i v_{it} q_{0ht} + \sum_{i=1}^{4} \sum_{k=1}^{8} \gamma_{ik} v_{it} z_{kht} + \\ & \frac{1}{2} w \rho q_{0ht} q_{0ht} + w \sum_{k=1}^{8} \mu_k z_{kht} q_{0ht} + \frac{1}{2} w \sum_{k=1}^{5} \sum_{n=1}^{5} \beta_{kn} z_{kht} z_{nht} + \\ & w \sum_{k=1}^{5} \sum_{n=6}^{8} \beta_{kn} z_{kht} z_{nht} \end{aligned} \tag{4.1}$$

The last term in the restricted profit function indicates that the cross-products of the dummies are not taken into account. α_{ih} denote farm h specific parameters. Symmetry is maintained by requiring α_{ij}=α_{ji} and β_{kn}=β_{nk}. The profit function is linearly homogeneous in prices because of the term $w = \sum_{l=1}^{4} \theta_l v_{lt}$, where θ_l are non-negative constants. In this study θ_l is the average share of netput l in total costs plus revenue, so they sum up to unity. They can be interpreted as fixed weights for the price index w. In order to identify all parameters, additional restrictions have to be imposed on the profit function:

$$\sum_{j=1}^{4} \alpha_{ij} \bar{v}_j = 0 \qquad \forall i = 1,..,4 \tag{4.2}$$

where $\bar{v}_j$ is an arbitrary point of observation. In this study $\bar{v}_j$ equals the sample mean of price j.

Using Hotelling's lemma, the supply functions for other output and demand functions for feed, dairy cattle and other variable input are given by:

$$q_{iht} = \alpha_{ih} + w^{-1}\sum_{j=1}^{4}\alpha_{ij}v_{jt} - \frac{1}{2}\theta_i w^{-2}\sum_{l=1}^{4}\sum_{j=1}^{4}\alpha_{lj}v_{lt}v_{jt} + \zeta_i q_{0ht} + \sum_{k=1}^{8}\gamma_{ik}z_{kht} + \frac{1}{2}\theta_i \rho q_{0ht}q_{0ht} + \theta_i\sum_{k=1}^{8}\mu_k z_{kht}q_{0ht} + \frac{1}{2}\theta_i\sum_{k=1}^{5}\sum_{n=1}^{5}\beta_{kn}z_{kht}z_{nht} + \theta_i\sum_{k=1}^{5}\sum_{n=6}^{8}\beta_{kn}z_{kht}z_{nht} \tag{4.3}$$

All netput equations have a farm-specific intercept. The model is completed by the milk supply function, which is only valid in the pre-quota period. The milk supply function does not include a farm-specific intercept, since consistent extimation requires the farm-specific effects to appear as slope coefficients in the netput equations. If included, these farm-specific effects would not disappear when the fixed effects model is transformed for estimation.

$$q_{0ht} = -\frac{1}{\rho}\left[w^{-1}\left(\sum_{i=1}^{4}\zeta_i v_{it} + v_{0t}\right) + \sum_{k=1}^{8}\mu_k z_{kht}\right] \tag{4.4}$$

After the introduction of the quota system, milk supply is exogenous and the milk supply equation does not apply. The marginal costs of milk supply, that is, the price that would have given rise to production at the quota level, is given by:

$$s_{0ht} = -\left[\sum_{i=1}^{4}\zeta_i v_{it} + w\left(\rho q_{0ht} + \sum_{k=1}^{8}\mu_k z_{kht}\right)\right] \tag{4.5}$$

Furthermore, the shadow price of milk quota r_{ht} is v_{0t}-s_{0ht}. The shadow prices of the fixed inputs are given by:

$$s_{kht} = \sum_{i=1}^{4}\gamma_{ik}v_{it} + w\left(\mu_k q_{0ht} + \sum_{n=1}^{8}\beta_{kn}z_{nht}\right) \tag{4.6}$$

4.3 Data and estimation

Data on specialised dairy farms[2], covering the period 1973/74-1992/93 are selected from a stratified sample of farms keeping accounts on behalf of the LEI-DLO farm accounting system. The data set used for estimation contains 9365 observations.

Two outputs, milk and other outputs, are distinguished. Other output is an aggregate of revenues from marketable crops, beef and veal, and other animals. The three variable inputs are purchased feed for (dairy) cattle, dairy cattle and other variable inputs. The latter consists of feed for animals other than dairy cattle, seeds, fertilisers, pesticides, contract work, veterinary services, fuel, energy and other cattle. Variable outputs and inputs are measured as revenues and costs. Fixed inputs are labour (hours), land (hectares), buildings (total invested capital at 1980/81 prices) and machinery (total invested capital at 1980/81 prices). Data on capital invested in buildings for tenant farms are incomplete (Elhorst, 1990 p.84). Therefore, simulated values for invested capital in tenant farmers' buildings are used. First, for owner-occupied farms, capital invested in buildings was regressed on costs of buildings and size of the farm. Second, predicted values for capital invested in buildings for tenant farms were determined and used in later stages of estimation. Other variables in the econometric model are a trend and regional dummies. The regions distinguished are sandy soils, northern clay and peat, and western pastures (see also van Dijk, Douma and van Vliet, 1995 p.16).

Tornqvist price indices were calculated for the compound variables (other outputs, feed input and other variable inputs). Implicit quantity indices were obtained as the ratio of value and the price index. The price indices vary over years but not over farms, implying that differences in the composition of a netput or quality differences are reflected in the quantity. Price and quantity indices for milk are standardised for a fat content of 3.7 per cent. Data on prices are obtained from LEI-DLO and CBS. The data for the average farm in 1992/93 are summarised in Appendix 4.A.

[2] Farms with more than 50 per cent of output coming from milk production.

The equations estimated are (4.3) and (4.4) with additional error terms, where the latter equation is only relevant for the pre-quota period. Every farm is assumed to have a different intercept reflecting differences in farm characteristics. This assumption is explicitly accounted for by a fixed effects model. The necessary transformation can also be applied to an incomplete panel like our data set, as long as a farm is present in the panel for at least two subsequent years (Thijssen, 1992). The farm-specific intercepts of the netput equations (α_{ih}) appear as slope coefficients in the profit function. In order to avoid direct estimation of the farm-specific intercepts[3], the profit function is left out of the estimated system.

The milk supply equation is included during estimation in the period before the quota introduction, causing a difference in the number of observations across equations. The covariance matrix of residuals used in estimating the system is corrected for the difference in the number of observations (Judge et al., 1988 p.462). In the pre-quota period, the quantity of milk can be related to the error term and an instrumental variable estimator must be applied. Endogenous variables are q_0, q_i (i=1,..,4), and all terms containing milk output (v_iq_0, q_0q_0, z_kq_0). All exogenous variables are used as instruments. Error terms may be correlated across equations. Therefore, non-linear 3SLS is an appropriate estimation technique (Judge et al., 1988 p.655).

The estimation results are reported in chapter 3, Table 3.2. At the 5 per cent significance level 49 per cent of the parameters is significantly different from zero. Most parameter estimates related to regional dummies are not significant. Therefore, an F-test[4] is used to test $H_0:\gamma_{i7}=\gamma_{i8}=\mu_7=\mu_8=\beta_{k7}=\beta_{k8}=0$ (i=1,..,4; k=1,..,5) against the alternative that at least one of these parameters is not equal to zero. The null hypothesis is rejected ($F_{(20,34662;a=0.05)} = 1.57 < 25$). The Hessian of prices is positive semi-definite, a necessary condition for farmers to be short-term profit maximisers.

The shadow prices of the fixed inputs are positively related to the quota level, so a more restrictive quota regime lowers the profitability of additional units of fixed inputs. The estimates μ_k imply that larger amounts of fixed inputs on the farm result in higher

[3] The farm-specific effects are calculated using the parameter estimates (denoted by hats) and the averages over time per farm (denoted by bars). It is assumed that the average of the remainder disturbance per farm, that is the part of the error term which is not farm-specific, is zero (Baltagi, 1995). See also equation (3.19) in chapter 3 and the related footnote.

[4] See also chapter 3.

shadow prices of quota. Moreover, the shadow price of quota is higher (μ_7) for farms on northern clay and lower (μ_8) for farms on western pastures, compared to farms on sandy soils with equal endowments of fixed inputs. Therefore, this model indicates a tendency to redistribute quotas from western pastures to northern clay and peat. Parameter estimates for β_{kn}, except β_{11} and β_{12}, indicate that larger amounts of labour, land, buildings or machinery result in lower shadow prices for any of these fixed inputs.

Shadow prices are given in chapter 3, Table 3.4. The shadow price of labour is low compared to hourly earnings of hired farm labour, which was 27.40 guilders in 1992 (LEI-DLO and CBS, 1994). The average shadow price of agricultural land (1629 guilders per hectare in 1992/93) resembles the actual rent of 1700 guilders per hectare (Huntjens, 1996). The value of agricultural land is higher in the western part of the Netherlands. It is probably the result of the relatively high pressure of alternative use of land in this part of the country.

Price and quantity elasticities for 1992/93 are shown in chapter 3, Table 3.3. The first column of the table gives the elasticities of milk supply in 1992/93. Because milk supply is subject to quotas the elasticity of milk supply with respect to the market price of milk has no practical meaning (the elasticity conditional on the quantity of milk does not exist). Therefore, the elasticities of milk supply are calculated using the marginal costs of milk. Increasing netput prices result in decreased milk supply. Milk supply is increased by increasing the quantity of fixed inputs. Looking at the conditional elasticities (conditional on the quantity of milk supply), milk and other outputs are substitutes at the farm level; also variable inputs are mainly substitutes, except dairy cattle and other inputs. Labour, land and machinery are substitutes for purchased feed input, indicating that the dairy farmer has a choice between buying feed or growing it on the farm. The fixed inputs become complements for purchased feed when the farmer has the possibility to adjust his level of milk supply (unconditional elasticities). For given milk quota, fixed inputs, except machinery, are substitutes for dairy cattle, and they become complements when quotas can be reallocated. Land, buildings and machinery are complements for the composite category of other variable inputs; labour is a substitute. They are all complements for other variable inputs if quotas are tradable.

4.4 Policy simulations and results

The model developed in the previous section (equations (4.3), (4.4) and (4.5)) is used to determine the effects of distortions in the market for milk quotas. Three simulations are performed and results are compared with a base simulation. The simulations describe the potential direction (demand or supply) of quota trade among farms. It is assumed that quota price is market determined, so the quota market clears. Hence, the trade distortions are valued in terms of the market price of quota. The prices of other output and variable inputs, the amount of fixed inputs at the farm level and national milk quota are kept constant throughout all the simulations.

The effects are determined for individual farms in the sample in 1992/93, representing 27515 farms in the sector. These farms represent a total quota of 10590 millon kilograms, which is 95 per cent of the national quota in 1992. It shows that in our sample, larger farms are over-represented (Reinhard et al, 1995 p.37-38). More than fifty per cent (14517) of the farms is situated on sandy soils. There are 6888 farms (25 per cent) located in the northern clay and peat region and 6110 (22 per cent) on western pastures. The simulations are described below.

4.4.1 Base simulation

The base simulation represents the situation for dairy farms in 1992/93. Quota trade is not allowed for, so the allocation of quotas is fixed at the 1992/93 level. Since endowments of fixed inputs differ across farms, this gives rise to farm-specific shadow prices of milk quota (r_h). The direction of potential quota trade in subsequent simulations is determined by these shadow prices. The results of the base simulation for the average dairy farm in 1992/93 are shown in Appendix 4.A.

4.4.2 Unconstrained quota trade (I)

This simulation assumes that quotas can be traded freely in a competitive market. It implies that even marginal amounts of quotas will be transferred and every farm faces the same market price of quota.

If the price of quota is too low, demand would exceed supply; if it is too high, supply would exceed demand. The market price of quota is the price at which total excess demand for quota is zero. The market price is calculated using the Minos solver in GAMS (Brooke, Kendrick and Meeraus, 1988). Individual quota levels and netputs are adjusted to profit maximising levels. Profit, after quota trade, for the individual farm h is given by the value of the netputs minus the value of net traded quotas:

$$\pi_h = v_0 q_{0h}^T + \sum_{i=1}^{4} v_i q_{ih} - r^T (q_{0h}^T - q_{0h}^{base}) \tag{4.7}$$

Here, π_h are profits, q_{0h}^{base} is the level of milk quota on farm h in the base simulation, q_{0h}^T is the quota level on farm h after trade and r^T is the market price of quota which is equal and given across farms. Both quota sellers and quota buyers gain from quota trade. That is, they all end up with higher profits after trade (see also Cox, 1987).

4.4.3 Trade distortions: thresholds (II)

In this simulation, thresholds in quota trade are introduced. Quota supply of less than ten thousand kilograms is not allowed in this simulation. When a farmer's optimal supply turns out to be less than ten thousand kilograms, he is assumed to supply either zero or ten thousand kilograms, depending on which gives him higher profits. Further, a maximum quota demand of 75 thousand kilogram is imposed. These thresholds coincide with the current regulations for quota lease in the Netherlands.

Again, the optimal market price for quotas is calculated as the price at which total excess demand for quotas is zero. Once the market price for quotas and the individual milk supply is known, equation (4.3) and (4.7) are used to determine demand and supply of netputs and profits. The efficiency loss due to thresholds is calculated as the difference in total profit compared to unrestricted quota trade (I).

4.4.4 Trade distortions: price margin (III)

The costs of a notary and estate agent cause a margin between the buyers' and sellers' price of milk quota. These additional costs are referred to as transfer costs[5] and they are expressed as a proportion of the sellers' price of quota. This proportion (t) is chosen to be 2 per cent. Thus, it is assumed that the buyers' price of quota (r_{dem}) is higher than the sellers'

[5] One might argue that this is a form of transactions costs.

price (r_{sup}), that is r_{dem}=(1+t)·r_{sup}. Using the relation r=v-s (we skip the subscript 0 here), the effect on the marginal costs of milk production can be written as s_{dem}=(1+t)·s_{sup}-t·v.

It is profitable for farmer h to demand quota when $s_{dem} > s_h$, which can be rewritten as $s_{sup} > (s_h + t \cdot v)/(1+t)$. Similarly, farmer h is a supplier of quotas if $s_{sup} < s_h$. When $s_h < s_{sup} < (s_h + t \cdot v)/(1+t)$ farmer h will remain at his initial quota level.

The value of s_{sup} (and using the relationship given above, also s_{dem}) is again calculated as the price at which the quota market clears. The price solutions (s_{sup} for a quota supplier and s_{dem} for a quota demander) are used to determine demand and supply of netputs, and profit. The difference between calculated total quota demand valued at the demanders' price and calculated total supply valued at the suppliers' price represents total transfer costs. Total efficiency loss is again the difference in total profit with simulation I.

4.4.5 Results

The effects of simulations I-III on the quota market are reported in Table 4.1. In Table 4.2 the results of the simulations are compared with the base simulation. Table 4.3 summarises the transfer costs and efficiency losses as a result of the simulated trade distortions compared to unconstrained trade.

From the unconstrained trade simulation (I) it becomes clear that the allocation of quotas in 1992/93 can still be improved upon, in spite of the earlier possibilities for farmers to trade quotas. For full efficiency, 1082 million kilograms of quota has to change hands (10.2 per cent of total national quota in the model). Each farmer will end up with higher profits and total profit increases by 9 per cent. The profit gain is higher for large farms (9.7 per cent) than for small farms[6] (8.1 per cent). The profit gain is highest for farms on northern clay. At the regional level, increasing the supply of milk and other output and decreasing the demand for variable inputs may go together. This is a result of aggregation; for individual farms this is not the case. The total profit increase is determined by an increasing supply of other outputs and decreasing demands of variable inputs. The optimal quota allocation comes about when the price of quota is 0.39 guilders per kg at 1992/93 prices. At the calculated price, all farmers in the sample participate in quota trade. There

[6] A particular farm is defined as large (small) if its milk production is higher (lower) than the average milk production in the base simulation. The results for large and small farms are not shown in the tables.

are 13263 (48.2 per cent) quota buyers and 14252 (51.8 per cent) quota suppliers, and none of the farmers leases out all their initial quota.

Table 4.1: Effects of unrestricted quota trade (I), thresholds in quota trade (II) and a price margin in quota trade (III) (percentage changes compared to base simulation).

		Sandy soils	Northern clay	Western pastures	Total sector
Milk output	I	1.45	1.98	-6.16	0
	II	1.64	-0.48	-3.27	0
	III	1.45	1.95	-6.11	0
Other outputs	I	6.02	11.00	7.73	7.52
	II	3.84	8.52	6.47	5.45
	III	6.02	11.01	7.71	7.52
Purchased feed	I	-6.01	-9.20	-18.25	-9.39
	II	-2.86	-10.32	-12.57	-6.81
	III	-6.01	-9.27	-18.17	-9.39
Dairy cattle	I	-7.98	-10.42	-17.56	-10.68
	II	-4.29	-10.30	-12.60	-7.75
	III	-7.97	-10.47	-17.49	-10.68
Other inputs	I	-6.56	-11.90	-7.16	-7.93
	II	-4.30	-8.73	-6.39	-5.75
	III	-6.56	-11.90	-7.16	-7.93
Profits	I	8.73	10.93	7.41	9.09
	II	5.93	7.92	6.29	6.60
	III	8.59	10.77	7.28	8.95

Including thresholds in the quota market (simulation II) has a substantial impact on the dairy sector. Profits increase by 6.6 per cent compared to the base simulation. However, as a result of the thresholds, the profit increase is higher for small farms (6.7 per cent) than for large farms (6.5 per cent). The amount of quota traded is 819 million kg (7.7 per cent of total quota in the model), at a price of 0.33 guilders per kg[7]. The number of quota demanders is 15732 (57.2 per cent), the number of suppliers is 11125 (40.4 per cent). In total, 658 farmers (2.4 per cent) do not participate in quota trade. Total efficiency losses

[7] The effects of including thresholds in quota trade fit the actual situation in the Netherlands. The average lease price of quota in 1992/93 was 0.40 guilders per kilogram, with an average of 4.4 per cent fat (LEI-DLO and CBS, 1994). So, for milk with 3.7 per cent fat, the lease price was 0.34 guilders. The total amount of transferred milk quota in 1992 was 927 million kg, which is 8.4 per cent of the total national quota.

are 2.29 per cent compared to unconstrained quota trade (see Table 4.2). By assumption, there are no transfer costs.

The effects of a price margin of two per cent (simulation III) are only slightly different when compared to unconstrained quota trade. Total profits after quota trade have increased by 8.9 per cent compared with the base run. The calculated suppliers' price of quota is 0.39 guilders per kg, the demanders' price is 0.40. Less quota is traded, a total of 1066 million kg is traded between 13106 (47.6 per cent) quota buyers and 14075 (51.2 per cent) quota suppliers. Because of the transfer costs, 334 farmers (1.2 per cent) will not operate on the quota market. Table 4.2 shows that 0.13 per cent of profits under unconstrained trade leaves the dairy sector as transfer costs. Total efficiency loss as a result of the two per cent price margin is 0.13 per cent.

Table 4.2: Transfer costs and efficiency losses as a result of thresholds (II) and a price margin (III) (percentage of profits under unrestricted quota trade (I)).

		Sandy soils	Northern clay	Western pastures	Total sector
Transfer costs	II	0	0	0	0
	III	0.14	0.15	0.09	0.13
Efficiency loss	II	2.57	2.71	1.05	2.29
	III	0.13	0.14	0.13	0.13

As the shadow prices have already indicated, farms on western pastures are net quota suppliers in the unconstrained trade simulation. Thus, quotas are reallocated to sandy soils and the northern clay and peat area. This is also the case when a price margin is included. However, the situation changes when thresholds on transactions are imposed. Farms on northern clay also become net quota suppliers and the whole quota flow is in the direction of the sandy soils. When milk production in a region is increased by quota buying, the shadow prices of all fixed inputs rise, and vice versa.

Table 4.3:Effects of unrestricted quota trade (I), thresholds in quota trade (II) and a price margin in quota trade (III).

