The EU's Grains, Oilseeds, Livestock and Feed Related Market Complex:

Welfare Measurement, Modelling and Policy Analysis

Roelof A. Jongeneel

Stellingen

1 Een verdergaande hervorming van het landbouwbeleid kan niet worden afgewezen op basis van 'second-best' argumenten. Evenmin kan op basis van 'first-best' overwegingen worden gesteld dat het beste landbouwbeleid geen beleid is.
(*Dit proefschrift*)

2 De efficiency-voordelen van een meer marktconform gemeenschappelijk landbouwbeleid worden vaak overschat omdat geen rekening wordt gehouden met de sociale kosten van publieke middelen.
(*Dit proefschrift*)

3 De maatschappelijke kosten van 1 gulden belastinggeld besteed aan het landbouwbeleid bedragen in de EU 1,25 gulden.
(*Dit proefschrift*)

4 Bij de meting van de welvaartseffekten moet rekening worden gehouden met de spill-over effekten die het ingrijpen op één markt creëert op gerelateerde markten. Wordt dat niet gedaan dan vindt meestal overschatting van de welvaartseffekten plaats.
(*Dit proefschrift*)

5 De gemengde schattingsprocedure (*mixed estimation*) verdient meer aandacht in het empirisch onderzoek. Enerzijds biedt het een consistente oplossing voor *data mining* en anderzijds kan het bijdragen aan de veredeling van simplistische calibratie-praktijken.
(*Dit proefschrift*)

6 De maatschappelijke waardering voor onbetaalde arbeid blijft achter bij de economische betekenis ervan.
(*H. Tieleman, In het teken van de economie. Ambo, Baarn, 1991*)

7 De neo-klassieke micro-economie, noch de transactiekostentheorie zijn in staat om het eigene van de onderneming aan te geven.
(F. Van Niekerk-Fourie, "In the beginning there were markets" in C. Pitelis ed. Transaction costs, Markets and Hierarchies, Blackwell, Oxford, 1993)

8 De relatie tussen economie en tijd is even complex als de relatie tussen economie en geld en verdient daarom afzonderlijke bestudering. Het debat rond de 24-uurseconomie moet daarom ook economen wakker maken.
(Th. van de Klundert, De vereconomisering van de samenleving, KUB, Centrum voor Wetenschap en Levensbeschouwing, Tilburg, 1999)

9 De Weber-these, waarin kapitalisme en calvinisme met elkaar worden verbonden, heeft geleid tot een verwrongen beeldvorming van het calvinisme.
(R. Jongeneel, Economie van de barmhartigheid, Kok, Kampen, 1996)

10 In rijke landen, waarin de basisbehoeften ruimschoots gelenigd zijn, blijkt de 'subjectieve welvaart' ondanks de economische groei stabiel te zijn. In arme landen, daarintegen, stijgt het welbevinden met de groei van het inkomen. Het is daarom niet alleen moreel, maar ook economisch om aan de groei en ontwikkelingsmogelijkheden van de arme landen prioriteit te geven.
(R.H. Frank "The frame of reference as a public good". Economic Journal, 1997)

11 Ethiek mag niet worden gezien als een zaak die is voorbehouden aan de filosofie en/of theologie: het raakt minstens zoveel de vakwetenschappen.

12 Bach: een wereld in vier letters.

Proefschrift van Roel Jongeneel
The EU's Grains, Oilseeds, Livestock and Feed-Complex; Welfare measurement, modelling and policy analysis
Wageningen, 18 februari 2000

The EU's Grains, Oilseeds, Livestock and Feed Related Markets Complex:

Welfare measurement, modelling and policy analysis

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Voorwoord

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INTRODUCTION

Chapter 1

THE SCOPE OF THE STUDY

1.1 Introduction

Agricultural policy, with the Mercantilist restrictions on free trade in agricultural product and the *impot unique*-tax of the Physiocrats as early examples, is probably one of the oldest policies of the general economic policy amalgam (Ekelund and Hebert, 1997, p.81). To outsiders it may be somewhat surprising that the agricultural sector is subject to large scale government intervention. Agriculture stands as an outstanding example of a sector characterized by full competition (a large number of small suppliers not being able to individually influence market prices). And it is common wisdom among economists that there is then no reason for government intervention. The *laissez faire* outcome is so-called Pareto-efficient (Oskam, 1996, p.130). However, according to a World Bank (1986) study, more than 80 countries are interfering in their agriculture. Not only the developed countries, but also the developing ones, even the most successful ones among them (East and Southeast Asia) have openly rejected the free market approach in the case of primary foodstuffs (Timmer, 1989, p.17).

Policy interference in agriculture is not only widespread, it also has a long tradition. The 'free market policy', which several European countries adopted after the repeal of the British Corn Laws in 1846 until the substantial cereal price declines of the early 1870s, is probably the main exception to this rule. At the end of the

19th century there was a clear wave of agricultural protectionism, which was followed by a second one during the Economic Depression of the 1930s. Since the Second World War there has been a continuing government involvement (Tracy, 1993, pp.148-162)

As long as agricultural policies have been in place, they have come under criticism. Mercantilist protectionist policies were criticized by free trade Physiocrats. The single reliance on land rent tax policies of the Physiocrats was criticized by the general labour theory of value developed by Smith and the other classicals. Ricardo and Malthus criticized each other by arguing respectively pro and contra the Corn Laws, which influenced the price level of cereals. Their antagonism on agricultural price policy constituted the first of the many following disagreements (Ekelund and Hebert, 1997, p.154). Similarly, in the Ricardo-Malthus-controversy, both agreed on the basic theory of rent. The disagreement on agricultural policies here is usually not based on the questioning of economic principles, but rather on differences in interpretation, order of magnitudes of the economic impacts of policy instruments, and on varying positions taken within the field of economic interests.

Also in recent years there has been mounting criticism of existing farm policies. Politicians tried to save on public funds by limiting the budgettary outlays going to agriculture. Economists emphasized that price support generates growing surpluses and product quota lead to inefficiencies in the production structure. Underpinning model studies demonstrate how costly these policies are. According to one estimate, for example, the present system of agricultural protection means that consumers in industrial countries have to pay more than $200 billion a year in needlessly high taxes and prices. Substracting the benefits that farmers receive from this protection, there still remains a net economic loss of some $70 billion (The Economist, 1990). Moreover, Gardner (1992) argued that the so-called *farm problem*-model, which was used for years as a basic legitimization of supportive farm policies, is not able to bear the test of criticism. In spite of these criticisms and political and financial pressure, however, the agricultural policies generally are adjusting only slowly, with overall government involvement in agriculture remaining substantial.

With respect to the EU, a marked shift took place with the so-called MacSharry reforms in 1992. Partly under pressure from the Uruguay Round of GATT negotiations, a policy package was agreed on which involved substantial price cuts for arable crops and beef, with compensatory payments to producers conditional on set aside (for 'large' producers). (In the US the FAIR Act of 1996 led to an even more pronounced decoupling of price and income support). The shift from general price support to direct income payments had two important distributional effects. Firstly, it implied a shift from an 'invisible' consumer payments financed agricultural policy to a more taxpayer financed one. Secondly, while the price support strongly favoured large farms, the direct income payments are, at least in principle, better suited to help the weak and the needy. At the same time, the increased reliance on public funds makes the 'cost' of the common agricultural policy (CAP) more visible and enlargens the risk that actual budgetary outlays will exceed the apriori planned budget ceiling. In such a context an intensification of debate on distributional issues, both between agriculture and non-agriculture, and also between various interest groups within agriculture, can be expected.