		Sandy soils	Northern clay	Western pastures	Total sector
Quota demand					
(kilogram *1000)	I	550 923	375 879	156 037	1 082 840
	II	426 223	241 216	151 257	818 696
	III	541 984	370 989	152 817	1 065 790
Quota supply					
(kilogram *1000)	I	473 759	315 635	293 445	1 082 840
	II	338 794	255 645	224 257	818 696
	III	464 756	311 904	289 130	1 065 790
Value quota demand					
(1992/93 guilders *1000)	I	216 501	147 712	61 319	425 533
	II	140 847	79 711	49 983	270 541
	III	215 179	147 291	60 671	423 141
Value quota supply					
(1992/93 guilders *1000)	I	186 177	124 038	115 318	425 533
	II	111 956	84 479	74 106	270 541
	III	180 900	121 404	112 540	414 845

4.5 Summary and caveats

This chapter has examined regional and national effects of distortions in Dutch milk quota trade on profit and quota allocation. Simulations show that free tradability of milk quotas increases profit (value of netputs) by 9 per cent and reallocates quotas from farmers on western pastures to farmers on sandy soils and the northern clay and peat area. The shadow price of milk quota is 0.39 guilders. The effects on these results of a 2 per cent price margin, representing transfer costs, are small. However if threshold levels for quota trade are introduced, profit increase is substantially smaller (6.6 per cent) and farmers in the northern clay and peat area switch from being net buyers to net suppliers of milk quota. The calculated market price with thresholds is 0.33 guilders. The policy implication of these results is that welfare gains can be obtained if restrictions on milk quota trade are removed. In the situation of trade restrictions, small farms gain more from quota trade than large farms. However, all farms obtain additional profit when quota trade is unconstrained.

The potential profit increase with free tradability of milk quotas is still underestimated by our model. This is because only specialised dairy farms are represented in our sample, whereas farms that supply quota in the Netherlands are often small unspecialised farms leaving the sector (van Everdingen, 1993). A number of other caveats can be mentioned. First, it was assumed that quantities of land, labour, machinery and buildings are constant in the short term. This assumption is unlikely to hold if changes in milk quota at the farm level are large. Second, although the simulations identify farmers as potential quota demanders and suppliers, information about actual quota trade and lease for these farmers is not available, so the accurateness of the model predictions could not be checked at the individual level.

The strength of the model is that it provides valuable information about the welfare effects of milk quota trade restrictions and transfer costs. It also identifies farmers that incur relatively large losses due to trade restrictions and it determines potential interregional trade flows.

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Chapter 5 TWO-TIER PRICING AND AGENDA 2000

5.1 Introduction and background

It is widely acknowledged that dairy policy in the European Union (EU) should be revised. There are three reasons for policy reform. First, EU dairy policy should be compatible with the 1994 GATT (General Agreement on Tariffs and Trade) agreement and the EU may anticipate to the new WTO (World Trade Organisation) round after 2000 (Agra Europe, 1996). Under the 1994 GATT-agreement subsidised dairy exports have to be reduced by 21 per cent, export subsidies have to fall by 36 per cent, a minimal market access of 5 per cent has to be established and (fixed) import tariffs have to be reduced by 36 per cent for dairy products (e.g. Hassan, 1996). Second, the enlargement of the EU with Central- and East European countries (CEECs) somewhere after 2000 will put pressure on the export budget of the EU when those countries become net exporters of dairy products. Third, the current, rigid milk quota system is an obstacle for structural adjustments and productivity growth in the EU dairy sector. Support prices are too high in relation to both the level of production and the level of productivity.

Within the EU, alternative systems, which combine lower support prices and more flexibility for the farmer regarding the production level, are examined. The discussion focuses on how farm prices should be brought in line with world market levels, whether and how farmers should be compensated for price reductions, and to what extent quota levels should be adjusted (Agra Europe, 1996). A two-tier price system is one of the options (with advocates particularly in France). Similar to the sugar regime, in a two-tier milk price system, A-milk is produced at a supported milk price and farmers are allowed to produce extra B-milk at the lower world market price. The advantage of the two-tier system is that it would enable dairy farms in the EU to export without export subsidies, a prerequisite given the 1994 GATT-agreement, while maintaining a high level of support for dairy farmers. However, there are high monitoring and administration costs involved (Agra Europe, 1996). Moreover, it is questionable if the WTO would accept the two-tier price system because it could be considered as unfair competition. Price support to A-milk increases the overall (A- and B-milk) average revenue of milk production (cross-subsidisation), and therefore, in a two-tier system the production of B-milk is indirectly subsidised.

The European Commission's options for reform are reflected in the Agenda 2000 agreement. The agreement (see Agra Europe, 1999a) contains a 15 per cent cut in dairy, i.e. butter and skimmed milk powder, intervention prices over the period 2005/06-2007/08 in order to improve competitiveness of EU dairy farming. As a result, the possibilities to sell dairy products are broadened. Therefore, a 2.4 per cent increase in total EU milk quotas until 2007/08 is justified. Compensation for the price decrease is given on a flat rate basis per tonne of quota. The complex proposal to compensate by a 'virtual' dairy cow premium, based on an assumed average yield of 5,800 kg per cow (Agra Europe, 1998), has been discarded. It is questionable if the Agenda 2000 agreement meets the needs of the new trade round. The elimination of export subsidies is not ensured and compensatory payments are not completely production-neutral. Therefore, the Agenda 2000 agreement is not WTO-compatible. Moreover, the enlargement issues are not explicitly considered (Agra Europe, 1999b).

The purpose of this chapter is to analyse the effects for dairy farmers of i) a two-tier milk price system, ii) the Agenda 2000 reform regarding dairy, and iii) quota abolition. Dutch dairy farming is considered to be one of the most efficient within the EU. Therefore, the effects on production of the two-tier price system and the Agenda 2000 agreement for the Dutch dairy sector will give an indication of the possible effects on EU production. The effects are analysed using a micro-econometric simulation model of Dutch dairy farms and they are calculated for individual farms and for the industry as a whole. The model used is from chapters 3 and 4. However, changes were made in order to simulate both the two-tier milk price system as the Agenda 2000 reform. Our theoretical model of the two-tier system is similar to the framework of Bureau et al. (1997) regarding the EU sugar sector, with A- and B-quotas and the possibility to produce C-sugar.

5.2 Model, data and estimation

In order to analyse a two-tier milk price system, a model of output supply and input demand for dairy farmers is developed (see chapter 3). Farmers are assumed to be short-run profit maximisers and price-takers in all input and output markets. In the short run, volumes of fixed inputs and the state of technology are assumed to be fixed and there is no exit and entry of farms. It is assumed that each farmer has access to the same production technology; farm-specific features (e.g. the quality of land and management) are modelled using fixed effects.

The outputs distinguished are milk (q_0), which is subject to supply constraints, and a composite of other outputs (q_1). Purchased feed (q_2), dairy cattle (q_3) and a composite of other inputs (q_4) are used as variable inputs. Netput prices v_0 to v_4 and quasi-fixed inputs labour (z_1), land (z_2), buildings (z_3) and machinery (z_4) are assumed given. The model also includes a time trend (z_5) representing technology and a dummy (z_6) allowing for a change in technology due to the introduction of milk quotas in 1984. Furthermore, there are dummies (z_7 and z_8) included to distinguish between three regions.

A restricted profit function is defined as the cost of producing the constrained output q_0 (Moschini, 1988). The properties of the restricted profit function are equivalent to those of the regular profit function. However, it is possible that restricted profit is negative. The symmetric normalised quadratic (SNQ) is used as the empirical specification (Kohli, 1993; Oude Lansink and Thijssen, 1998) of restricted profit at the farm level.

From the restricted profit function, the netput equations (q_i, i=1,..,4) for each farm are derived using Hotelling's lemma. The intercepts of the netput equations represent farm-specificity. The model is completed by the milk supply function, which is only valid in the pre-quota period (1973/74-1983/84). In the post-quota period (1984/85-1992/93), milk supply is exogenously given for the individual farm and the milk supply equation does not apply. In that case, the marginal costs of producing at the quota level are relevant.

The netput equations and the milk supply function, with additional error terms, are estimated on a panel data set[1] of 9365 observations on specialised dairy farms over the period 1973/74-1992/93. The data are described in chapter 3. The data for the average farm in 1992/93 are presented in Table 5.1.

The milk supply equation is included during estimation in the pre-quota period. In the pre-quota period, the quantity of milk can be related to the error term and an instrumental variable estimator must be applied. Error terms may be correlated across equations. Therefore, 3SLS is an appropriate estimation technique (Judge et al., 1988 p.

[1] The willingness of the Agricultural Economics Research Institute (LEI-DLO) in The Hague to make the data available is gratefully acknowledged.

655). A detailed discussion on the estimation procedure and results can be found in chapter 3. The Hessian of prices is positive semi-definite, a necessary condition for farmers to be short-run profit maximisers.

Table 5.1: Data and base simulation for the average specialised dairy farm in 1992/93 (total no. of farms: 27515).

	Price index (1980/81=1.00)	Dimension	Data	Base simulation	
				Quantity[a]	Shadow price (1992/93 gld)
Milk output	1.17	Kilogram *1000	384.868	-	0.311
Other output	1.05	Guilders *1000 (1980/81 prices)	78.477	87.917	-
Purchased feed	0.82	Guilders *1000 (1980/81 prices)	71.090	61.901	-
Dairy cattle	1.12	Guilders *1000 (1980/81 prices)	4.020	3.493	-
Other input	1.14	Guilders *1000 (1980/81 prices)	74.909	70.086	-
Profits	-	Guilders *1000	205.151	228.697	-
Labour	-	Hours	3916	-	7.676
Land	-	Hectares	31.117	-	1629
Buildings	-	Inventory value, guilders *1000 (1980/81 prices)	245.363	-	0.036
Machinery	-	Inventory value, guilders *1000 (1980/81 prices)	197.110	-	0.086

[a] The base simulation represents the situation in which quotas are tradable in a competitive market.

5.3 Theoretical framework of a two-tier price system

The estimated model of the previous section is used to simulate the effects of the two-tier price system for individual Dutch dairy farms and the sector as a whole. In the theoretical model a distinction between a two-tier system with and without quota transfers is made. When trade in A-quotas is allowed, it is assumed that there are no quota trade restrictions. The theory behind the two-tier system is described in this section (see also Bureau et al., 1997). It shows that the estimated model, wherein no distinction is made between A- and B-milk, can be used to simulate a two-tier milk price system.

5.3.1 No quota trade

In a two-tier price system, a fixed amount of A-milk ($\breve{q}_{Ah}$) at the farm level (denoted by h) is produced at a given supported price (v_A). Farmers are free to produce milk beyond their A-quota (q_{Bh}), but they will receive the lower world market price (v_B) for this B-milk. Thus, the milk price v_0 is now partitioned into v_A and v_B, such that $v_A > v_B$, and $q_{0h}=q_{Ah}+q_{Bh}$. Therefore, given the world market price for milk, and given the level of A-quota, the farmer chooses his B-production where profits are maximised:

$$\pi_h(\mathbf{v},z_{kh}) = \max_{q_{Ah},q_{Bh}} \{v_A q_{Ah} + v_B q_{Bh} + g_h(v_i, q_{0h}, z_{kh})\}$$
$$s.t. \qquad q_{Ah} \le \breve{q}_{Ah} \qquad (5.1)$$
$$q_{Bh} \ge 0$$

Here, $\mathbf{v}$ is a vector of prices consisting of v_A, v_B and v_i, $g_h(\cdot)$ is restricted profit. The maximisation problem is restated as the Lagrangian:

$$L(\mathbf{v},\breve{q}_{Ah},z_{kh}) = v_A q_{Ah} + v_B q_{Bh} + g_h(v_i, q_{0h}, z_{kh}) - r_{Ah}(q_{Ah} - \breve{q}_{Ah}) + r_{Bh} q_{Bh} \qquad (5.2)$$

where, r_{Ah} and r_{Bh} are farm-specific Lagrange multipliers corresponding to the constraints in (5.1). They represent the extra profit of the farm when the constraint is relaxed by one unit. Therefore, they are also referred to as the shadow price of the constraint (Chiang, 1984 p.727). Thus, r_{Ah} and r_{Bh} represent the value of A-quota and B-milk respectively. Using the definition of marginal production costs, $-\frac{\partial g_h(\cdot)}{\partial q_{0h}} = s_{0h}$, the Kuhn-Tucker conditions for an optimum are:

$$v_A - s_{0h} = r_{Ah} \qquad ; \; r_{Ah}(\breve{q}_{Ah} - q_{Ah}) = 0 \qquad (5.3a)$$

$$v_B - s_{0h} = -r_{Bh} \qquad ; \; r_{Bh} q_{Bh} = 0 \qquad (5.3b)$$

The farm's shadow price of A-quota (r_{Ah}) equals the difference between the market price of A-milk and the farm's marginal cost of total production, and $-r_{Bh}$ is equal to the difference between the price of B-milk and marginal cost. If both constraints in (5.1) are indeed binding (r_{Ah}, r_{Bh}>0), the optimal production of A-milk equals the quota level and there is no B-milk produced ($q^*_{Ah}=\breve{q}_{Ah}$ and $q^*_{Bh}=0$, optima are denoted by an asterisk). Thus, the optimal total production level equals the quota level. If only the quota constraint is binding (r_{Ah}>0 and r_{Bh}=0), optimal A-milk production equals the quota level and the optimal total milk production is found by solving (5.3b) ($q^*_{Ah}=\breve{q}_{Ah}$ and $q^*_{Bh}= q^*_{0h}-\breve{q}_{Ah}$). If only the second constraint is binding (r_{Ah}=0 and r_{Bh}>0), there is no B-milk produced and total milk production is found by solving (5.3a) (q^*_{Bh}=0 and $q^*_{0h}=q^*_{Ah}$). Since it is assumed that $v_A > v_B$, it cannot be that both constraints are not binding.

5.3.2 Free quota trade

If the exchange of A-quota is allowed within a two-tier system, a farmer may choose to expand milk production beyond his initial A-quota ($\breve{q}_{Ah}$), either by producing B-milk at the low world price v_B, or by buying extra A-quota at its market price (r_A^T)[2]. However, a farmer may also want to sell part of his A-quota, expanding B-milk production instead. The following profit maximising problem holds:

$$\pi_h(\mathbf{v},\breve{q}_{Ah},z_{kh},r_A^T) = \max_{q_{Ah},q_{Bh}}\left\{v_A q_{Ah} + v_B q_{Bh} + g_h(v_i,q_{0h},z_{kh}) - r_A^T(q_{Ah}-\breve{q}_{Ah})\right\} \quad s.t. \quad q_{Bh} \geq 0 \tag{5.4}$$

The corresponding Lagrangian is:

$$L(\mathbf{v},\breve{q}_{Ah},z_{kh},r_A^T) = v_A q_{Ah} + v_B q_{Bh} + g_h(v_i,q_{0h},z_{kh}) - r_A^T(q_{Ah}-\breve{q}_{Ah}) + r_{Bh}q_{Bh} \tag{5.5}$$

Again, r_{Bh} is the farm-specific Lagrange multiplier corresponding to the constraint that B-milk production cannot be negative. The conditions for an optimum are:

$$v_A - s_{0h} = r_A^T \tag{5.6a}$$

$$v_B - s_{0h} = -r_{Bh} \quad ; \; r_{Bh}q_{Bh} = 0 \tag{5.6b}$$

Equation (5.6a) implies that the farm's marginal cost of total milk production equals the difference between the market prices of A-milk and A-quota. If the constraint is binding (r_{Bh}>0), there is no B-milk produced (q^*_{Bh}=0). The optimal milk production and market price of quota ($q^*_{0h}=q^*_{Ah}$ and $r_A^{T}*$) are found where the aggregate A-quota level ($\breve{Q}_A$) is given by $\sum_{h=1}^{H} q_{0h} = \breve{Q}_A$, and the marginal costs are equal across farms $s_{0h} = s_{0f}$ (h,f=1,..,H). The market price of quota (r_A^T*) is the price at which there is no excess demand or supply of quota. If the constraint is not binding (r_{Bh}=0), the market price of quota equals the

[2] r_A^T is the rental price of quota user rights which is not the same as the price of buying quota ownership rights.

difference between the price of A-milk and the world price ($r_A{}^{T}{*}=v_A\text{-}v_B$). Optimal milk production (q^*_{0h}) can be found by solving (5.6a) or (5.6b). The composition of q^*_{0h} (i.e. the share of A and B milk in it) is indeterminate, but it makes no difference for the profit level of the farm.

5.4 Policy simulations and results

The policy simulations are elaborated in this section. First, the effects of the two-tier system are determined. Then, the effects of the Agenda 2000 reform, wherein quota is 1.5 per cent higher and milk prices are 15 per cent lower, are calculated. Finally, the effects of abolishing quotas are simulated.

Note that long-term effects of dairy policy changes cannot be simulated, because of the short-run character of the model. Moreover, input and output prices are held constant, which could be unrealistic if there were large changes in total milk production. Furthermore, the model does not include consumer demand and budget costs, therefore, welfare analysis is not possible. Finally, manure legislation in the Netherlands could be restrictive if farmers want to increase their milk production. This is not incorporated in the policy simulations.

The simulations describe the effects on farm profits, input demand and output supply, especially milk production, and the shadow prices of fixed inputs. Profits are calculated as the value of the netputs. If profits decrease as a result of the simulation, compensating payments, necessary to offset this profit loss, per hectare and per tonne of quota are calculated. Here we use the initial quota in 1992/93 as the base for compensating payments. This implies that the level of compensation does not influence production decisions. Prices of the other output and variable inputs and the amount of fixed inputs at the farm level are kept constant throughout all simulations. In the simulation model, the effects are determined for all individual farms in the sample for 1992/93, representing 27515 farms in the sector. These farms represent a total initial quota of 10590 million kilograms, which is 95 per cent of the national quota in 1992. For ease of presentation, simulation results are presented for the average farm as percentage changes compared with the base simulation. The base simulation and the other simulations and their results are discussed now.

5.4.1 Base simulation

The base simulation (see Table 5.1) represents the situation where quotas are transferable in a competitive market and every farm trades up to the point where the marginal costs of production are equal for all farms. The calculated market price of quota equals 0.39 guilders/kg. So the base simulation does not represent the actual situation but represents the situation where all efficiency gains from quota trade are realised (see chapter 4).

5.4.2 Two-tier price system

In a two-tier price system, policy makers can use several instruments: i) allow for quota trade, ii) set the level of A-quota, and iii) set the level of A-prices. To keep the presentation clear we assume that the price of A-milk is fixed at 0.70 guilders per kilogram[3] which is also the price of milk in the base simulation. Further, we assume farm level A-quotas to be the same as in the base simulation. One could argue that quotas should be reduced in a two-tier system, because maintaining the present level of quota would imply that the 1994 GATT-agreement conditions would not be fulfilled. The simulations do not account for quota reductions in order to avoid that the effects of the two-tier system are confused with the effects of quota reduction. The main unknown variable is the price for B-milk (world market price[4]). Therefore, simulations are presented for a range of prices for B-milk.

The effects of a two-tier price system when quotas are tradable are shown in Table 5.2 and in Figure 5.1. As in the base simulation the calculated marginal cost for all farms is 0.31 guilders/kg. This is also the average marginal cost of producing A-milk, because of the linear supply equation. In the trajectory where the price of B-milk is less than the average marginal costs of producing A-milk, no B-milk is produced. Thus, the relevant quota price r_A^{T*} is 0.39 guilders/kg (=0.70-0.31).

[3] Milk prices are standardised for 1992/93 and a fat content of 3.7 per cent.

[4] The average world market price of milk is assumed to be 0.35 guilders/kg (Ministry of Agriculture, 1996).

Table 5.2: Effects of a two-tier price system at different levels of the price of B-milk if quotas are transferable[a] (percentage changes compared to base simulation).