The debate on costs and benefits, that was so prominent in the early 1980s due to complaints by the UK about its unfair treatment, is likely to revive (see among others the cost/benefit studies from Koester, 1977; Rollo and Warwick, 1979; Meester, 1980; Buckwell *et al*, 1982; and De Hoogh 1980). Moreover, new challenges are underway. The EU still struggles with the enlargement question and the required adjustment of the CAP (Commission, 1997). Further, new trade negotiations (Millennium Roundof the WTO) will take place. This generates a number of interesting research questions for economists, who according to Arrow have the task to be the 'guardians of economic rationality'.

At the heart of the debate will be the EU's feed-livestock economy, more in particular the grains, oilseeds, livestock-complex, and compound feed (GOLF), which consists of several agricultural subsectors, including the arable sector, the cattle/dairy sector, and the intensive livestock sector. Livestock production plays not only a significant role in EU's agriculture, but livestock products also have a prominent position in food consumption and agricultural trade. Moreover, since the final outputs of the GOLF-complex are in one way or another processed feeds, any policy change affecting those sectors will also affect the arable sector and the compound feed industry. More than 70% of the total agricultural land area is used for pasture and feed crops. Imported feeds account for the major value-share of total agricultural imports (Parris and Tisserand, 1988, p.375). The large increase in livestock production during the past has indeed generated an associated rise in animal feed production and consumption. But it has not yet led to a concomitant increase in home-produced cereals use, the so-called 'cereal substitute'-problem. This illustrates the diverging interests and tensions with regard to the GOLF-complex in the past, as well as their potential for the future (Peeters and Surry, 1997, p.381). Several intriguing research questions now arise, ranging from modelling the economic behaviour of food consumers and of several agricultural subsectors, and the measurement of welfare costs and benefits in a related market context, to detecting the various visible and invisible financial streams generated by the CAP under different policy scenario's.

1.2 Subject of the study

The subject of this thesis is an economic analysis of the impact of various agricultural policies on the EU's grain, oilseeds, livestock and feed (GOLD)-complex. This task is divided into three parts. Part one examines the methodology of economic policy analysis which is traditionally the subject of welfare economics. This methodology, its scope and its limitations are all explored. Issues considered include operational welfare evaluation concepts, welfare analysis in a related market context, and the balance of payments function as a device for multiple country welfare evaluations, etc. Questions to be answered are:

- How should welfare effects be appropriately measured?
- What is the role of horizontally and vertically related market spill-over effects?
- What is the significance of welfare measures in incomplete consumer demand and producer supply models?
- What is the exact meaning of social costs in a second best environment, and what role do the costs of public funds play in this regard?

The second part deals with the modelling and empirical estimation of the behavioural relationships within the GOLF-complex. Several groups are distinguished, including the final consumers of the GOLF-sector's products, the arable farmers, the cattle/dairy farmers, the intensive livestock farmers, and the compound feed industry. Their economic behaviour is modelled at EU member state level and subsequently empirically estimated using a mixed estimation procedure, which relies on both time series, and non-sample data. Particular issues of concern are:

- The integration of prior information derived from previous economic research and sample information in model estimation;
- The integration of prior information based on (non-economic) technical knowledge (*e.g.* psysical balance constraints, feed technology requirements) into the estimation of economic models.

These models are used in the third part as ingredients of the EU GOLFSIM-model which is a simulation model consisting of behavioural submodels, and incorporating the agricultural policy instruments, and linkages of the EU with the rest of the world (model closure relationships). The simulation model is used to gain insight into:

- The impacts of the MacSharry reform, both in theory and practice;
- The Agenda 2000 proposal of March 1999;
- The potential impacts of a further WTO liberalisation scenario.

1.3 An outline

The structure of this thesis is as follows. It begins with a discussion of the methodological apparatus for economic evaluation of agricultural policies. This is mainly an investigation into welfare economics, in particular the measurement-issues (Part I). A brief discussion about the role and place of welfare economics in agricultural policy analysis is provided in Chapter 2. Chapter 3 deals with the operational welfare evaluation concepts that will be used, and discusses their theoretical consistency and exact interpretation. Chapter 4 focuses on welfare measurement in a related market context and provides a discussion of the partial versus general equilibrium welfare measurement-issue.

Part II introduces in Chapter 5 the EU GOLF-complex and its delineation and also describes the basic modelling and estimation approach (mixed estimation procedure) that will be used. The following chapters of Part II each present the economic modelling and estimation results of the various subsectors considered in this study: the final consumption block (Chapter 6), the arable subsector (Chapter 7), the cattle/dairy subsector (Chapter 8), the intensive livestock subsector (Chapter 9) and the compound feed industry (Chapter 10). As already mentioned in the previous section, Part II provides the ingredients necessary to build the EU GOLFSIM simulation model, which is the subject of the third part of this study.

Part III presents the simulation model and provides the results and discussion of the policy simulations. The model structure, particularly the modelling of the institutional structure of the CAP, and the model closure (including the linkages of the EU with the rest of the world) are described in Chapter 11. Policy simulations, their analysis and conclusions are provided in Chapter 12.

PART I

THE ECONOMICS OF POLICY ANALYSIS

Chapter 2

NORMATIVE ECONOMICS OF AGRICULTURE

2.1 Introduction

Policy analysis is traditionally the subject of welfare economics. Hallam (1988, p.442), for example, states: "Welfare economics is first and foremost a policy science". Paraphrasing Robbins' (1936) famous definition of economics[1] it could be said that the aim of welfare analysis is to compare projects or policies relating to the employment of relative scarce means which have alternative uses. Lesourne (1975,2) sees this comparison of alternative solutions as the basic function of economists in practical affairs. Boadway and Bruce (1984, p.2) emphasize that the evaluation and ranking of allocations of resources or 'social states' is inevitably a normative procedure, since it involves some evaluation criterion. Welfare economics provides a theoretical framework on how to carry out such comparisons. It is therefore often labelled as normative economics (Mishan 1981) in contrast with (positive) neo classical economics (price theory). Although welfare economics implies value judgements, in particular regarding efficiency, it is confusing to mingle them with ethical principles. It is easy to think of an action which is inefficient, without it being morally wrong (*e.g.* not traveling from point *A* to point *B* by using the shortest route). Economic normativity and moral normativity are distinct and irreducible categories.

Given that government interference in the economy is the rule rather than the

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1 Robbins defined economic as 'the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses' (Robbins (1936, p.16).

exception, one would expect welfare economics to be the most relevant and useful part of the whole of economic science. However, most macroeconomic models aimed at supporting policy makers, are not at all based on an explicit welfare theoretical framework. Their outcomes are not changes in standard welfare effects for different groups or deadweight loss estimates as a result of policy changes, but rather give information on things like national income (GNP), economic growth, (un)employment, investments, balance of trade and budget deficits of the governments. From this list only GNP has a direct welfare measure interpretation (Weizman, 1976). Already it becomes clear, however, that although the income effects for different groups are highly political sensitive information, politicians are interested in more than the pure efficiency-effects of their policies. Because in agriculture the situation is not much different from elsewhere in the economy, this raises the question: what contribution can welfare economic analysis make to the policy process?

The purpose of this chapter is to give an overview of the main reasons for government interference in agriculture, to discuss the role of welfare economics in the policy making process, and to highlight the main lessons learned from welfare economic thinking.

The chapter is organized as follows. It starts with a discussion of the main reasons for government intervention in agriculture in general and the derived policy goals of the EU's common agricultural policy in particular (Section 2). Section 3 goes into the relation between economists and policy makers, their different tasks, approaches and responsibilities. Section 4 indicates some of the main lessons to be learned from welfare economic analysis both in the first- and second-best worlds, and discusses their significance for agricultural policy analysis. Section 5 provides a number of concluding statements.