Price of B-milk (1992/93 gld/kg)	Netput quantities					Profit	Shadow prices			
	Milk output	Other output	Purchased feed	Dairy cattle	Other input		Labour	Land	Buildings	Machinery
$v_B \leq 0.311$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.35	3.17	-0.68	6.00	5.10	0.18	0.10	5.16	8.95	51.91	37.61
0.40	7.18	-1.79	13.95	11.96	0.70	0.52	11.67	20.26	117.47	85.12
0.45	11.68	-3.36	23.37	20.23	1.69	1.38	19.00	32.98	191.24	138.56
0.50	15.69	-5.05	32.17	28.07	2.92	2.49	25.52	44.28	256.80	186.07

[a] A-quotas are the same as in the base simulation and the price of A-milk is 0.70 guilders/kg.

Figure 5.1 shows that milk supply does not change if $v_B \leq 0.31$. There is no production of B-milk, but just as in the base simulation 1060 million kg of A-quota change hands at the market price of 0.39 guilders/kg. There are 12567 quota buyers and 14948 quota sellers. If $v_B > 0.31$, there is also B-milk produced and there is less quota trade. The most efficient farmers produce B-milk instead of buying quota. The relevant quota price r_A^{T*} is 0.70-v_B and therefore lower than in the base simulation. Profits are higher than in the base simulation. The supply of the other output is lower than in the base simulation, while the demand for variable inputs is higher.

The results indicate that, at low levels of world market prices (lower than the industries' average marginal costs of producing A-milk i.e. 0.31 guilders/kg), a two-tier milk price system with free quota trade will not change milk production and farm profits. Higher world market prices induce the farmer to produce B-milk and profits will increase. Provided that the world market price of milk is high enough, the quota price under a two-tier system would be lower than the present quota price, because the most efficient farmers will produce B-milk instead of buying A-quota. Note that quota transfer costs as in chapter 4 are not accounted for here.

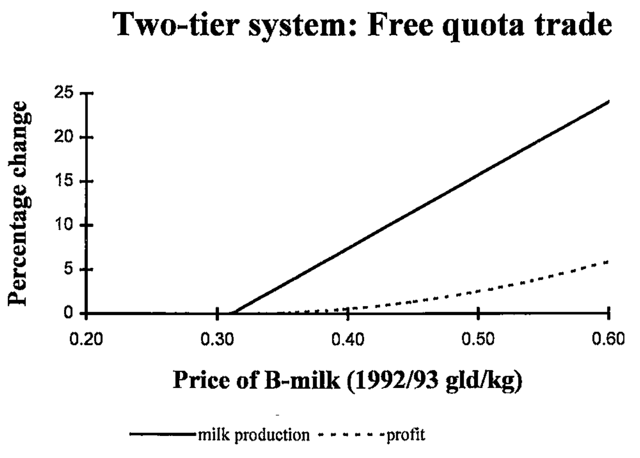

Figure 5.1: Effects of a two-tier system if trade in A-quotas is allowed.

5.4.3 Agenda 2000

In the reform agreement of the European Commission intervention prices of butter and skimmed milk powder are cut by 15 per cent in three annual steps of 5 per cent between 2005/06 and 2007/08 (Agra Europe, 1999a). Furthermore, a 1.5 per cent quota increase is to be implemented in three steps in parallel with the price reductions. Additionally, specific quota increases totalling 1.39 million tonnes in two years (2000/01-2001/02) are to be implemented for Italy, Greece, Spain, Ireland and Northern Ireland.

For simplicity, the Agenda 2000 reform is simulated here by allowing the present Dutch farm quota level to increase instantly with 1.5 per cent and reducing the milk price instantly by 15 per cent for all farms. Thus, the future change is applied to the situation in 1992/93. It is assumed that the reduction in intervention prices of butter and skimmed milk powder are fully reflected in the producers price. With more favourable world market conditions this may not be the case. The resulting milk price becomes 0.60 guilders/kg and the average amount of milk quota per farm is 390,640 kg. The quota increase is allocated evenly among all farms in the sample. Free trade of milk quotas is assumed.

A 15 per cent milk price reduction, combined with a 1.5 per cent increase in quotas, result in less supply of the other outputs (-0.30 per cent) and increased demand for variable inputs (purchased feed 2.81 per cent, dairy cattle 2.38 per cent and other input 0.06 per cent). The shadow prices of fixed inputs also increase (labour 2.44 per cent, land 4.23 per cent, buildings 24.56 per cent and machinery 17.79 per cent). However, profits decrease by 17.06 per cent compared to the base simulation, because quota rents decrease. An average direct payment of 106 guilders per tonne of initial milk quota will offset farmers for this loss in profits. This compensation should be higher for the average intensive farm (119 guilders per tonne) than for the average extensive farm (95 guilders per tonne)[5]. If the compensation were given per hectare, the average payment should be 1291 guilders/ha.

The proposed compensation of the EU for Dutch dairy farms amounts to 24.87 euro per tonne. The dairy cow premium is divided into a statutory EU element of 17.24 euro per tonne (from 2007 onwards) and a national element of 7.63 euro per tonne (from 2008 onwards). The latter element allows Member States to decide how to allocate part of the CAP aid payments. Using an exchange rate of 1 euro = 2.20371 guilders, the proposed compensation is 55 guilders per tonne, which would cover 52 per cent of the calculated loss in profits. The calculated market price of milk quota is 0.27 guilders/kg, which is smaller than in the base simulation.

The advantage of the Agenda 2000 measures over the two-tier system for the policy maker is that the increase in milk production is controlled i.e. fixed. However, farm profits are much lower inducing a policy of compensation, whereas profits are non-decreasing in the two-tier system. Quota trade prices are difficult to compare because support prices and the level of quota differs between the two-tier and the Agenda 2000 cases. However, in the way we have modelled both policies, the calculated market price of quota in the two-tier system equals the quota price in the Agenda 2000 simulation if the world market price of milk is 0.43 guilders/kg.

5.4.4 Quota abolition

Although the Commission agreed that milk quotas will stay until 2006, the abolishment of quotas is still an interesting case to analyse (especially for the Danish it seems to be a preferable alternative). Moreover, reviews of the dairy regime might be necessary before the agreed reforms have been finalised (Agra Europe, 1999b). If milk quotas are abolished, the price of milk determines milk production, as it did before quotas were implemented in 1984. The price of milk is determined either by the policy makers or by the market. Since

[5] Intensity is calculated as the initial milk output per hectare. If a farms' intensity is higher (lower) than the average intensity, it is determined to be an intensive (extensive) farm.

the model does not include the consumption side of the milk market, it is assumed that the milk price is given exogenously. For a given milk price v_0, the milk supply equation is used to simulate the corresponding milk supply q_{0h}. The results of quota abolition are determined for a range of prices for milk.

Table 5.3: Effects of quota abolition (percentage changes compared to base simulation).

Price of milk	Netput quantities					Profit	Shadow prices			
(1992/93 gld/kg)	Milk output	Other output	Purchased feed	Dairy cattle	Other input		Labour	Land	Buildings	Machinery
0.20	-9.35	1.02	-16.23	-13.33	0.70	-84.15	-15.20	-26.38	-152.99	-110.85
0.25	-5.34	0.77	-9.54	-7.93	0.18	-76.64	-8.69	-15.08	-87.43	-63.35
0.30	-0.84	0.15	-1.54	-1.29	-0.01	-67.81	-1.36	-2.36	-13.66	-9.90
0.35	3.17	-0.68	6.00	5.10	0.18	-59.62	5.16	8.95	51.91	37.61
0.40	7.18	-1.79	13.95	11.96	0.70	-51.10	11.67	20.26	117.47	85.12
0.45	11.68	-3.36	23.37	20.23	1.69	-41.14	19.00	32.98	191.24	138.56
0.50	15.69	-5.05	32.17	28.07	2.92	-31.93	25.52	44.28	256.80	186.07

The results of abolishing quotas are summarised in Table 5.3 and Figure 5.2. Milk supply and the shadow prices of fixed inputs decrease compared to the base simulation when the price of milk is less than 0.31 guilders/kg. Profits decrease over the simulated range of milk prices. The demand for purchased feed and dairy cattle decrease, while the supply of the other output increases up to the point where the milk price is 0.31 guilders/kg. The demand for other input increases, except when the milk price is between 0.29 and 0.31 guilders/kg.

The results show that, for the simulated range of milk prices, farm profits decrease as a result of quota abolition. Total milk production equals the national production in the base simulation when the price of milk is 0.31 guilders/kg. In that case, profits are 65.8 per cent lower than in the base simulation. Therefore, the average direct compensation for this loss in profit should be 344 guilders/tonne (or 4477 guilders/ha). In Table 5.4 the necessary average compensations are shown for given milk prices. The compensation decreases with an increasing milk price.

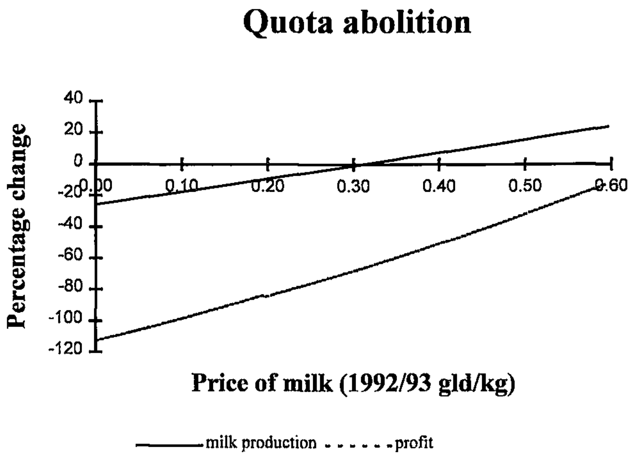

Figure 5.2: Effects of quota abolition.

If quotas are abolished and the (world market) price of milk becomes 0.60 guilders/kg, the profit decrease (-13 per cent) is smaller than in the Agenda 2000 simulation (where the price of milk is also 0.60 guilders/kg). Therefore, the necessary compensation for farmers is smaller if quotas are abolished. However, milk production is unconstrained if the quota system is abolished and therefore larger (23.7 per cent) than in the Agenda 2000 case.

Comparing the results of quota abolishment and the two-tier system with quota trade (Tables 5.2 and 5.3) shows that the increases in milk production (and shadow prices) are equal if the milk price is high enough. In both simulations the world price determines milk production (at the margin). However, part of the production in the two-tier system (production of A-milk) is supported and therefore profits are higher in that case.

Table 5.4: Necessary average compensation for loss in profit when quotas are abolished (1992/93 guilders per ha and per tonne).

Price of milk (1992/93 gld/kg)	Compensation per tonne	Compensation per hectare
0.20	456	5830
0.25	411	5281
0.30	357	4628
0.35	306	4014
0.40	252	3371
0.45	189	2611
0.50	130	1903

5.5 Conclusions

This research determines the short-run effects of a two-tier price system for the Dutch dairy sector. The effects of the Agenda 2000 reform, with a reduced milk price and increased quota levels, and the effects of abolishing the quota system, are also shown.

The results indicate that in a two-tier milk price system with free quota trade, B-milk will be produced if the world market price is higher than the industries' average marginal costs of producing A-milk (0.31 guilders/kg). In that case, profits, defined as the value of the netputs, will increase. If the world market price of milk were 0.31 guilders/kg, the present level of total milk production would not be exceeded. Provided that the world market price of milk is higher than 0.31 guilders/kg, the quota price under a two-tier system would be lower than the present quota price, because the most efficient farmers will produce B-milk instead of buying A-quota.

The results of simulating Agenda 2000 for dairy farming indicate a 17 per cent loss in profits. The proposed direct payment per tonne of initial quota only compensates 52 per cent of this profit loss. Accounting for feed cost and slaughter premiums, Silvis and van Bruchem (1999), find a 64 per cent income coverage of the Agenda 2000 compensation in 2007. The profit loss is mainly due to the decrease in milk prices. Because of the 1.5 per cent quota increase, the demand for variable inputs will increase, while the supply of other output decreases. The diminished milk price also results in a lower quota price compared with the base simulation.

If quotas were abolished, milk production increases if the price of milk is higher than the current average marginal costs. However, profits decrease, asking for compensating payments. At a world price of 0.60 guilders/kg, the necessary compensation in the case of quota abolishment is smaller than in the Agenda 2000 case, while milk production is higher.

The model presented is a flexible tool to analyse the short-term effects of EU dairy policy changes in the Netherlands. The results show that the disadvantages of Agenda 2000, i.e. increased budget costs and the insufficiency to meet future WTO demands, are complemented with strong negative income effects for Dutch dairy farmers. The income of the farmer is guaranteed in a two-tier price system and it serves farmers with some flexibility (partly giving in to the WTO demands), while the burden on the government budget is relatively lower..Quota abolition is for Dutch dairy farmers from an income point of view still less attractive (although highly dependent on the price at the world market) but more freedom in production could outweigh this disadvantage. The fact that the Dutch government did not opt for quota abolition probably has to do with the fear that a rise in milk production would increase environmental problems and would lead to a weakened financial position of farmers because their quota lose value.

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Chapter 6 LAND DEMAND AND PHOSPHATE SURPLUS TAXES

6.1 Introduction

The effects of farm support programs and other policies affecting agriculture, like environmental and wildlife protection policies, are reflected in land values (Barnard et al., 1997). The change in land value has an impact on the competitiveness of a sector. Furthermore, land prices are an important determinant of the income distribution between farmers that enter and exit the sector. Consequently, land prices and the demand for land have been areas of continuous interest in the agricultural economics literature.

In particular, environmental and agricultural policies are often directly or indirectly linked to farmland. For example, set aside programs are directly related to land whereas policies aimed at reducing production intensity are often indirectly linked to land. The interdependence between agricultural, environmental and resource policies has recently gained attention (see e.g. Just and Bockstael, 1991).

Empirical studies on land demand and land prices (see Weersink et al., 1996 for an overview) usually focus on the aggregate level, with the value of returns to farming being the driving force behind land prices (Just and Miranowski, 1993). A shortcoming of the net returns to farming approach is that it is an ad hoc method; net returns include the returns to labour and capital goods as well. This approach may be misleading, since a decrease in net returns to farming may go along with increasing land prices, due for example to technological change that increases economies of size (Doll, Widdows, and Velde, 1983). The use of aggregate data conceals differential behaviour among groups of farms in a sector, especially when agricultural and environmental policies have farm-specific impacts. Another group of empirical studies uses hedonic price functions to estimate the effects of government payments and other determinants (e.g. land productivity, site characteristics, urbanisation/population density, pollution, erosion control etc.) on land values (Barnard et al., 1997; Roka and Palmquist, 1997; Boisvert, Schmit and Regmi, 1997). A disadvantage of these studies is that subjective farmers' estimates are used as data for farmland values.

This chapter presents a short-run, micro-economic simulation model that simultaneously determines the market price of land and the demand for land by individual

Dutch dairy farms. The model is then developed to show the impact of a phosphate surplus tax on land demand and land prices.

This chapter makes four contributions to the literature. First, a theoretically consistent micro-economic model is used to determine land demand and land prices. That is, the shadow price of land determines land prices and land demand. Chavas (1993) provided a micro-economic framework, which was generalised by Hennessy (1997), for determining the market price of land and demand for land, but without providing empirical evidence. Schäfer (1985) used shadow prices to determine the impact of government policies but did not calculate equilibrium prices.

Second, this chapter recognises land market imperfections. Following previous studies, attention focuses on demand rather than supply by assuming that the total quantity of land supplied is fixed (Burt, 1986). Imperfections on the demand side of the market are modelled by giving farms a probability of purchasing land. These imperfections are caused by frictions such as a discrepancy between the location of supply and demand.

Third, this chapter adds to the literature by showing that modelling individual farm behaviour is relevant to the analysis of land demand, given the differential impact of farm policies that affect land values. Agricultural and environmental policies, like the phosphate policy addressed in this chapter, are increasingly farm-specific. The use of time-series conceals the impacts of policies on different (groups of) farms.

Finally, this chapter explicitly analyses the effects of manure policies on land prices. Manure policies have been effective in the Netherlands since 1984, but most dairy farms were not restricted by this policy. From 1998 on, a new policy is effective, whereby a farm is taxed on its production of phosphate from manure in excess of 120 kg phosphate per hectare of grassland[1]. We show that this surplus tax increases the shadow price of land because farmers with a surplus can reduce the tax by buying or renting additional land. Previous studies analysed the consequences of a national nitrogen tax on production costs and prices in agriculture (Johnson, Atwood and Thompson, 1991) and the effects of a nitrogen surplus tax for arable farming (Oude Lansink and Peerlings, 1997). The micro-economic effects of phosphate surplus taxes on land prices have not been studied before.

[1] Nitrate is also part of the manure registration and surplus tax system. However, criteria are set such that this tax is not effective.

The chapter proceeds with a discussion of the micro-economic simulation model that is used to determine the demand for land and land prices. The effects of a phosphate surplus tax on land demand are also shown. Next, the results of different policy simulations are discussed. The chapter concludes with comments.

6.2 A micro-economic model of land demand

This section develops a micro-economic simulation model of land demand by Dutch dairy farmers. Land demand is derived from a static profit function, assuming that dairy farmers are maximising short-term profit given their levels of milk quota, land and other fixed inputs. In the long term, dairy farmers can adjust the quantity of land in order to maximise long-term profit. First, the basic micro-economic model is specified and estimated. Land demand is derived next, and finally it is shown how a tax on phosphate surplus is included in this framework.

Micro-economic models of input demand and output supply have been applied frequently in the agricultural economics literature (see Shumway, 1995 for an overview). This also holds for the dairy sector in the Netherlands (Boots, Oude Lansink and Peerlings, 1997; Helming, Oskam and Thijssen, 1993). Models of Dutch dairy farming have to take into account that individual dairy farms have operated under a quota constraint since 1984.

Dairy farming is modelled by assuming that the farm produces two outputs; milk (z_0), which is subject to a supply constraint, and a composite of other outputs (q_1). Three variable inputs are used; purchased feed (q_2), dairy cattle (q_3), and a composite of other inputs (q_4). Furthermore, four quasi-fixed inputs are distinguished; land (L), labour (z_1), buildings (z_2) and machinery (z_3). The model also includes a time trend (z_4) representing technology and a dummy (z_5) allowing for a change in technology due to the introduction of milk quotas in 1984. Furthermore, two dummies (z_6 and z_7) are included to distinguish three regions. Restricted profit (g) is defined as revenue of other output minus all variable costs. Profit, subject to the quota constraint, is given by the restricted profit maximisation problem:

$$g(\mathbf{v},\mathbf{z},L) = \max_{\mathbf{q}}\{\mathbf{v}\,\mathbf{q}\} \qquad (6.1)$$

Here $\mathbf{v}$ and $\mathbf{q}$ are vectors of netput prices and netput quantities, $\mathbf{z}$ is a vector of milk quota, fixed input quantities, trend and dummies, and L represents land. The restricted profit function $g(\cdot)$ is convex, continuous and twice differentiable in prices, increasing in output prices and fixed inputs and decreasing in input prices and milk output. Netput equations are derived by taking the first order derivative of the restricted profit function with respect to netput prices (Hotelling's Lemma): $\mathbf{q} = \partial g(\cdot)/\partial \mathbf{v}$.

6.2.1 Empirical model

The symmetric normalised quadratic (SNQ) is used as the empirical specification (Kohli, 1993; Oude Lansink and Stefanou, 1997) of the restricted profit function. The SNQ is a flexible functional form that allows for negative profit and for curvature conditions (convexity in prices) to be imposed globally. Another advantage is that the estimation results do not depend on the choice of a numeraire netput (as is the case for the also frequently used normalised quadratic). The SNQ takes the following form:

$$
\begin{aligned}
g(v_i, z_k, L) = {} & \sum_{i=1}^{4} \alpha_i v_i + \frac{1}{2} w^{-1} \sum_{i=1}^{4}\sum_{j=1}^{4} \alpha_{ij} v_i v_j + \sum_{i=1}^{4} \zeta_i v_i L + \sum_{i=1}^{4}\sum_{k=0}^{7} \gamma_{ik} v_i z_k + \\
& \frac{1}{2} w \rho L^2 + w \sum_{k=0}^{7} \mu_k z_k L + \frac{1}{2} w \sum_{k=0}^{4}\sum_{n=0}^{4} \beta_{kn} z_k z_n + \\
& w \sum_{k=0}^{4}\sum_{n=5}^{7} \beta_{kn} z_k z_n
\end{aligned}
\tag{6.2}
$$

The last term in the restricted profit function indicates that the cross products of the dummies are not taken into account. Symmetry is maintained by requiring $\alpha_{ij}=\alpha_{ji}$ and $\beta_{kn}=\beta_{nk}$. Linear homogeneity in prices is imposed by the term $w = \sum_{l=1}^{4} \theta_l v_{l}$. Here θ_l are non-negative constants determined as the average shares of netput l (l=1,..,4) in total costs plus revenues. Additional restrictions $\sum_{j=1}^{4} \alpha_{ij} \bar{v}_j = 0 \; (\forall i = 1,..,4)$ have to be imposed, in order to identify all parameters α_{ij}. Here, $\bar{v}_j$ is an arbitrary point of observation.

Netput equations (i=1,..,4) are derived using Hotelling's lemma:

$$
\begin{aligned}
q_i = {} & \alpha_i + w^{-1} \sum_{j=1}^{4} \alpha_{ij} v_j - \frac{1}{2} \theta_i w^{-2} \sum_{l=1}^{4}\sum_{j=1}^{4} \alpha_{lj} v_l v_j + \zeta_i L + \sum_{k=0}^{7} \gamma_{ik} z_k + \frac{1}{2} \theta_i \rho L^2 + \\
& \theta_i \sum_{k=0}^{7} \mu_k z_k L + \frac{1}{2} \theta_i \sum_{k=0}^{4}\sum_{n=0}^{4} \beta_{kn} z_k z_n + \theta_i \sum_{k=0}^{4}\sum_{n=5}^{7} \beta_{kn} z_k z_n
\end{aligned}
\tag{6.3}
$$

The milk supply function for the period before the introduction of milk quotas is derived, by using the first order condition for profit maximisation: $-\partial g(\cdot)/\partial z_0 = v_0$. Solving for z_0 yields:

$$z_0 = -\frac{1}{\beta_{00}}\left[w^{-1}\left(\sum_{i=1}^{4}\gamma_{i0}v_i + v_0\right) + \mu_0 L + \sum_{k=1}^{7}\beta_{k0}z_k\right] \tag{6.4}$$

6.2.2 Data and estimation

Data on specialised dairy farms covering the period 1973/74-1992/93 come from a stratified sample of farms keeping accounts on behalf of the LEI-DLO farm accounting system. The data set used for estimation contains 9365 observations on 1961 farms.

Data on variable outputs and inputs are measured as revenues and costs. Other output is an aggregate of revenues from marketable crops, beef and veal, and other animals. Other variable inputs consists of feed for animals other than dairy cattle, seeds, fertilisers, pesticides, contract work, veterinary services, fuel, energy and other cattle. Fixed inputs are labour (hours), land (hectares) buildings and machinery (total invested capital at 1980/81 prices). Other variables in the empirical model are a trend and regional dummies. The regions distinguished are sandy soils, northern clay and peat, and western pastures.

Tornqvist price indices were calculated for the composite variables (other output, feed input and other variable input). Implicit quantity indices were obtained as the ratio of value and the price index. The price indices vary over the years, but not over the farms, implying that the differences in the composition of a netput, or quality differences, are reflected in the quantity. Data for the average farm in 1992/93 are given in Appendix 6.A.

The system of equations that is estimated is (6.3) and (6.4), with additive error terms included prior to estimation. Every farm is assumed to have a farm-specific intercept, reflecting differences in farm characteristics (e.g. management quality and soil quality). A fixed-effects model explicitly accounts for this assumption. The necessary transformation for such a model can also be applied to an incomplete panel, like our data set. The profit function is not estimated along with the netput equations, since the intercepts of the netput equations appear as slope coefficients in the profit function. Including the profit function during estimation requires direct estimation of all farm-specific intercepts. Note that all parameters of the profit function are identified in the netput equations.

The milk supply equation is included during estimation in the period before the quota introduction, causing a difference in the number of observations across equations. In the pre-quota period, the quantity of milk can be related to the error term and an instrumental variable estimator must be applied. Endogenous variables are z_0, q_i (i=1,..,4), and all terms containing milk output (z_0z_0, z_0z_k). All exogenous variables are used as instruments. Error terms may be correlated across equations. Therefore, the estimation technique used is non-linear 3SLS (Judge et al., 1988 p.655). The covariance matrix of residuals used in estimating the system is corrected for the difference in observations (Judge et al., 1988 p.462).

The estimation results can be found in Appendix 6.B and show that 49 per cent of the parameters are significant at the critical 5 per cent level.

6.2.3 Land demand at the farm level

The basic micro-economic model above assumes that the quantity of land is exogenous, i.e. farmers take the quantity of land as given and maximise profit over all variable inputs and outputs. When the farmer has the possibility of buying or renting additional land, land becomes an endogenous variable with price r per hectare, and the following long term profit maximisation problem applies:

$$J(\mathbf{v},r,\mathbf{z}) = \max_{L}\{g(\mathbf{v},\mathbf{z},L) - rL\} \tag{6.5}$$

with first order condition:

$$\frac{\partial g(\mathbf{v},\mathbf{z},L)}{\partial L} = r \tag{6.6}$$

This is the shadow price equation of land. Solving this expression for land, using the equation in (6.2) for $g(\cdot)$, gives the demand equation for land:

$$L = \frac{1}{\rho}\left[r - \sum_{i=1}^{4}\zeta_i v_i - w\sum_{k=0}^{7}\mu_k z_k\right] \tag{6.7}$$

The first column in Table 6.1 gives the elasticities of the demand for land with respect to prices of netputs and land, and quantities of milk output and fixed inputs. The results show that the input of purchased feed is a substitute for land, implying that the farmer decides to grow more feed on the farm if the price of purchased feed increases. Milk quota is a complement for land, indicating that an increase (purchase) of milk quotas has to go together with an increase in land. Land is less important in the production of other outputs. The small (and positive) effect of dairy cattle prices on land demand is striking. Buildings and machinery, as well as technology (trend), are substitutes for land. Due to annual technological development the demand for land decreases, *ceteris paribus*.

Table 6.1: Average price and quantity elasticities of land, simulated for 1992/93 (weighted calculated mean).

	Elasticity of land demand	Elasticity of land demand including surplus tax
With respect to prices:		
Other output	0.51	0.36
Purchased feed	0.51	0.37
Dairy cattle	0.01	0.01
Other input	-0.42	-0.38
Land	-0.62	-0.49
Surplus tax		0.13
With respect to quantities:		
Milk quota	1.74	1.48
Labour	0.03	0.03
Buildings	-0.33	-0.28
Machinery	-0.41	-0.35
Technology	-0.67	-0.57
Threshold		0.13

6.2.4 Land market

The market for land consists of land demanders and suppliers. Inspection of our data shows that most of the farms in our sample do not sell land. Rather they purchase land[2], usually from small farms and farms that are discontinued. Neither are represented in the sample. Therefore, all farms are restricted to be potential buyers of land. Exogenous supply, denoted by *E*, is assumed to be perfectly price inelastic. The equilibrium price of land is

[2] Here purchasing is considered to include also renting land and using land for free (e.g. from relatives).

determined as the price that equalises supply and demand for land. Formally this land market is given by:

$$\sum_{h=1}^{H} x_h J_h(\mathbf{v},r,\mathbf{z}_h) = \sum_{h=1}^{H} x_h \max_{L_h}\left\{g_h(\mathbf{v},\mathbf{z}_h,L_h^*) - r^* \cdot L_h^*\right\}$$
$$s.t. \quad \sum_{h=1}^{H} x_h\left(L_h^* - L_h\right) = E \qquad (6.8)$$
$$L_h^* - L_h \geq 0$$

Here r^* and L_h^* are the equilibrium price of land and the optimal quantity of land on farm h respectively. The number of farms in the sample is denoted by H (h=1,..,H). A weighting factor x_h for each farm h (given in the data set), denotes the number of farms in the sector which are represented by the farm in the sample. The weighting factors are used to aggregate the results to the sector level. Note that the equilibrium price of land is equal for all farms. Also note that the second restriction implies that all farms have to buy land or stay at their initial quantity L_h.

The model so far assumes that all farms have equal access to the market, i.e. the location of the land has no impact on the decision to buy land. The model is extended by conjecturing that farmers have a probability of buying land, representing friction between the location of supply and demand for land (a market imperfection[3]). Formally this model is expressed as:

$$\sum_{h=1}^{H} x_h J_h(\mathbf{v},r,\mathbf{z}_h) = \sum_{h=1}^{H} x_h \max_{L_h}\left\{g_h(\mathbf{v},\mathbf{z}_h,L_h^*) - r^* \cdot L_h^*\right\}$$
$$s.t. \quad P\sum_{h=1}^{H} x_h\left(L_h^* - L_h\right) = E \qquad (6.9)$$
$$L_h^* - L_h \geq 0$$

The first restriction now explicitly includes the probability of buying land, denoted by P. Because of the weighting factor, the probability determines that for each farm h in the sample, $P \cdot x_h$ of the farms in the sector buy land (and $(1-P) \cdot x_h$ do not buy). The effect of the probability is that farms with high shadow prices of land cannot participate in the bidding process as much as they would like to. Therefore, farmers, whose shadow price of land was

[3] Other imperfections in land demand may stem from the unavailability of credit or the lack of successors. In this model, farms with very low shadow prices of land will never buy land, while, in practice, these farms may have the opportunity to attract credit and buy land.

too low to buy land in the model in (6.8), will now be enabled to buy land. The resulting equilibrium price of land will therefore be lower.

6.2.5 Effects of a phosphate surplus tax

In order to analyse the effects of phosphate surplus taxes on land demand, the model has to include a functional relationship between the phosphate surplus and output supply along with the demand for variable inputs and land. The approach that is adopted in this chapter requires the estimation of a phosphate production function.

In the policy on manure surplus taxes in the Netherlands, phosphate production is calculated by using standards for phosphate production for each unit of livestock on the farm. Calculating the phosphate surplus therefore requires data on livestock numbers and knowledge of standards that apply. However, data on livestock numbers are not available in the data set that was used in this study. Therefore, data on total phosphate production m, and livestock values were used to estimate a phosphate production function. The phosphate production function is specified as:

$$m = \kappa_3 q_3 + \kappa_{4a} q_{4a} + \kappa_{4b} q_{4b} + \kappa_{4c} q_{4c} \tag{6.10}$$

Here q_3 represents the volume of dairy cows (variable input in the basic micro-economic model) and q_{4a}, q_{4b} and q_{4c} represent other bovine cattle, pigs and other livestock. The volumes of q_{4a}, q_{4b} and q_{4c} are part of other variable input q_4 in the basic micro-economic model. Estimation of the phosphate production is reported in Appendix 6.C.

The phosphate surplus tax is included in the model using a methodology that was developed by Oude Lansink and Peerlings (1997) to determine the effects of nitrogen surplus taxes using a micro-economic simulation model of Dutch arable farming. Phosphate surplus S is defined as:

$$S = m(q_3, q_{4a}, q_{4b}, q_{4c}) - b \cdot L \tag{6.11}$$

Here b is a threshold level of acceptable phosphate surpluses per hectare, which is a policy parameter, and L is land.

The effects of a phosphate surplus tax are determined by incorporating the cost of the phosphate surplus tax into the restricted profit function as follows:

$$g^S(\mathbf{v}, \mathbf{z}, L) = \sum_{i=1}^{4} v_i q_i - t \cdot S \tag{6.12}$$

The surplus tax t is related to the basic micro-economic model through the elements of $m(\cdot)$ and through the quantity of land L (see equation 6.11). It can be seen that q_3 and L are directly linked to the basic micro-economic model. The other elements, q_{4a}, q_{4b} and q_{4c}, have no direct relationship. However, by making the assumption that the demand for other inputs q_4, is homogeneously separable in its components, such a link can be established (see Boyle and O'Neill, 1990). Denoting the shares of q_{4a}, q_{4b} and q_{4c} in q_4, by c_{4a}, c_{4b} and c_{4c}, the new netput equations are derived as:

$$
\begin{aligned}
q_i^S &= q_i - t\left[\frac{\partial m(\cdot)}{\partial q_3}\frac{\partial q_3}{\partial v_i} + c_{4a}\frac{\partial m(\cdot)}{\partial q_{4a}}\frac{\partial q_4}{\partial v_i} + c_{4b}\frac{\partial m(\cdot)}{\partial q_{4b}}\frac{\partial q_4}{\partial v_i} + c_{4c}\frac{\partial m(\cdot)}{\partial q_{4c}}\frac{\partial q_4}{\partial v_i}\right] \\
&= q_i - t\cdot\kappa_3\left[w^{-1}\alpha_{3i} - \theta_i w^{-2}\sum_{j=1}^{4}\alpha_{3j}v_j - \theta_3 w^{-2}\sum_{j=1}^{4}\alpha_{ij}v_j + \right. \\
&\left.\frac{1}{2}\theta_3\theta_i w^{-3}\sum_{i=1}^{4}\sum_{j=1}^{4}\alpha_{ij}v_i v_j\right] - t\cdot\left(c_{4a}\cdot\kappa_{4a} + c_{4b}\cdot\kappa_{4b} + c_{4c}\cdot\kappa_{4c}\right)\cdot \\
&\left[w^{-1}\alpha_{4i} - \theta_i w^{-2}\sum_{j=1}^{4}\alpha_{4j}v_j - \theta_4 w^{-2}\sum_{j=1}^{4}\alpha_{ij}v_j + \frac{1}{2}\theta_4\theta_i w^{-3}\sum_{i=1}^{4}\sum_{j=1}^{4}\alpha_{ij}v_i v_j\right]
\end{aligned}
\tag{6.13}
$$

Using the definition of restricted profit under a phosphate surplus tax (6.12) and the first order condition for profit maximisation, similar to (6.6), the equation for land demand is derived as:

$$
\begin{aligned}
L^S &= \frac{1}{\rho(w - t(\theta_3\kappa_3 + \theta_4(c_{4a}\cdot\kappa_{4a} + c_{4b}\cdot\kappa_{4b} + c_{4c}\cdot\kappa_{4c})))}\cdot \\
&\left[r - \sum_{i=1}^{4}\zeta_i v_i - w\sum_{k=0}^{7}\mu_k z_k + t\cdot\left\{\kappa_3\left(\zeta_3 + \theta_3\sum_{k=0}^{7}\mu_k z_k\right) + \right.\right. \\
&\left.\left.\left(c_{4a}\cdot\kappa_{4a} + c_{4b}\cdot\kappa_{4b} + c_{4c}\cdot\kappa_{4c}\right)\cdot\left(\zeta_4 + \theta_4\sum_{k=0}^{7}\mu_k z_k\right) - b\right\}\right]
\end{aligned}
\tag{6.14}
$$

Note that all parameters κ and the parameter ρ are negative, so that the denominator is strictly negative. Given this, it can be seen that the threshold level b and the tax rate t increase the demand for land. Furthermore, the impact of prices and fixed input quantities on land demand is moderated by the denominator (if w>1) and the additional term $t\cdot\{\cdot\}$ in (6.14).

The last column in Table 6.1 shows that the elasticities of land demand decline when the phosphate surplus tax is included in the model. The surplus tax can be interpreted as the price of phosphate for dairy farming. The surplus tax and the threshold level for acceptable phosphate application have a small positive effect on land demand.

6.3 Policy simulations

With the model described in the previous section, three policy simulations are conducted. The results of the simulations are compared with a base simulation. The base simulation represents the situation for individual farms in the sample in 1992/93, and covers 27515 farms in the dairy sector (using the weights x_h). Simulated values of the variables in the base simulation are given in Appendix 6.A. The effects of the other simulations are determined for individual farms. However, they are reported only for the weighted average farm and for the weighted average farm with an initial phosphate surplus.

6.3.1 Land demand

The land market is simulated in which 20,000 hectares of farmland (E=20,000) are exogenously supplied[4]. This figure of twenty thousand hectares is based on the net increase of available land in our sample from 1991/92 to 1992/93, which was 21,324 hectares and includes both purchases and new land tenancies. Land demand is simulated using the system in equation (6.9). All farms are regarded as potential land demanders. The farm with the highest shadow price of land buys land. As a result, its shadow price of land decreases to the level of the farm with the next highest shadow price. The farm with the next highest shadow price of land also participates in the demand for land and the land price further decreases. In this way we move along the demand curve for land until the total exogenous supply of land is exhausted. Thus, the equilibrium market price of land is found when the last marginal unit of the exogenous supplied land is purchased.

Farmers are provided with a fixed probability that the land is supplied in their neighbourhood, i.e. the probability that they actually purchase land. For simplicity, the probability is assumed to be the same for all farms in the sample. This simulation is repeated for different values for the probability (1, 0.5, 0.4, 0.3, 0.2 and 0.1). The equilibrium market price on the land market is calculated at the point where the exogenous

[4] The model we use allows us to account for regional differences in the exogenous supply of land in the Netherlands. Thus, regional land markets can be simulated. In order to keep the presentations of the simulations clear, these regional simulations are not included here.

supply of land equals the sum of demand. Farm demand equals farm h's desired demand times the weight factor times the probability (see also the first restriction in equation 6.9). This implies that the market price of land decreases if the probabilities decrease, because farms with lower shadow prices get the opportunity to purchase land. However, given the probabilities, not all farms in the sector will be able to buy[5].

6.3.2 Simulation results for land demand

Table 6.2 shows that, if twenty thousand hectares of land are supplied to our sample of dairy farmers, the equilibrium land price is 3541 guilders per hectare[6] (the probability of purchasing is 1). In this case, there are 1407 farms (5 per cent of all farms) purchasing on average 14.21 hectares. When the probability of purchasing land declines, the market price of land decreases. The number of purchasing farms is larger, although fluctuating, just as the average amount of land bought per transaction is smaller. For the non-purchasing farms nothing changes with respect to the base simulation. Comparing the resulting land market prices in Table 6.2 with the actually observed rent of circa 1700 guilders per hectare (Huntjens, 1996) suggests that the probability of actually purchasing land in the Netherlands is rather low.

Table 6.2: Effects of supplying 20,000 hectares to dairy farming (prices in guilders/hectare).

	Probability of purchasing land					
	1	0.5	0.4	0.3	0.2	0.1
Market price of land	3541	2841	2632	2365	1991	1339
Average shadow price of land for farmers that are willing to buy land before purchase	4746	3777	3588	3296	2877	2335
Average number of purchased hectares per farm	14.21	11.03	11.27	10.98	10.44	11.74
Number of purchasing farms[a]	1407	1813	1774	1822	1916	1704

[a] Number of farms in the sector that are willing to buy land multiplied with the probability.

[5] Resulting values of netputs and profits for the farms in the sector are determined in the same way as the demand for land, i.e. the results (value of netputs and profits) determined under the assumption that the farm in the sample actually buys the desired amount of land multiplied by $P \cdot x_h$, plus the results (value of netputs and profits) if the farm in the sample does not buy the land multiplied by $(1-P) \cdot x_h$.

[6] This price is on an annual basis, therefore it is comparable with the rental price of land.

Table 6.3 shows that an increase in land leads, on average, to less feed purchases and dairy cattle input, and to an increase in other output, other input use and profit. Purchasing land reduces the phosphate surplus, since there is more land available on which to apply the maximum amount of 120 kg phosphate per hectare, and the input of dairy cows decreases. However, reducing the surplus is not a driving factor for purchasing land because there is no penalty for having a phosphate surplus in this simulation, it is merely a result of purchasing land. When the probability of purchasing land is lower the increase in other output and the decrease in purchased feed and dairy cattle become smaller. The increase in other input becomes larger, whereas the increase in profit remains more or less constant.

Table 6.3: Simulation results for the average farm of supplying 20,000 hectares to dairy farming (percentage changes compared to base simulation).

	Probability of purchasing land					
	1	0.5	0.4	0.3	0.2	0.1
Other output	1.96	1.77	1.71	1.63	1.52	1.33
Purchased feed	-2.78	-2.54	-2.46	-2.36	-2.22	-1.99
Dairy cattle	-1.67	-1.40	-1.31	-1.20	-1.04	-0.78
Other input	0.07	0.27	0.34	0.42	0.54	0.73
Profit	0.33	0.34	0.33	0.33	0.33	0.33
Land	2.34	2.34	2.34	2.34	2.34	2.34
Phosphate surplus[a]	-139.08	-129.06	-125.89	-121.82	-116.12	-106.50

[a] Absolute change in kg.

Table 6.4: Simulation results for the average farm with an initial phosphate surplus of supplying 20,000 hectares to dairy farming (percentage changes compared to base simulation).

	Probability of purchasing land					
	1	0.5	0.4	0.3	0.2	0.1
Other output	2.78	2.55	2.47	2.35	2.15	1.83
Purchased feed	-3.71	-3.44	-3.35	-3.21	-2.96	-2.58
Dairy cattle	-2.42	-2.05	-1.93	-1.77	-1.51	-1.11
Other input	0.11	0.41	0.51	0.62	0.77	1.00
Profit	0.47	0.50	0.50	0.49	0.49	0.49
Land	4.18	4.25	4.26	4.25	4.15	4.02
Phosphate surplus[a]	-234.69	-221.41	-216.78	-209.50	-195.61	-174.11

[a] Absolute change in kg.

Table 6.4 shows the results for the average farm with an initial phosphate surplus. These farms buy more land than the average farm, and therefore, the effects on netputs and profit are larger.

6.3.3 Phosphate surplus taxes

The effects of taxing phosphate surpluses for dairy farms are now determined. The surplus tax is 2.5 guilders per kg for phosphate surpluses lower than 10 kg per hectare and 10 guilders per kg for phosphate surpluses larger than 10 kg per hectare (Ministry of Agriculture, 1996). Simulating the effects of a phosphate surplus tax involves four stages (see also Figure 6.1).

In the first stage, the initial phosphate surplus on the farm is determined, using the phosphate production function (equation (6.C.1) in Appendix 6.C) and a threshold of b=120 kg phosphate per hectare. The end solution is obtained for farms that do not have a surplus in this stage (e.g. farm B1 in Figure 6.1). For these farms nothing changes if a tax is introduced.

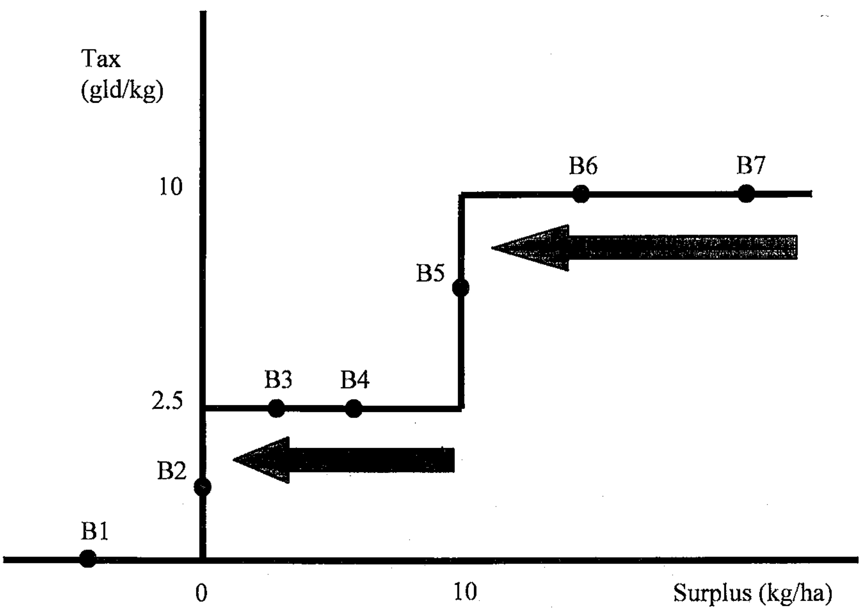

Figure 6.1: (Corner) solutions of simulating phosphate surplus taxes.

In the second stage, farms with an initial surplus of between 0 and 10 kg per hectare are faced with a tax of 2.5 guilders per kg. Farms with a surplus larger than 10 kg per hectare face a tax of 10 guilders per kg, however, the first 10 kg per hectare is charged with the lower tax of 2.5 guilders per kg. Farms with an initial surplus between 0 and 10 kg per hectare (or more than 10 kg per hectare), that still have a surplus between 0 and 10 kg per hectare (or more than 10 kg per hectare) after incorporating the taxes in this stage have reached the end solution (e.g. farms in Figure 6.1 going from B4 to B3 and from B7 to B6 respectively). Corner solutions are obtained for farms which had an initial surplus between 0 and 10 kg per hectare and have no surplus in this stage, or for farms which initially had a surplus of more than 10 kg per hectare and now have a surplus of less then 10 kg per hectare.

In the third stage, for the farms with a corner solution, the surplus is fixed at zero. In the profit maximising process, a farm-specific shadow tax that yields a zero surplus is then calculated. The end solution is obtained for farms with a non-negative shadow tax smaller than 2.5 guilders per kg (e.g. a farm going from B3 or B6 to B2 in Figure 6.1).

For farms with a shadow tax between 2.5 and 10 guilders per kg the surplus is set to be 10 kg per hectare in stage four and the new shadow tax is calculated, which should be between 2.5 and 10 guilders per kg (e.g. a farm going from B6 to B5 in Figure 6.1). If the new shadow tax is smaller than 2.5 guilders per kg, the end solution is obtained at a tax level of 2.5 guilders per kg and the corresponding surplus lies between 0 and 10 kg per hectare (e.g. a farm going from B6 to B4). The (shadow) tax and corresponding surplus in the different stages are used to determine the quantity of netputs and profit.

6.3.4 Simulation results for surplus taxes

When using the estimated phosphate production function (equation 6.12), with initial simulated values of q_3 and q_{4a}, q_{4b} and q_{4c}, the average initial phosphate production is 3824 kg per farm. With a threshold of 120 kg phosphate per hectare, 14 per cent of the farms have an initial surplus between 0 and 10 kg per hectare, 37 per cent have a surplus higher than 10 kg per hectare, and 49 per cent of the farms have no surplus initially. The average surplus per farm is 90 kg (somewhat higher than the 70 kg reported by Silvis and van Bruchem, 1996 p.162). The average surplus for farms that have a surplus is 918 kg per farm, the average for non-surplus farms is -766 kg. The average quantities of inputs, outputs and profit are higher on surplus farms than on non-surplus farms. The average amount of land on surplus farms is lower.

In the simulation, almost all the farms with an initial surplus reach a corner solution. The calculated shadow taxes (relevant for farms with an initial surplus) vary between 0.005 and 5.77 guilders per kg. The average shadow tax for farms with an initial surplus is 0.81 guilders per kg. The effects of introducing a tax on phosphate surpluses are shown in Table 6.5. The average surplus falls from 90 kg to -369 kg, the average surplus for the farm with an initial surplus falls from 918 kg to 15 kg. The reduction in phosphate surplus on farms with an initial surplus is not exactly 100 per cent because some farms reach a corner solution at a surplus of 10 kg per hectare instead of 0 kg and some farms reach a solution between 0 and 10 kg per hectare.

Farms with an initial surplus avoid paying the phosphate tax by reducing the input of dairy cattle. Thus, the flexibility for the farmer is found in adjusting his variable netputs, especially decreasing his dairy herd. Note that the production of milk is fixed in this model because of the quota regime. As a result, farms produce exactly at their quota level and are not allowed to adjust their milk output (not even downwards) by trading quota. The shadow price of milk quota decreases (-1.52 per cent) showing that producing milk has become less attractive. The shadow price of land increases (3.97 per cent for the average farm) because the tax can be avoided if a farm would have more land.

Table 6.5: Simulation results for phosphate surplus taxes (percentage changes compared to base simulation).

	Average farm	Average farm with an initial phosphate surplus
Other output	-0.77	-1.27
Purchased feed	0.28	0.43
Dairy cattle	-14.65	-24.82
Other input	-0.19	-0.33
Profit	-0.01	-0.02
Phosphate surplus[a]	-458.68	-903.29

[a] Absolute change in kg.

6.3.5 Combined land demand and phosphate surplus taxes

Simulating the effects of land demand in combination with a tax on phosphate surpluses involves calculating the market price of land, identifying the potential buyers in the sample and calculating the amount of land that potential buyers would be willing to buy. These results can be aggregated to the sector level and the changes in netputs, profit and phosphate surpluses can be determined.

Land demand by farms (for both surplus and non-surplus farms) is simulated simultaneously with the introduction of the surplus tax. Thus, the system in (6.9), with the profit function given in (6.12) and netput equations (6.13), is simultaneously solved. The procedure followed for the surplus tax is identical to the one described in the previous simulation. After this procedure, potential buyers and their desired land demand are known. However, given the probabilities, only a fraction ($P \cdot x_h$) of all potential buyers can actually buy land. Effects on netputs, profit and phosphate surpluses of the land purchasing farms are calculated as described in footnote 5. For potential buyers that are not able to buy land ($(1-P) \cdot x_h$), the effects on netputs, profit and phosphate surpluses are only determined by the tax (so the outcomes for these farms are identical to calculated effects in the previous simulation).

6.3.6 Simulation results of combined land demand and phosphate surplus taxes

If our sample of dairy farms faces phosphate surplus taxes and at the same time twenty thousand hectares of land is exogenously supplied, the equilibrium market price of land is 3642 guilders per hectare (probability of purchasing is 1, see Table 6.6). Thus, the market price is higher compared with the situation without a surplus tax (see Table 6.2). This effect is expected because introducing a tax increases the demand for land. There are 1392 farms (5 per cent of all farms) purchasing on average 14.37 hectares. From the group of land-purchasing farms, 86 per cent had an initial phosphate surplus, whereas 9 per cent of the farms with an initial surplus purchase land at a probability of 1.

In this simulation almost all surplus farms reach a corner solution. The shadow taxes vary between zero and 3.86 guilders/kg. The average shadow tax for farms with an initial surplus is 0.69 guilders/kg. In comparison to the situation with only a surplus tax both purchasing land and/or adjusting the input of livestock reduces the phosphate surplus.

Table 6.6: Simulation results for the average farm of phosphate surplus taxes and of supplying 20,000 hectares to dairy farming (percentage changes compared to base simulation, market price in guilders/hectare).

	Probability of purchasing land					
	1	0.5	0.4	0.3	0.2	0.1
Market price of land	3642	2903	2690	2403	2019	1346
Other output	1.32	1.11	1.04	0.96	0.84	0.63
Purchased feed	-2.55	-2.30	-2.22	-2.12	-1.98	-1.74
Dairy cattle	-14.04	-13.99	-14.01	-14.01	-14.08	-14.23
Other input	-0.10	0.11	0.17	0.25	0.36	0.56
Profit	0.29	0.31	0.30	0.31	0.31	0.31
Land	2.34	2.34	2.34	2.34	2.34	2.34
Phosphate surplus[a]	-526.14	-523.19	-523.41	-523.07	-524.48	-527.73

[a] Absolute change in kg.

Table 6.7: Simulation results for the average farm with an initial phosphate surplus of phosphate surplus taxes and of supplying 20,000 hectares to dairy farming (percentage changes compared to base simulation).

	Probability of purchasing land					
	1	0.5	0.4	0.3	0.2	0.1
Other output	1.71	1.46	1.37	1.24	1.02	0.67
Purchased feed	-3.35	-3.07	-2.98	-2.84	-2.58	-2.18
Dairy cattle	-23.37	-23.38	-23.45	-23.48	-23.61	-23.90
Other input	-0.16	0.13	0.23	0.34	0.48	0.71
Profit	0.41	0.45	0.45	0.46	0.45	0.46
Land	4.18	4.25	4.26	4.25	4.15	4.02
Phosphate surplus[a]	- 997.13	- 997.61	- 999.74	- 999.76	- 999.82	-1003.65

[a] Absolute change in kg.

Comparing Tables 6.6 and 6.7 shows that, farms with an initial phosphate surplus buy relatively more land but also reduce their livestock more than farms without an initial surplus. The profit of the farms with an initial surplus also increases more. The reduction of the surplus is larger on farms with an initial surplus. Comparing Tables 6.5 and 6.6/6.7 shows that the negative effects of the surplus tax are largely offset by the increase in land. However, the profit increase is of course smaller than in a situation without a surplus tax (Tables 6.3 and 6.4).

6.4 Conclusion and discussion

This chapter develops an empirical micro-simulation model, in which land prices and the demand for land by individual Dutch dairy farms are determined. It also shows how this demand is affected by a phosphate surplus tax. Moreover, the separate effects (not related to land demand) of the phosphate surplus tax for Dutch dairy farming are analysed. The empirical micro-simulation model, based on shadow prices, is a theoretically sound alternative to the net return approach for determining land values and land demand. The complex system of phosphate surplus taxes is smoothly incorporated.

The results show that the equilibrium price in the land market for dairy farms, with perfectly inelastic supply and frictionless demand, is higher than the equilibrium price in the situation with frictions. Comparing the simulated land prices with actual prices suggest that in reality the probability of purchasing land is low, that is, there are substantial imperfections on the demand side of the market.

Since all farms reach corner solutions, the current phosphate surplus tax is an effective instrument to reduce manure surpluses in the Netherlands. In order to avoid paying the tax, farmers sharply reduce the input of livestock in the model. The opportunity to attract additional land has a minor impact on surplus reduction. However, for the average farm, purchasing land offsets the small negative effects of the surplus tax on profit. Introducing the phosphate surplus tax increases the demand for land and therefore the market price of land is higher than in a situation without a surplus tax.

A few remarks should be made regarding our model. First, phosphate surpluses are mainly related to the input of livestock in the model. However, it is not likely that farmers will reduce the number of dairy cows by as much as 25 per cent, while maintaining the level of milk production. In practice, farmers may also transport phosphate (manure) off the farm or reduce the input of phosphate in feed. In the model, these possibilities are not accounted for.

Second, the effects of milk quota trade on land demand are not taken into account. Given the changes in shadow prices for milk quota it is to be expected that, with a phosphate surplus tax and a changed amount of land, farmers also would like to adjust their milk production, by exchanging milk quotas. The large decrease in dairy cattle would then have to go together with selling milk quota (or buying quota would result in a more moderate decrease in dairy cattle). However, given the high shadow prices of milk quota and the minor change in these shadow prices, this effect is probably small.

Finally, for further research it would be interesting to include dynamic elements in the model. Adjustment costs related to land demand and infrequencies of land purchases could then be incorporated. For example, if a farmer gets a chance to buy land only once in a decade, perhaps he would buy more land than is economically efficient.

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Chapter 7 DISCUSSION AND CONCLUSIONS

This final chapter is devoted to the general discussion of the methods used and the results obtained in this thesis. The purpose of the thesis was to assess individual farmers' responses to specific policy changes and therefore also to develop an econometric model of individual dairy farm behaviour. Interesting policy issues for dairy farming were identified and the econometric model was developed and adapted in subsequent chapters to simulate the policy effects for Dutch dairy farms. In the previous chapters, specific issues have already been discussed. In this chapter, more general discussion and conclusions regarding the methodology and the results of the estimations and policy simulations are given. Finally, general conclusions regarding the model are drawn.

7.1 Methodology

7.1.1 Farm level approach

Decisions regarding production, e.g. about what to produce, in which quantities and how to produce it are taken on the individual farms. Reactions to policy changes also differ between farms, because conditions on which policy measures are based often depend on farm-level characteristics. This observation is taken as the starting point of modelling dairy farmers' behaviour at the individual level. Since differences in the efficiency of milk production drive the adjustments to policy changes on the farm, a micro-economic method is required. The farm level approach ensures that the empirical implementation is connected with neoclassical micro-economic theory and that information on production, price and policy are simultaneously considered. A natural approach would be to incorporate all heterogeneity in the behavioural modelling at the individual level, i.e. carrying out a separate simulation of each individual's behaviour. As Stoker (1993) indicated "Microsimulations models have the potential for the most realistic representation of aggregate data movements...". However, these micro-simulation models are practically impossible to implement, because of the large amount of detailed information that is necessary and because of the difficulty of aggregate validation. In this thesis this micro or individual model is combined with an approach that accounts for aggregation over individuals (see e.g. Kleijnen and van Groenendaal, 1992 p.69).

The privilege to use the rich panel data set of the farm accountancy network of the LEI-DLO enabled us to model dairy farming at the individual level. For the sake of a clear presentation, data and results were aggregated for different farm classes (e.g. regions) and for the dairy sector as a whole. Again, this was made possible by the data set that provides a weighting factor denoting the representation of each farm in the sector. However, the weighting factor is based on certain criteria that may differ from the particular variable that is aggregated. Hence, the weighting factor is not an exact base for aggregation, but it is the best available. The composition of the sample also plays a role here. The farm accountancy network does not include very small farms (Reinhard et al., 1995). Moreover, we limited the sample by selecting only those farms that receive more than fifty per cent of their revenues from milk production and that are present in the sample for at least two subsequent years. Therefore, questions related to substitution e.g. switching from milk production to other types of production (agricultural or outside of agriculture) cannot easily be answered because relevant factors, such as the number of hours of family labour supplied outside the farm, are not included in the sample (Elhorst, 1996).

Notwithstanding the fact that we used a micro-simulation model, farms were not analysed in isolation from each other. Prices and most of the estimated behavioural parameters were the same across farms and farms interacted on markets during the simulations.

7.1.2 Econometric model

In agricultural production analysis there are broadly two types of modelling approaches available: mathematical programming and econometric modelling (Rausser, 1982; Oskam et al., 1992). Mathematical programming uses information on the technical features of production on the farm in order to optimise the assumed objectives of the farm. Usually it is based on standard production relations and not on observed results in reality. Thus, one (or a few) typical farm(s) are modelled based on normative behaviour. Effects of changing circumstances, e.g. as a result of new policy, are easily determined by incorporating new production activities or restrictions to the mathematical programming model. At this point it is argued that econometric modelling is inadequate, because it uses perceived historical data to determine farmers behaviour and therefore cannot include new policy measures (e.g. see Berentsen, 1999). However, the way in which the econometric model is used in this thesis, i.e. for simulations, shows that econometric models can be suitable for exploring the future. Hence, historical information on production behaviour and technology was combined with new policy parameters in order to assess the effects of policy measures. This required adapting the models with policy relevant parameters, see section 7.1.3. New technologies, such as the introduction of milking three times a day, are still ignored in such an approach.

For the econometric modelling, the static dual approach was used. The dual model ensures that derivations and results are easily interpreted. Chapter 3 has already discussed why a simple functional form that is applicable for the purpose of the research (i.e. policy simulation) is preferred. Since the normalised quadratic (NQ) is not invariant with the choice of the numeraire and resulted in simulation effects wherein all variability is absorbed by the numeraire, the symmetric normalised quadratic (SNQ) was chosen. A more general discussion on functional forms is given by Oude Lansink and Thijssen (1998).

Taking up all possible outputs and production factors in detail in the profit function would imply that many parameters have to be estimated and a lot of zero-observations would occur, because not all variables are relevant on every farm (although, with the functional forms used in this thesis, zero-observations are easily handled). Therefore, several products and production factors are aggregated into one variable. For example, the variable 'other output' in our model includes all farm products besides milk. Here, again an aggregation problem arises, because a weakly separable profit function is implicitly assumed (Elhorst, 1996; Rausser, 1982). Another problem relates to the way in which inputs and outputs are measured. For example, dairy cattle is measured in terms of annual revenues and costs, which makes it easy to compare and add-up, but is not easy to interpret. How many cows are involved if a farm has 4020 guilders worth of dairy cattle in terms of rental value in 1992/93? Dairy cattle on its own is already a difficult variable because it has both the character of an input and an output. It definitely is an input necessary to produce milk, but redundant cows and calves also generate revenue when they are sold. Moreover, there is the question of cattle being a variable or a fixed input (see below).

Individual farm behaviour could have been emphasised even more by incorporating socio-economic farm characteristics, such as farmers' age and education, composition of the farm household, etc. If the farm is not only viewed as a production unit but also as a consumption unit (because of the family farm structure), the supply of family labour could have been incorporated in the analysis. However, for the purpose of this study, it was not necessary to include these farm characteristics.

The econometric model and estimation procedure used in this thesis includes some marked features. First, as already mentioned, the SNQ was used as a functional form. Second, the regime switch of introducing milk quotas is emphasised. The model includes a dummy that allows for technical change as a result of the introduction of the milk quota system. Apart from this dummy and an annual trend, no specific technical change is modelled. However, the model does allow for differences in technology levels between farms because of the farm-specific intercepts and the differences in the levels of the inputs. Third, dairy cattle is regarded as a variable input because cows are rather easily traded, while in most studies it is assumed to be a fixed input, i.e. livestock capital. The large and unrealistic adjustment in dairy cattle in chapter 6 shows that this also has its disadvantage, especially when milk quotas cannot be easily adjusted. Incorporating the dairy herd as an exogenous variable or constraining the reduction in cow numbers in chapter 6 could have been more appropriate. Moreover, since the rental value based on the inventory value of the herd is used in this thesis, technology shifts may not be measured appropriately. Fourth, the estimation procedure accounts for the difference in the number of observation across the equations in the estimated system, because the milk supply function is only estimated for the observations in the pre-quota period. In earlier econometric estimations that include quota introduction, for example by Helming, Oskam and Thijssen (1993) and Guyomard et al. (1996), it has not become clear if they corrected for the difference in the number of observations.

7.1.3 Simulations

Where the empirical model is based on historical data, i.e. describing behaviour that is the result of existing and past institutions and market conditions, simulations are used to analyse farm behaviour in possible institutional frameworks and market conditions in the future. The policy issues discussed in chapter 2 were translated into specific possible future circumstances, for which the simulations were carried out in the subsequent chapters. The basic empirical model has been the same, that is, behavioural relationships were fixed, however each policy simulation asked for specific adaptations and extensions of the model. In chapter 5 the existing quota volumes were split into A-quota and B-milk volumes, while in chapter 6 a phosphate production function was added to the model. Note that the simulations are valid only within the experimental domain or historical range of the variables in the empirical model.

Simulations are performed for the most recent data of dairy farms in the data set available, i.e. 1992/93. Due to, for example, weather influences, agricultural production and prices can be volatile and the use of data for one year could lead to untypical simulation results. However, the behavioural reactions are estimated on data for the period 1973/74 to 1992/93. Therefore, simulation results will not depend too much on the data of just one year. Moreover, 1992/93 was a rather typical year for dairy farming (van Dijk, Douma and van Vliet, 1995).

The equilibrium conditions imposed during simulation, for example, balancing the demand and supply of milk quotas, are commonly used in micro-economics. In this thesis it is shown how distortions in the market, e.g. due to government regulation or transaction costs, affect the optimum or equilibrium. However, we focused on specified distortions, e.g. the discrepancy between the location of land demand and supply in chapter 6. Thus, any possible unspecified distortion is ignored (e.g. instant adjustment is assumed). Note also that this is a partial equilibrium approach; other markets are assumed not to be affected.

In the short-run model used here, static equilibrium conditions were applied. The volume of assets were fixed at the farm, implying that there was no explicit time path from the initial to the final situation given. Adjustments are assumed to take place instantly. As a consequence, the impact of investments could not be studied. Thus, only short-run quota trade, i.e. quota lease, was analysed and shadow prices of fixed inputs were given in terms of annual rental prices. In this respect, the financial situation of the farm is also important, but not regarded in this thesis. Adjustments at the farm that follow from the economic model could in reality have been prevented because of financial restrictions. Moreover, the group of agents was assumed fixed, i.e. the possibility of new farms entering and incumbent farms exiting the dairy sector is ignored.

7.2 Results and implications

7.2.1 Model validation

The micro-economic model was estimated using annual data from Dutch dairy farms over the period 1973/74 to 1992/93. The performance of the estimated model was measured by the parameter estimations, the elasticities and the shadow prices. Elasticities and shadow prices were calculated for each individual farm and weighted averages were presented. The theoretical assumptions of the static dual micro-economic model were fulfilled, especially the estimates were such that the profit function was convex in prices.

Two types of elasticities were calculated for the data in 1992/93 in chapter 3 and 4. The conditional elasticity is conditional on the fixed volume of milk supply (=quota) on the farm and can be referred to as a short-term elasticity. The unconditional elasticity is an intermediate-term elasticity since milk supply is variable (quotas are tradable), but the fixed inputs are still taken as given. The unconditional own price elasticities were larger (in absolute terms) than the conditional elasticities, satisfying the Le Chatelier-Samuelson principle. Price and quantity elasticities of milk supply had the expected signs (decreasing in netput prices and increasing in fixed input quantities). In chapter 6 the unconditional (land is tradable) elasticities of land demand with respect to netput prices and fixed input quantities were calculated. Introducing a tax on phosphate surpluses at the farm increases the demand for farmland.

It is difficult to compare the elasticities with results from other studies for several reasons. Most of the studies in the literature use aggregate data, which are likely to result in larger elasticities because of changes in the number, size and distribution of farms if prices change and because of the larger price elasticities of mixed farms (Thijssen, 1992). Moreover, if micro data are used, the definition of the inputs and outputs may differ, e.g. Thijssen (1992) distinguishes only one output for dairy farming. Helming, Oskam and Thijssen (1993) used the same type of data as in this thesis and also distinguished two outputs, including milk quota, for dairy farming. However, they reported average elasticities over the period 1970/71-1988/89 and used the NQ as a functional form. Their elasticities are even quite different from the elasticities calculated in this thesis (calculated only for 1992/93).

Shadow prices were calculated in order to determine the value of the fixed inputs and milk quotas for the dairy farms in 1992/93. The fixed inputs and milk quotas are at their long-run equilibrium level if the shadow price equals the actual rental price (Segerson and Squires, 1993). The average calculated shadow price of milk quota was 39 cents per kilogram, while in the same year the actual lease price (after correcting for fat content) was 34 cents per kilogram in the Netherlands. The difference indicates an incentive to invest in quota. However, when regulatory distortions in quota trade are being included in the model (see chapter 4), the calculated shadow price of milk quota becomes 33 cents per kilogram. Compared with the actual lease price, this indicates a quota market that performs at its equilibrium. This result is conditional on the regulatory distortions, assuming that there are no other distortions and of course on the correctness of the model and data used. However, the observed quota lease price is the result of a dynamic process of trading, while in the model quota trade is a one-time event. Resulting shadow prices of quota in the Agenda 2000 and two-tier system (chapter 5) cannot be validated to the actual lease price because conditions differ.

The average shadow price calculated for agricultural land, 1629 guilders per hectare, closely resembled the actual free rental price of land, i.e. demand and supply of grassland for dairy farming are more or less balanced. However, the results in chapter 6 indicate that dairy farmers are willing to purchase additional farmland if more land would be available in the Netherlands, i.e. there is a shortage of farmland. The shadow price of labour, 7.68 guilders per hour, was low compared to hourly earnings of hired farm labour. This is a well-known result in agriculture and indicates either, that agricultural labour is satisfied with lower wages because they are attached to the farm, or official off-farm wages are higher than real off-farm earnings for farm labour (Elhorst, 1996).

7.2.2 Policy simulations

The simulation results of alternative policies in chapters 4, 5 and 6 were compared to a base simulation. The base simulation represented the initial situation for the dairy farms when no additional policies were implemented. When the effect of quota trade was important in the policy analysis (e.g. in chapters 4 and 5), the simulation results were also compared to a base simulation in which milk quotas were efficiently reallocated in a free quota market. Thus, the base simulation is used as the benchmark in our comparative static model.

In chapter 4 we saw that, despite the earlier possibilities for farmers to trade milk quotas (in the period 1984-1992, included in the estimations), the allocation of quotas in 1992/93 could still be improved upon if quota trade were unconstrained. The equilibrium quota price is 0.39 guilders per kg. The effects of a two per cent margin between the buying and selling price of quota, representing transfer costs, are small. However, thresholds in quota trade (minimum supply of ten thousand kg and maximum demand of 75 thousand kg per transaction) result in substantial smaller profit increases. The equilibrium quota price with thresholds is 0.33 guilders per kg. Thus, efficiency gains can be obtained if restrictions on milk quota trade are removed. However, the trade restrictions protect small farms because they gain more from quota trade than large farms. The welfare losses should outweigh the perceived advantages of the quota trade restrictions.

As the shadow prices already indicated, farms at western pastures are net quota suppliers in the unconstrained trade simulation. Thus, quotas are reallocated to sandy soils and the northern parts. This is also the case when a price margin is included. However, the situation changes when thresholds on transactions are imposed. Farms on northern clay also become net quota suppliers and the whole quota flow is in the direction of the sandy soils.

The price of quota in a two-tier system depends on the level of the world market price of quota; the higher the world price, the lower the quota price. Because of the milk price decrease and quota increase, the equilibrium price of milk quota under the Agenda 2000 reform becomes 0.27 guilders per kg (see chapter 5). In the discussion on quota lease, this implies that, in order to obtain lower quota prices, introducing a centralised quota exchange is not required, because quota prices will probably already decrease because of the Agenda 2000 reform. However, the timing aspects should be kept in mind here; Agenda 2000 will show its full effects only in 2008, whereas we simulated it for 1992/93.

The results in chapter 5 show that, in a two-tier milk price system with free quota trade, B-milk will be produced if the world market price is higher than the industries' average marginal costs of producing A-milk (0.31 guilders per kg). In that case, profits will increase. If the world market price of milk were 0.31 guilders per kg, the present level of total milk production would not be exceeded. Provided that the world market price of milk is higher than 0.31 guilders per kg, the quota price under a two-tier system would be lower than the present quota price, because the most efficient farmers will produce B-milk instead of buying A-quota. Moreover, less quota would be traded than currently.

The Agenda 2000 reform for dairy farming, a 15 per cent milk price reduction combined with a 1.5 per cent increase in quotas, results in a 17 per cent fall in profits (defined as the value of netputs). However, with more favourable world market conditions, milk price reduction and profit reduction would probably be less severe. The proposed direct payment per tonne of initial quota (55 guilders) only compensates for 52 per cent of this profit loss. Silvis and van Bruchem (1999) found a cover for 64 per cent of income loss. The profit reduction is mainly due to the decrease in milk prices. Because of the 1.5 per cent quota increase, the demand for variable inputs will increase, while the supply of other output decreases. If quotas were abolished, milk production increases if the price of milk is higher than the current average marginal costs. However, profits decrease, asking for compensating payments. At a world price of 0.60 guilders per kg, the necessary compensation in the case of quota abolishment is smaller than in the Agenda 2000 case, while milk production is higher.

The disadvantages of Agenda 2000, i.e. increased budget costs and the insufficiency to meet future WTO demands, are complemented with strong negative income effects for Dutch dairy farmers. The income of the farmer is guaranteed in a two-tier price system and it serves farmers with some flexibility (partly giving in to the WTO demands). The burden on the government budget in a two-tier system is probably lower because price support, export subsidies and compensation payments are lower. Quota abolition is, from an income point of view, still less attractive for Dutch dairy farmers (although highly dependent on the price at the world market) but more freedom in production could outweigh this disadvantage. The fact that the Dutch government did not opt for quota abolition probably has to do with the fear that a rise in milk production would increase environmental problems and would lead to a weakened financial position of farmers because their quota lose value.

The results in chapter 6 show that the equilibrium price in the land market for dairy farms, with perfectly inelastic supply and frictionless demand, is higher than the equilibrium price in the situation with frictions (i.e discrepancy between the location of land demanded and supplied). Comparing the simulated land prices with actual prices suggest that in reality the probability of purchasing land is low, that is, there are substantial imperfections on the demand side of the market.

The current phosphate surplus tax is an effective instrument to reduce manure surpluses in the Netherlands. In order to avoid paying the tax, farmers reduce the input of livestock. However, it is not likely that farmers will reduce the number of dairy cows by as much as 25 per cent, while maintaining the level of milk production. Using the rental value based on the inventory value of the dairy herd may have contributed to this result. In practice, farmers may also transport phosphate (manure) off the farm or reduce the input of phosphate in feed. In the model, these possibilities are not accounted for. The opportunity to attract additional land has a minor impact on surplus reduction. However, for the average farm, purchasing land offsets the small negative effects of the surplus tax on profit. Introducing the phosphate surplus tax increases the demand for land and therefore the market price of land is higher than in a situation without a surplus tax. The phosphate surplus is reduced by both purchasing land and adjusting the input of livestock. Farms with an initial phosphate surplus buy relatively more land but also reduce their livestock more than farms without an initial surplus. By purchasing land, profit of the farms with an initial surplus increases more than profit of the average farm.

7.3 General conclusions on model use

In constructing and using a model, the model purpose is crucial. The purpose could be descriptive or explanatory analysis, forecasting or policy impact analysis. The latter is of direct interest in policy formulation and usually the most demanding because it also requires the construction of descriptive and causal models. In essence, the research strategy for model development and use (i.e. specification, estimation, validation and effective use of economic models) is determined by the trade-off between simplicity and accuracy of the model (Rausser, 1982). In this thesis, the modelling is typically intended to support policy analysis for Dutch dairy farming. Major issues of the model specification (e.g. the appropriate level of aggregation, the selection of endogenous and explanatory variables, the choice between a stochastic and a deterministic model or between a static and a dynamic model), estimation and validation have already been discussed. However, the question remains if the model is appropriate for answering dairy policy questions accurately.

The micro-economic model developed in this thesis is a single-purpose model in the sense that it is intended to support dairy policy analysis. However, where it is used to analyse different types of policies relevant to dairy farming it is a multi-purpose model. Once the basic model is available, it should be adapted in order to address specific policy questions. Thus, quick answers are not to be expected by this procedure, but it provides relevant and interesting policy insights. The micro-econometric and micro-simulation approach ensures that systematic individual differences in economic behaviour are accounted for.

Model outcomes should be used as an indication of the direction and size of the effects of policy changes, relative to the value of the exogenous variables. Results generated by simulating variables beyond their historic range should carefully be interpreted. The choice of the functional form for the empirical model is especially important if the model is to be used for simulating policy issues. Simulating alternative policies requires appropriate model adjustments and additions. Of course, this type of modelling and simulating is only possible if the proper data is available. Developing and adjusting the model take some time, therefore this type of modelling is less adequate in giving rapid response to requests for policy impact scenarios.

To conclude, the empirical micro-economic model developed in this thesis proved to be a flexible tool for analysing alternative policies. The approach of combining historical information on production technology and production behaviour of individual farmers with information on future or new policy measures is suitable for analysing policy effects at the farm level.

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APPENDIX

3.A: Normalised Quadratic

For each farm h and year t, the normalised quadratic restricted profit function (Moschini, 1988) is written as:

$$\tilde{g}_{ht}(\tilde{v}_{it}, q_{0ht}, z_{kht}) = \alpha_{0h} + \sum_{i=1}^{3}\alpha_{ih}\tilde{v}_{it} + \varepsilon q_{0ht} + \sum_{k=1}^{8}\beta_k z_{kht} + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3}\alpha_{ij}\tilde{v}_{it}\tilde{v}_{jt} +$$
$$\sum_{i=1}^{3}\zeta_i\tilde{v}_{it}q_{0ht} + \sum_{i=1}^{3}\sum_{k=1}^{8}\gamma_{ik}\tilde{v}_{it}z_{kht} + \frac{1}{2}\rho q_{0ht}q_{0ht} + \qquad (3.A.1)$$
$$\sum_{k=1}^{8}\mu_k z_{kht}q_{0ht} + \frac{1}{2}\sum_{k=1}^{5}\sum_{n=1}^{5}\beta_{kn}z_{kht}z_{nht} + \sum_{k=1}^{5}\sum_{n=6}^{8}\beta_{kn}z_{kht}z_{nht}$$

The last term in the restricted profit function indicates that the cross-products of the dummies are not taken into account. Farm h specific parameters are denoted by α_{0h} and α_{ih}. Symmetry is maintained by requiring $\alpha_{ij}=\alpha_{ji}$ and $\beta_{kn}=\beta_{nk}$. The normalised prices $\tilde{v}_i$ (i=1,2,3) ensure that the profit function is linear homogeneous in prices. The price of other input is used as the numeraire. Furthermore, the profit function is convex in prices if the Hessian matrix of prices is positive semi-definite.

Using Hotelling's lemma, the supply function for other output and demand equations for feed and dairy cattle (i=1,2,3) are derived:

$$q_{iht} = \alpha_{ih} + \sum_{j=1}^{3}\alpha_{ij}\tilde{v}_{jt} + \zeta_i q_{0ht} + \sum_{k=1}^{8}\gamma_{ik}z_{kht} \qquad (3.A.2)$$

Note that the netput equations contain a farm-specific intercept. The demand for other input follows from the definition of normalised profit, $\tilde{g}_{ht} = \sum_{i=1}^{3}\tilde{v}_{it}q_{iht} + q_{4ht}$, and is:

$$q_{4ht} = \alpha_{0h} + \varepsilon q_{0ht} + \sum_{k=1}^{8}\beta_k z_{kht} - \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3}\alpha_{ij}\tilde{v}_{it}\tilde{v}_{jt} + \frac{1}{2}\rho q_{0ht}q_{0ht} +$$
$$\sum_{k=1}^{8}\mu_k z_{kht}q_{0ht} + \frac{1}{2}\sum_{k=1}^{5}\sum_{n=1}^{5}\beta_{kn}z_{kht}z_{nht} + \sum_{k=1}^{5}\sum_{n=6}^{8}\beta_{kn}z_{kht}z_{nht} \qquad (3.A.3)$$

The model is completed by the milk supply function, which is only valid in the pre-quota period. Note that the milk supply function does not include a farm-specific intercept.

$$q_{0ht} = -\frac{1}{\rho}\left[\tilde{v}_{0t} + \varepsilon + \sum_{i=1}^{3}\zeta_i\tilde{v}_{it} + \sum_{k=1}^{8}\mu_k z_{kht}\right] \tag{3.A.4}$$

After the introduction of the quota system, milk supply is exogenously given for the individual farm and the milk supply equation does not apply. The marginal cost of milk supply, that is, the price that would have given rise to producing at the quota level, is given by:

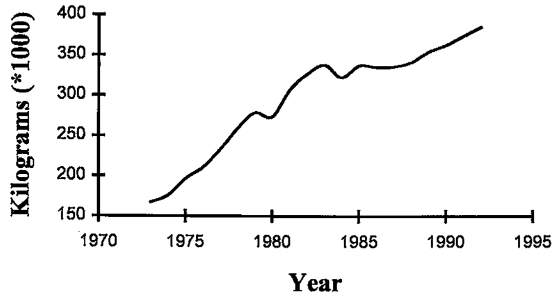
$$s_{0ht} = -\left[\varepsilon + \sum_{i=1}^{3}\zeta_i\tilde{v}_{it} + \rho q_{0ht} + \sum_{k=1}^{8}\mu_k z_{kht}\right] \tag{3.A.5}$$

The farm shadow price of milk quota, r_{ht}, equals v_{0t}-s_{0ht}. The shadow prices of the quasi-fixed inputs (k=1,..,5) are calculated as:

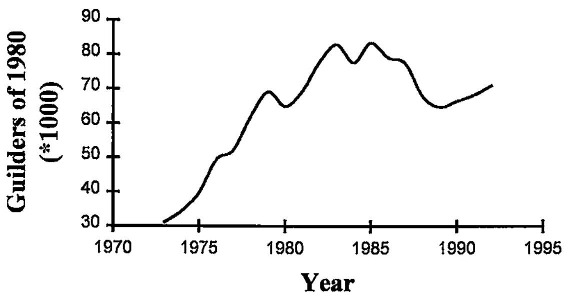
$$s_{kht} = \beta_k + \sum_{i=1}^{3}\gamma_{ik}\tilde{v}_{it} + \mu_k q_{0ht} + \sum_{n=1}^{8}\beta_{kn}z_{nht} \tag{3.A.6}$$

3.B: Data for the average specialised dairy farm (yearly weighted averages).

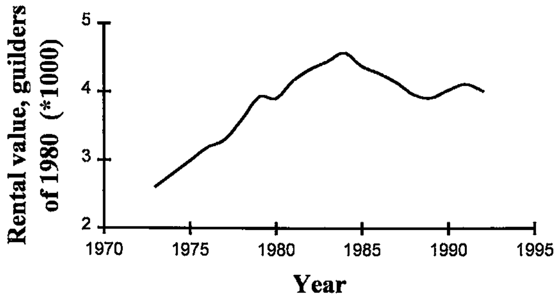
Milk production



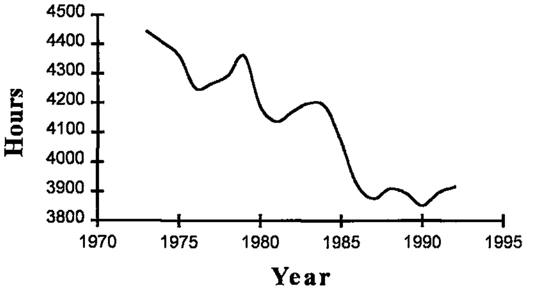
Purchased feed



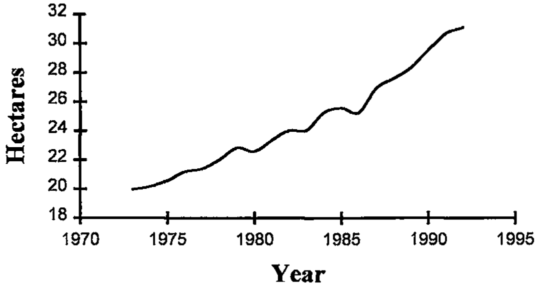
Dairy cattle



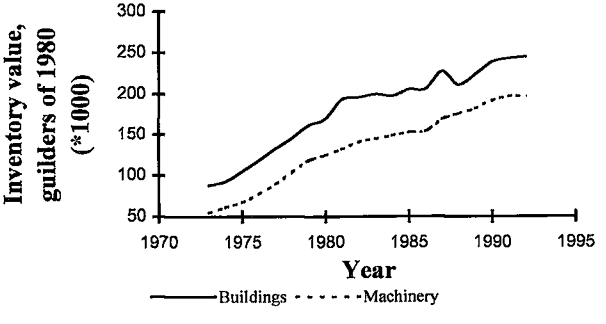
Labour



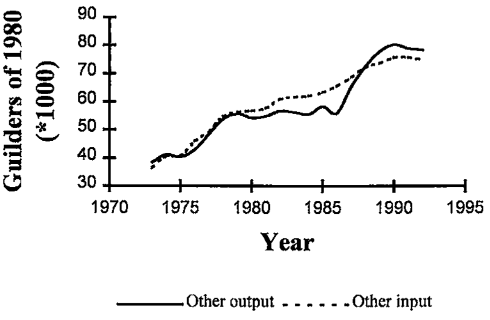
Land



Buildings and machinery



Other output and other input



3.C: Results of the estimation including fixed effects in the milk supply equation (SNQfem) and of the weighted estimation (SNQweight).

Parameter	SNQfem		SNQweight		Parameter	SNQfem		SNQweight	
	Estimate	t-ratio	Estimate	t-ratio		Estimate	t-ratio	Estimate	t-ratio
α_{11}	16.970	5.38	14.256	5.52	γ_{48}	11.847	0.79	1.813	0.15
α_{12}	1.789	0.93	1.882	1.25	ρ	-0.011	-16.92	-0.010	-11.60
α_{13}	-1.451	-3.85	-1.309	-2.72	μ_1	1.0E-4	9.69	6.0E-5	7.05
α_{22}	2.391	1.20	2.962	1.92	μ_2	0.027	12.76	0.026	11.31
α_{23}	-0.425	-3.18	-0.258	-1.56	μ_3	0.002	12.91	0.003	11.04
α_{33}	1.586	5.14	1.479	3.67	μ_4	0.006	14.65	0.005	10.56
ζ_1	0.107	9.78	-0.287	-17.71	μ_5	0.041	9.21	1.9E-5	0.01
ζ_2	-0.306	-36.55	-0.697	-45.89	μ_6	-0.530	-16.98	0.165	1.82
ζ_3	-0.011	-22.40	-0.033	-29.08	μ_7	0.064	0.53	0.012	0.67
ζ_4	-	-	-0.167	-10.15	μ_8	0.034	0.26	-0.093	-4.43
γ_{11}	7.4E-6	0.00	0.004	2.39	β_{11}	3.5E-7	0.38	4.9E-7	0.43
γ_{12}	1.209	5.99	1.522	6.49	β_{12}	3.5E-6	0.04	-7.5E-5	-0.67
γ_{13}	0.124	7.93	0.051	2.93	β_{13}	-2.0E-5	-2.85	-1.6E-5	-1.89
γ_{14}	0.093	2.97	0.272	6.72	β_{14}	-9.3E-5	-6.47	-1.0E-4	-5.45
γ_{15}	0.003	0.00	-0.585	-0.85	β_{15}	-3.5E-5	-0.11	0.001	1.64
γ_{16}	4.463	0.57	-5.442	-0.71	β_{16}	0.002	1.00	-0.003	-1.29
γ_{17}	-0.776	-0.06	-2.019	-0.20	β_{17}	0.003	0.84	4.0E-4	0.12
γ_{18}	-5.288	-0.34	-19.215	-1.43	β_{18}	0.003	0.76	-0.001	-0.28
γ_{21}	-0.003	-1.62	0.002	0.88	β_{22}	-0.152	-9.45	-0.106	-6.12
γ_{22}	1.561	7.62	1.840	7.71	β_{23}	-0.005	-4.61	-0.005	-3.65
γ_{23}	0.068	4.20	0.003	0.17	β_{24}	-0.003	-1.81	-0.007	-3.06
γ_{24}	0.068	2.11	0.273	6.55	β_{25}	-0.127	-3.22	-0.091	-1.98
γ_{25}	0.236	0.32	-0.798	-1.13	β_{26}	2.336	7.98	0.751	1.68
γ_{26}	3.637	0.45	-5.372	-0.67	β_{27}	-0.278	-0.53	0.082	0.14
γ_{27}	-1.550	-0.13	-3.036	-0.31	β_{28}	-1.195	-1.76	0.166	0.22
γ_{28}	9.249	0.60	-5.462	-0.42	β_{33}	-3.8E-4	-4.42	-0.001	-5.66
γ_{31}	-1.6E-4	-1.61	1.0E-4	0.87	β_{34}	-0.001	-6.69	-0.002	-8.10
γ_{32}	0.022	1.64	0.041	2.62	β_{35}	-0.013	-3.74	0.011	2.87
γ_{33}	0.006	6.06	0.001	1.13	β_{36}	0.094	3.84	-0.127	-3.39
γ_{34}	0.003	1.34	0.016	5.69	β_{37}	-0.025	-0.86	-0.035	-1.03
γ_{35}	0.029	0.61	-0.044	-0.94	β_{38}	0.023	0.73	0.014	0.43
γ_{36}	0.279	0.53	-0.309	-0.59	β_{44}	-0.004	-10.23	-0.003	-5.71
γ_{37}	0.307	0.44	0.111	0.16	β_{45}	-0.008	-1.17	0.002	0.21
γ_{38}	0.710	0.74	-0.291	-0.33	β_{46}	0.129	2.87	-0.188	-2.95
γ_{41}	-0.004	-2.70	0.001	0.43	β_{47}	0.004	0.06	-0.015	-0.19
γ_{42}	-1.108	-5.69	-0.571	-2.53	β_{48}	-0.026	-0.32	0.172	1.87
γ_{43}	0.078	5.13	0.005	0.27	β_{55}	0.410	1.98	0.200	0.98
γ_{44}	-0.011	-0.35	0.159	4.05	β_{56}	-3.035	-1.56	1.184	0.60
γ_{45}	-1.389	-2.00	-1.726	-2.57	β_{57}	-0.054	-0.05	0.490	0.46
γ_{46}	7.674	1.01	-3.139	-0.42	β_{58}	0.794	0.66	-0.629	-0.53
γ_{47}	1.625	0.14	0.795	0.08	ε	-0.390	-2.68	-	-
Observations	9 365								
Farms	1 961								
Period	1973/74-1992/93								

4.A: Data and base simulation (between brackets) for average specialised dairy farms in 1992/93.

	Dimension	θ	$\bar{v}_j$	Price index[a]	Sandy soils	Northern clay	Western pastures	Total sector
(No. of farms)					(14 517)	(6 888)	(6 110)	(27 515)
Milk output	Kilogram *1000	-	-	1.17	366.412	441.047	365.380	384.868
Other outputs	Guilders *1000	0.323	1.04	1.05	84.121	72.112	72.243	78.477
	(1980/81 prices)				(87.603)	(75.379)	(75.114)	(81.769)
Purchased feed	Guilders *1000	0.337	0.94	0.82	73.321	70.348	66.626	71.090
	(1980/81 prices)				(69.174)	(70.010)	(64.364)	(68.315)
Dairy cattle	Guilders *1000	0.022	1.04	1.12	3.852	4.562	3.809	4.020
	(1980/81 prices)				(3.743)	(4.463)	(3.685)	(3.910)
Other inputs	Guilders *1000	0.317	0.98	1.14	81.134	69.382	66.349	74.909
	(1980/81 prices)				(82.051)	(71.241)	(67.539)	(76.122)
Profits	Nominal guilders *1000	-	-	-	189.364	244.293	198.531	205.151
					(195.508)	(245.999)	(202.190)	(209.632)
Labour	Hours	-	-	-	3869	4054	3871	3916
Land	Hectares	-	-	-	28.738	37.790	29.244	31.117
Buildings	Inventory value, guilders *1000 (1980/81 prices)	-	-	-	235.160	277.324	233.572	245.363
Machinery	Inventory value, guilders *1000 (1980/81 prices)	-	-	-	195.540	211.498	184.619	197.110

[a] 1980/81=1.00, w=1.003 in 1992/93.

6.A: Data and base simulation for the average specialised dairy farm in 1992/93.

	θ[a]	Price index[b]	Dimension	Data	Base simulation	
					Quantity	Shadow price
Milk output	.	1.17	Kilogram *1000	384.868	.	0.311
Other outputs	0.323	1.05	Guilders *1000 (1980/81 prices)	78.477	81.769	.
Purchased feed	0.337	0.82	Guilders *1000 (1980/81 prices)	71.090	68.315	.
Dairy cattle	0.022	1.12	Guilders *1000 (1980/81 prices)	4.020	3.910	.
Other inputs	0.317	1.14	Guilders *1000 (1980/81 prices)	74.909	76.122	.
Profit	.		Nominal guilders *1000	205.151	209.632	.
Labour	.		Hours	3916	.	7.676
Land	.		Hectares	31.117	.	1629
Buildings	.		Inventory value, guilders *1000 (1980/81 prices)	245.363	.	0.036
Machinery	.		Inventory value, guilders *1000 (1980/81 prices)	197.110	.	0.086
Phosphate production	.		Kilogram	4057	3824	.
Other bovine cattle[c]	.		Guilders *1000 (1980/81 prices)	2.394	2.452	.
Pigs[c]	.		Guilders *1000 (1980/81 prices)	0.315	0.322	.
Other livestock[c]	.		Guilders *1000 (1980/81 prices)	0.186	0.193	.

[a] Note that $w = \sum_{l=1}^{4} \theta_l v_{lt}$ in 1992/93 equals 1.003. [b] 1980/81=1.00. [c] Two farms (0.5 per cent) have no other bovine cattle, 331 farms (81 per cent) have no pigs and 277 farms (68 per cent) have no other livestock.

6.B: Estimation results.

Parameter	Estimate	t-ratio	Parameter	Estimate	t-ratio
α_{11}	18.163	5.69	γ_{47}	1.180	0.08
α_{12}	2.382	1.24	ρ	-0.085	-5.27
α_{13}	-1.662	-3.08	μ_0	0.020	10.72
α_{22}	2.619	1.32	μ_1	2.3E-5	0.22
α_{23}	-0.453	-2.39	μ_2	-0.004	-2.99
α_{33}	1.752	3.96	μ_3	-0.006	-2.69
ζ_1	1.405	5.58	μ_4	-0.089	-1.85
ζ_2	1.775	6.89	μ_5	1.277	2.59
ζ_3	0.035	2.10	μ_6	0.098	0.16
ζ_4	-0.860	-3.53	μ_7	0.045	0.06
γ_{10}	-0.247	-16.58	β_{00}	-0.009	-11.17
γ_{11}	0.004	2.20	β_{01}	5.4E-5	6.70
γ_{12}	0.059	3.07	β_{02}	0.003	10.61
γ_{13}	0.292	6.75	β_{03}	0.004	10.17
γ_{14}	-0.976	-1.10	β_{04}	0.007	2.22
γ_{15}	-7.595	-0.77	β_{05}	0.102	1.08
γ_{16}	-0.972	-0.07	β_{06}	0.038	2.00
γ_{17}	-15.583	-0.97	β_{07}	-0.108	-4.63
γ_{20}	-0.678	-48.65	β_{11}	5.2E-7	0.45
γ_{21}	0.002	0.97	β_{12}	-8.4E-6	-0.98
γ_{22}	-0.001	-0.04	β_{13}	-1.2E-4	-6.07
γ_{23}	0.276	6.18	β_{14}	0.001	2.07
γ_{24}	-0.785	-0.86	β_{15}	-0.005	-1.62
γ_{25}	-9.075	-0.88	β_{16}	-0.001	-0.21
γ_{26}	-1.730	-0.14	β_{17}	-0.001	-0.20
γ_{27}	-1.632	-0.10	β_{22}	-0.001	-5.75
γ_{30}	-0.035	-35.47	β_{23}	-0.002	-7.16
γ_{31}	1.3E-4	0.96	β_{24}	0.007	1.57
γ_{32}	0.002	1.71	β_{25}	-0.102	-2.42
γ_{33}	0.017	5.70	β_{26}	-0.073	-1.97
γ_{34}	-0.046	-0.77	β_{27}	-0.021	-0.52
γ_{35}	-0.510	-0.76	β_{33}	-0.002	-5.14
γ_{36}	0.294	0.35	β_{34}	-0.004	-0.44
γ_{37}	-0.004	-0.00	β_{35}	-0.171	-2.69
γ_{40}	-0.179	-11.98	β_{36}	0.072	0.84
γ_{41}	4.6E-4	0.24	β_{37}	0.265	2.56
γ_{42}	0.014	0.78	β_{44}	0.246	0.93
γ_{43}	0.191	4.53	β_{45}	1.385	0.55
γ_{44}	-2.332	-2.69	β_{46}	-0.254	-0.19
γ_{45}	-4.926	-0.51	β_{47}	-1.221	-0.79
γ_{46}	1.662	0.14			
Observations	9365				
Farms	1961				
Period	1973/74-1992/93				

6.C: Estimation of the phosphate production function

A weighted OLS estimation procedure is used to estimate the phosphate production function. The data provides a weighting factor for each farm in each year, denoting the number of farms in the sector that are represented by the farm in the sample. The phosphate production function is estimated for the 409 observations (=farms) in the sample in 1992/93, representing 27515 farms in the sector. Data regarding phosphate production for the average farm in 1992/93 are reported in the bottom part of the table in Appendix 6.A.

$$\begin{array}{lllll} m = & -797.84 \cdot q_3 & -212.34 \cdot q_{4a} & -306.50 \cdot q_{4b} & -437.89 \cdot q_{4c} \\ & (-25.30) & (-4.23) & (-4.80) & (-3.98) \end{array} \qquad (6.C.1)$$

Here the t-ratios are given in brackets and R^2 is 0.69. Note that the variables on the right hand side have the expected sign because the netputs q_3 and q_{4a} to q_{4c} are inputs and therefore have negative values. The estimation results imply that the numbers of dairy cows, other bovine cattle, pigs and other livestock are positively related to phosphate production.

SUMMARY

The dairy sector is to a large extent influenced and restricted by environmental and agricultural policies. These policies are often very detailed in nature and oriented at the farm level. That is, policy measures and regulations, such as taxes and support payments often depend on local farm circumstances and farm management. Dairy farmers constantly face minor and major policy changes, causing farm-specific uncertainties and adjustments in production. This thesis aims to quantify the effects of specific policies on production decisions and profit of individual Dutch dairy farms. Thus, the individual behaviour of dairy farmers in response to policy changes is the main focus here.

Chapter 2 describes some of the relevant policies faced by dairy farms and serves as background for the research and delineates the research questions of the thesis. A distinction is made between policies directed by the EU, such as the Common Agricultural Policy (CAP) with respect to dairy and the milk quota system, and typical Dutch policies, especially quota trade and manure policy. In these fields policy changes are expected or recently introduced.

The supply constraint, enforced by the milk quota regime, combined with the price support and border protection measures, play a central role in dairy policy. However, the EU seeks to readjust dairy policy. The alternative EU policies analysed in this thesis are a two-tier milk price system, quota abolition, and the Agenda 2000 reform, which includes quota increases, price cuts and compensating premiums. Within the milk quota system, quota mobility and the organisation of quota trade have been debated constantly. In the Netherlands, milk quotas are traded in a fairly liberal quota market. The efficiency of milk quota trade and the effects of distortions in quota trade are analysed. Another policy issue of interest for Dutch dairy farms consists of the nutrient surplus taxes recently introduced. The effects of phosphate surplus taxes, especially in relation to the demand for farmland, are investigated.

An empirical economic model of the production behaviour of dairy farming is developed and applied to determine the effects of policy changes. It is assumed that farmers react differently to policy changes, especially because policies become increasingly farm-specific. Therefore, a micro-economic approach is used. The micro-economic model for analysing production behaviour and profit of dairy farms that are

subject to milk quotas is developed in chapter 3. The decisions behind model choices are explained and some alternative specifications and estimations are reported. Moreover, the data that is used throughout the thesis, as well as estimation results are discussed.

The basic theoretical assumption is that dairy farmers maximise profits in the short run, while facing technical and market restrictions. When farm-level effects of policy changes are determined, they are aggregated in order to resolve the effects for the dairy sector. The availability of a rich panel data source, provided by LEI-DLO, allowed us to identify dairy farmers' behaviour at the micro level and check the theoretical assumptions. In this thesis the static dual approach is adopted, using a flexible functional form specification for the profit function. Micro level demand and supply equations were derived and a fixed-effects model was used, which assumes equal functional forms across farmers, however with different intercepts. The analysis relied on a strong empirical orientation, hence technical details of policy changes were explicitly incorporated. The model is estimated with data on 1961 dairy farms over the period 1973/74 to 1992/93.

The empirical model consists of a system of simultaneous equations, which accounts for the introduction of milk quotas (a regime switch) through a difference in the number of observations across equations. Since estimating such a model, using an unbalanced panel data set, is complicated, the structure of the model is kept as simple as possible (keeping in mind also the applicability for policy simulations). Therefore, the normalised quadratic (NQ) would have been preferred to the symmetric normalised quadratic (SNQ) as a functional form. However, the NQ is not invariant with the numeraire and resulted in one-sided simulation effects, that is, all variability is absorbed by the variable used as the numeraire. The SNQ is used to avoid this problem.

Two alternative estimation procedures, using the SNQ, are compared with the central model that is used further in this thesis. The data used are selected from a stratified sample of farms, which gives an opportunity to obtain weighted estimators. Estimation results of the weighted estimation are similar to the results of the unweighted estimation. However, further research is necessary to test for the difference between weighted and unweighted estimation. The estimation of the central model does not account for the weights. Weighting factors are only used to present averages and totals.

The available panel data set makes it possible to apply fixed effects or random effects estimators. In this study the fixed effects model is used, because the model is mainly used to make inferences about the behaviour of individual farms in the sample. A more complicated system, i.e. including additional fixed effects in the milk supply equation, was also estimated. However, they could only be derived for the pre-quota period, whereas the model is used for simulating behaviour in the post-quota period (the most recent year, 1992/93, is taken as the base year).

In chapter 4 the issues of milk quota trade efficiency and resulting quota prices are addressed. Although the Dutch quota market is known as fairly liberal, there still exist some distortions in quota trade, resulting in efficiency losses for dairy farming. Distortions are caused by limits on the amount of quota that can be traded according to the regulations. Costs related to transaction services by a middleman or a notary are less visible. Both types of trade distortions are simulated and compared with unconstrained quota trade. Unconstrained tradability of milk quotas increases total profit by 9 per cent and reallocates quotas from farmers on western pastures to farmers on sandy soils and the northern clay and peat area. The equilibrium quota price is 0.39 guilders per kg. The effects of a two per cent margin between the buying and selling price of quota, representing transfer costs, are small. However, thresholds in quota trade (minimum supply of ten thousand kg and maximum demand of 75 thousand kg per transaction) result in substantial smaller profit increases and farmers in the northern clay and peat area switch from being net buyers to net suppliers of milk quota. The equilibrium quota price with thresholds is 0.33 guilders per kg. Thus, efficiency gains can be obtained if restrictions on milk quota trade are removed. However, the trade restrictions protect small farms because they gain more from quota trade than large farms.

The effects of alternative EU dairy policy changes are assessed in chapter 5. The theoretical model is extended to allow for a two-tier milk price system, in which A-milk is produced at a supported milk price and farmers are allowed to produce additional B-milk at the lower world market price. Further complication is introduced by simulating a two-tier system in which milk quota trade occurs. Moreover, quota abolition and the agreed price cuts for dairy products and quota increases of Agenda 2000 are simulated. In a two-tier milk price system with free quota trade, B-milk will be produced if the world market price is higher than the industries' average marginal costs of producing A-milk (0.31 guilders per kg). In that case, profits will increase. If the world market price of milk were 0.31 guilders per kg, the present level of total milk production would not be exceeded. Provided that the world market price of milk is higher than 0.31 guilders per kg, the quota price under a two-tier system would be lower than the present quota price, because the most efficient farmers will produce B-milk instead of buying A-quota. Moreover, less quota will be traded than currently.

The Agenda 2000 reform for dairy farming, a 15 per cent milk price reduction combined with a 1.5 per cent increase in quotas, results in a 17 per cent fall in profits. The proposed direct payment per tonne of initial quota (55 guilders) only compensates for 52 per cent of this profit loss. The profit reduction is mainly due to the decrease in milk prices. Because of the 1.5 per cent quota increase, the demand for variable inputs will increase, while the supply of other output decreases. If quotas were abolished, milk production would increase if the price of milk were higher than the current average marginal cost. However, profits decrease, asking for compensating payments. At a world price of 0.60 guilders per kg, the necessary compensation in the case of quota abolition is smaller than in the Agenda 2000 case, while milk production is higher.

The disadvantages of Agenda 2000, i.e. increased budget costs and the failure to meet future WTO demands, are complemented with strong negative income effects for Dutch dairy farmers. The income of the farmer is guaranteed in a two-tier price system and it offers farmers some flexibility (partly giving in to the WTO demands). The burden on the government budget in a two-tier system is probably lower because price support, export subsidies and compensation payments are lower. Quota abolition is, from an income point of view, still less attractive for Dutch dairy farmers (although highly dependent on the price at the world market) but more freedom in production could outweigh this disadvantage. The fact that the Dutch government did not opt for quota abolition probably has to do with the fear that a rise in milk production would increase environmental problems and would lead to a weakened financial position of farmers because their quota loses value.

In chapter 6, the core issues are land demand and the introduction of phosphate surplus taxes. The model is adapted in order to simulate an imperfect market for farmland. Additionally, phosphate surplus taxes per farm are calculated and incorporated in the model in such a way that the surplus tax to be paid depends on the amount of farmland and the input of livestock. The equilibrium price in the land market for dairy farms, with perfectly inelastic supply of twenty thousand hectares and frictionless demand, is higher than the equilibrium price in the situation with frictions. Frictions in the land market are caused by discrepancy between the location of the land supplied and demanded. The phosphate surplus tax is an effective instrument to reduce manure surpluses in dairy farming. In order to avoid paying the tax, farmers reduce the input of livestock. However, it is not likely that farmers will reduce the number of dairy cows by as much as 25 per cent, while maintaining the level of milk production. In practice, farmers may also transport phosphate (manure) off the farm or reduce the input of phosphate in feed. In the model, these possibilities are not accounted for. The opportunity to attract additional land has a minor impact on surplus reduction. However, for the average farm, purchasing land offsets the small negative effects of the surplus tax on profit. Introducing the phosphate surplus tax increases the demand for farmland and therefore the equilibrium price of land is higher than in a situation without a surplus tax.

Finally, in chapter 7 the various policy simulations and their effects for dairy farming are discussed. The model is evaluated on its theoretical and practical applications. The empirical micro-economic model presented in this thesis is a flexible tool to show short-term behaviour of individual Dutch dairy farms in response to policy changes. The approach of combining historical information on production technology and production behaviour with information on future or new policy measures is suitable for analysing policy effects at the farm level.

SAMENVATTING

De zuivelsector wordt in hoge mate beïnvloed en beteugeld door het landbouw- en milieubeleid. Dit beleid is vaak tot in detail uitgewerkt en gericht op het bedrijfsniveau. Dat wil zeggen dat beleidsmaatregelen, zoals belastingen en inkomenssteun, vaak gebaseerd zijn op lokale bedrijfsomstandigheden en afhankelijk zijn van het bedrijfsmanagement. Melkveehouders hebben doorlopend te maken met kleine en grote beleidsveranderingen, welke bedrijfsspecifieke onzekerheden en aanpassingen in de bedrijfsvoering met zich meebrengen. Dit proefschrift heeft tot doel de effecten van specifieke beleidsmaatregelen op produktiebeslissingen en winsten van individuele Nederlandse melkveehouders te kwantificeren. De individuele reactie van melkveehouders op beleidsveranderingen staat hier dus centraal.

Hoofdstuk 2 geeft een beschrijving van enkele relevante vormen van beleid waarmee melkveehouders te maken hebben. Het hoofdstuk geeft achtergrondinformatie en bakent de onderzoeksvragen voor dit proefschrift af. Onderscheid wordt gemaakt tussen het beleid dat door de Europese Unie (EU) wordt opgelegd, zoals het gemeenschappelijk landbouwbeleid met betrekking tot zuivelprodukten en het melkquotum systeem, en typisch Nederlands beleid, zoals de quotumhandel en het mestbeleid. Op deze terreinen worden beleidsveranderingen verwacht of zijn zij recentelijk doorgevoerd.

Produktiebeperkingen binnen het melkquotum systeem, in combinatie met prijssteun en beschermende maatregelen aan de grens, spelen een centrale rol in het zuivelbeleid. De EU wil het zuivelbeleid echter wijzigen. Alternatieven voor het EU zuivelbeleid die in dit proefschrift worden uitgewerkt zijn een tweeprijzen systeem, afschaffing van de quota en de Agenda 2000 hervormingen waarin verruiming van het quotum wordt gecombineerd met prijsdalingen en compensatiebetalingen. Binnen het melkquotum systeem zijn de quotummobiliteit en de organisatie van de quotum handel constante onderwerpen van discussie. In Nederland bestaat een redelijk vrije handel in melk quota. De efficiency van quotumhandel en de effecten van belemmeringen in de quotummarkt worden in dit proefschrift geanalyseerd. Daarnaast is de recentelijk ingevoerde heffing op het fosfaat en nitraat overschot van belang voor de melkveehouderij. De effecten van een fosfaat overschotheffing, in combinatie met de vraag naar landbouwgrond, worden tevens onderzocht in dit proefschrift.

Om de effecten van beleidsveranderingen te bepalen, wordt een empirisch model van het produktiegedrag van melkveehouders ontwikkeld en toegepast. Er wordt verondersteld dat melkveehouders verschillend reageren op beleidsveranderingen, met name omdat beleidsmaatregelen gebaseerd zijn op bedrijfsspecifieke omstandigheden. Een micro-economische aanpak wordt daarom gebruikt. In hoofdstuk 3 wordt het micro-economisch model voor de analyse van het produktiegedrag van melkveehouders, die te maken hebben met een melkquotum, ontwikkeld. Overwegingen en keuzen ten aanzien van het model worden verklaard en enkele alternatieve modelspecificaties en schattingen worden besproken. Verder worden de gebruikte data en schattingsresultaten besproken.

De centrale theoretische veronderstelling is dat melkveehouders hun korte termijn winsten maximaliseren, gegeven een aantal technische en markt restricties. Berekende beleidseffecten op bedrijfsniveau worden geaggregeerd naar sectorniveau. De gebruikte panel dataset van het LEI-DLO biedt de mogelijkheid om het gedrag van melkveehouders op micro niveau te analyseren en vervolgens te aggregeren, en om de theoretische veronderstellingen te checken. In dit proefschrift wordt de duale benadering gehanteerd waarbij voor de winstfunctie een flexibele functievorm wordt gebruikt. Vraag- en aanbodvergelijkingen worden van de winstfunctie afgeleid. Een zogenaamd 'fixed effects' model wordt toegepast: voor alle bedrijven wordt dezelfde functievorm verondersteld, de constante varieert echter over de bedrijven. De analyse is sterk empirisch georiënteerd, dat houdt in dat technische details van beleidsveranderingen expliciet worden meegenomen in het model. Het model is geschat met behulp van gegevens van 1961 verschillende melkveehouderij bedrijven over de periode 1973/74 tot en met 1992/93.

Het empirisch model bestaat uit een systeem van simultane vergelijkingen, waarin, door middel van een verschil in het aantal observaties over de vergelijkingen, rekening wordt gehouden met de introductie van melkquota in 1984. De structuur van het model is zo eenvoudig mogelijk gehouden, omdat schatting van het model met behulp van de 'incomplete' panel dataset al gecompliceerd is. De genormaliseerde kwadratische (NQ) functievorm zou daarom te verkiezen zijn boven de symmetrisch genormaliseerde kwadratische (SNQ) vorm. De simulatie effecten met de NQ zijn echter sterk afhankelijk van de gekozen numeraire. Alle veranderingen ten gevolge van de simulatie worden volledig geabsorbeerd door de numeraire. Daarom wordt in dit proefschrift de SNQ gebruikt.

In hoofdstuk 3 worden twee alternatieve schattingsprocedures vergeleken met het basismodel dat verder in dit proefschrift wordt gebruikt. De gebruikte data is geselecteerd uit een gestratificeerde steekproef van bedrijven, welke het mogelijk maakt een gewogen schatting uit te voeren. De schattingsresultaten van de gewogen schatting verschillen echter niet veel van die van de ongewogen schatting. Verder onderzoek is nodig om de verschillen tussen gewogen en ongewogen schatting te testen. Schatting van het basismodel in dit proefschrift houdt geen rekening met weging. Wegingsfactoren worden alleen gebruikt om gemiddelden en totalen te berekenen en te rapporteren.

De beschikbare panel dataset maakt het ook mogelijk om 'fixed effects' en 'random effects' schatters te hanteren. In dit proefschrift wordt het 'fixed effects' model gebruikt omdat het model vooral wordt gebruikt om conclusies ten aanzien het gedrag van individuele melkveehouders in de steekproef te trekken. Een gecompliceerder systeem waarin extra 'fixed effects' aan de aanbodfunctie van melk worden toegevoegd is ook geschat. Deze effecten konden echter alleen worden bepaald voor de periode tot 1984 (vòòr de invoering van melkquota), terwijl het model verder gebruikt wordt om gedrag te simuleren in de na-quotum periode (het meest recente jaar, 1992/93, is het basisjaar).

De efficiency van de handel in melkquotum en de resulterende quotumprijzen zijn de onderwerpen in hoofdstuk 4. Hoewel er in Nederland een vrij liberale quotumhandel is, bestaan er nog steeds enige belemmeringen in de markt die tot efficiencyverliezen voor melkveehouders kunnen leiden. Deze belemmeringen zijn enerzijds het gevolg van regelgeving, die bepaalt dat de hoeveelheid quotum die mag worden verhandeld is begrensd. Anderzijds zijn er kosten gerelateerd aan quotumhandel, zoals kosten van een tussenpersoon of notaris. Beide vormen van handelsbelemmeringen worden gesimuleerd en vergeleken met een volledige vrije quotumhandel.

Volledig vrije handel in melkquotum resulteert voor het gemiddelde bedrijf in het model tot een winststijging van 9 procent ten opzichte van de basissituatie. De handelsstroom van quotum loopt van bedrijven in de Westelijke weidegebieden naar bedrijven in de zandgebieden en Noordelijke klei- en veenweidegebieden. De berekende quotumprijs is 39 cent per kg. Effecten van kosten van quotumhandel, in de vorm van een marge van twee procent tussen de prijs waartegen quotum ge- en verkocht wordt, zijn klein. Fysieke grenzen in de quotumhandel (aanbod van minimaal tienduizend kg en vraag van maximaal vijfenzeventigduizend kg per transactie) resulteren in kleinere winststijgingen en bedrijven in de Noordelijke klei- en veenweidegebieden worden gemiddeld netto verkopers van melkquotum. De berekende quotumprijs is 33 cent per kg. Er kunnen dus efficiencyvoordelen behaald worden door restricties in de quotumhandel te vermijden. De handelsrestricties beschermen kleine melkveehouderij bedrijven echter ten opzichte van grote bedrijven, omdat kleine bedrijven meer profiteren van quotumhandel.

In hoofdstuk 5 worden alternatieven voor het huidige EU zuivelbeleid geëvalueerd. Het theoretisch model is uitgebreid zodat een tweeprijzen systeem kan worden geanalyseerd. In een tweeprijzen systeem wordt A-melk geproduceerd tegen een gegarandeerde prijs, daarnaast kan B-melk geproduceerd worden tegen de lagere prijs op de wereldmarkt. Bovendien wordt rekening gehouden met handel in melkquota binnen een tweeprijzen systeem. Daarna volgt een simulatie van het afschaffen van quota en van de overeengekomen prijsdalingen en quotaverruiming in Agenda 2000.

In een tweeprijzen systeem met vrije quotumhandel zal B-melk worden geproduceerd als de prijs op de wereldmarkt hoger is dan de gemiddelde marginale kosten om A-melk te produceren (31 cent per kg). In dat geval zullen winsten stijgen. Het huidige niveau van melkproduktie zal gehandhaafd blijven als de wereldmarktprijs 31 cent per kg is. Bij hogere prijzen op de wereldmarkt zal de quotumprijs in een tweeprijzen systeem lager zijn dan de huidige quotumprijs, omdat de meest efficiënte bedrijven B-melk zullen gaan produceren in plaats van A-quotum te kopen. Bovendien zal er minder quotumhandel plaatsvinden.

Een melkprijsdaling van 15 procent gecombineerd met een quotumverruiming van 1,5 procent, als gevolg van de Agenda 2000 hervormingen, leiden tot een gemiddelde winstdaling van 17 procent. De voorgestelde inkomenstoeslag van 55 gulden per duizend kg melkquotum dekt maar 52 procent van deze winstdaling. De teruggang in de winst is vooral het gevolg van de gedaalde melkprijzen. Vanwege de quotumverruiming stijgt de vraag naar variabele inputs terwijl het aanbod van overige outputs daalt. Als de melkquota zouden worden afgeschaft en de prijs van melk is hoger dan de huidige gemiddelde marginale kosten, dan stijgt de produktie van melk. Winsten zullen echter dalen zodat er een vraag naar inkomenscompensatie ontstaat. Bij een wereldmarktprijs van 60 cent per kg melk is de noodzakelijke compensatie in het geval van afschaffing van quota kleiner dan in de Agenda 2000 simulatie, terwijl de melkproduktie hoger is.

Nadelen van Agenda 2000 zijn stijgende budgetkosten, het niet kunnen voldoen aan de afspraken binnen de wereld handelsorganisatie (WHO) en negatieve inkomensgevolgen voor de Nederlandse melkveebedrijven. In een tweeprijzen systeem is het inkomen van de boer gegarandeerd, bovendien biedt het de boeren enige flexibiliteit (waarbij deels wordt voldaan aan de WHO afspraken). Het beslag dat een tweeprijzen systeem legt op het overheidsbudget is waarschijnlijk lager omdat prijssteun, export subsidies en inkomenscompensaties lager zijn. Afschaffing van het quotum systeem is minder aantrekkelijk voor Nederlandse melkveehouders vanwege de verwachte inkomensdaling, hoewel deze sterk afhankelijk is van de prijzen op de wereldmarkt. Het geeft boeren echter wel meer produktievrijheid. Vanwege grotere milieuproblemen en een verzwakking van de financiële positie van melkveehouders kiest de Nederlandse overheid waarschijnlijk niet voor afschaffing van het melkquotum systeem.

Hoofdstuk 6 richt zich op de vraag naar landbouwgrond en de invoering van een heffing op fosfaat overschot. Het model is aangepast zodat een imperfecte markt in grond kan worden gesimuleerd. Bovendien worden fosfaatoverschotheffingen per bedrijf berekend en aan het model toegevoegd, zodanig dat de te betalen heffing afhankelijk is van de hoeveelheid grond en de veestapel op het bedrijf. De berekende evenwichtsprijs voor grond, bij een volledig inelastisch (exogeen) aanbod van twintigduizend hectare en ongerestricteerde vraag naar grond door melkveehouders, is hoger dan de evenwichtsprijs in het geval van gerestricteerde vraag. Restricties in de grondmarkt worden onder andere veroorzaakt door een verschil in locatie van de gevraagde en aangeboden grond.

De fosfaatoverschotheffing is een effectief instrument om mestoverschotten in de melkveehouderij te reduceren. In het model voeren melkveehouders hun koeien versneld af, zodat ze geen fosfaatheffing hoeven te betalen. In werkelijkheid is het echter onwaarschijnlijk dat de veestapel met 25 procent wordt ingekrompen terwijl de melkproduktie op peil blijft. Boeren zullen hun mest (fosfaat) van hun bedrijf afvoeren en het fosfaatgehalte in het veevoer reduceren. Met deze mogelijkheden is geen rekening gehouden in het model.

De mogelijkheid om naast het afvoeren van koeien extra grond te kopen om het fosfaatoverschot te reduceren heeft maar weinig effect. Door de aankoop van grond kan het gemiddelde bedrijf echter wel het kleine negatieve effect dat de fosfaatheffing heeft op de winst compenseren. De vraag naar grond stijgt door invoering van de overschotheffing. De evenwichtsprijs voor grond is daarom hoger dan in de situatie waarin geen overschotheffing wordt toegepast.

In hoofdstuk 7 worden de verschillende beleidssimulaties en hun effecten voor de melkveehouderij nogmaals besproken. Het gebruikte model wordt geëvalueerd op zijn theoretische en praktische toepassingen. Het empirische micro-model dat in dit proefschrift wordt gepresenteerd is een flexibel instrument om korte termijn gedrag van individuele Nederlandse melkveehouders in reactie op beleidsveranderingen te tonen. Het gecombineerde gebruik van historische gegevens met betrekking tot produktietechnologie en -gedrag en van gegevens over toekomstig of nieuw beleid is geschikt om beleidseffecten op bedrijfs- en sectorniveau te analyseren.

CURRICULUM VITAE

Maria Geertruida (Maroeska) Boots werd op 21 augustus 1969 geboren te Ursem, gemeente Wester-Koggenland. In juni 1987 behaalde zij haar VWO diploma aan het Han Fortmanncollege te Heerhugowaard. In 1987 begon zij met de studie Agrarische Economie aan de Landbouwuniversiteit Wageningen, waarvan zij in augustus 1993 het diploma in ontvangst mocht nemen.

In januari 1994 begon Maroeska als Assistent in Opleiding (AIO) met haar promotieonderzoek bij de toenmalige vakgroep Algemene Agrarische Economie, Landbouwuniversiteit Wageningen. Gedurende haar AIO-schap tot januari 1998, heeft zij het diploma van het landelijk Netwerk Algemene en Kwantitatieve Economie (NAKE) behaald.

Sinds augustus 1998 werkt Maroeska als wetenschappelijk medewerker bij de unit Beleidsstudies van het Energieonderzoek Centrum Nederland (ECN) te Petten. Haar werk is vooral gericht op de liberalisering van de elektriciteits- en aardgasmarkten in Europa.