2.2 Reasons for government interference

There are several reasons why governments interfere in their agriculture. Some governments want to protect their consumers and producers from large price fluctuations (market stabilization). Others try to keep food prices low in order to keep the costs of living low, or to avoid political unrest. In most developed countries governments support prices of several products in order to guarantee a 'fair' income to their farmers (De Hoogh, 1994, pp.1-13, Tyers and Anderson, 1992, p.81). Moreover, there is the strategic argument according to which countries do not want to be too much dependent on world markets for their food supply (food security). Related motives are the wish to preserve rural communities, and to protect the traditional system of family farming (Dabbert *et al* 1998). More recently, prevention of environmental damage to the country side, nature preservation, protection of landscape-values and (agricultural) ethical concerns (animal well-being) have received increased attention in the policy process (Commission, 1997). Reviewing the issues and discussions of the past, it can be concluded that the decisive arguments for policy intervention are mainly related to income distributional concerns (Gardner, 1987b, Johnson, 1991, p.4).

Realizing that, at least in the industrializing and industrialized economies, agriculture belongs to the relatively contracting sectors with the usual declining income and adjustment problems, the focus on income support is understandable (Tracy, 1993a, p.132-139; Tyers and Anderson, 1992, pp.30-40). This can be further seen by spelling out the so-called "farm problem", which refers to the economic difficulties facing agriculture. Following Schultz, Gardner (1992, p.63) identifies the farm problem to be the low and unstable earnings of most farmers due to the particular economic structure of the agricultural economy. The basic features of the agricultural economy are: 1) the very (price and income) inelastic demand side for agricultural products (Engels's law), (2) the sluggish increase in demand over time (low population growth), (3) the inelastic and unstable supply (weather and disease-sensitive biological production cycle with a typical decision/realisation-lag), (4) relative to demand, the strong over time growth of supply (biological and technical progress), and (5) some form of production factor specifity and fixity. The latter factor in particular relates to land and labour. It slows the adjustment of the sectoral structure to the new equilibrium structure[2]. It can easily be seen that this stylized supply-demand model of agriculture, labelled as the farm problem-model, has the implication of declining farm product prices. It only requires a rate of technical progress sufficient to generate only a slightly larger rate of supply growth as compared to demand, and relatively small transitory supply or demand shocks to generate significantly falling and substantially fluctuating agricultural output prices and related farm incomes.

The economic significance of agriculture in terms of providing employment, influencing inflation, and contributing to balance of payments is rather low, or at least declining. In fact, industrializing economies have a tendency to ultimately grow out to service-economies. In this context, given the farm problem-model, it is non-surprising that agricultural policies in those countries have a relevatively strong focus on income (re)distribution. Looking in more detail to the EU's explicitly formulated aims of agricultural policy, Article 39 of the Treaty of Rome is important, which reads as follows:

> The objectives of the common agricultural policy shall be: *a)* to increase agricultural productivity by promoting technical progress and by ensuring development of agricultural production and the optimum utilisation of the factors of production, in particular labour; *b)* thus to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture; *c)* to stabilise markets; *d)* to assure the availability of supplies; *e)* to ensure that supplies reach consumers at reasonable prices.

This article is often interpreted as a justification of an unconditional guaranteed global support to the farm sector. However, as Tracy (1993b, p.19) argues, the text in fact carefully balances public, producers, and consumers interests. Item *a* fits in with the more general objective of pursuing GNP growth. It also contains a classical argument for public support of the farm sector, since it can be argued that due to

2 See Gardner (1992) for an extensive review of the farm problem model (including many references), and a discussion of the different explanantions for the low factor mobility in agriculture (p.74). Gardner's hypothesis that asset fixity finds little empirical support seems somewhat overstated since most empirical tests mentioned are based on aggregated time series analysis. Moreover, at least for the EU, income disparaties are still present, while for years general labour market conditions were unfavourable for the inflow of farm labour (Brown, 1990; Hill, 1997). In addition, the empirical evidence, also in this study, still confirms the other mentioned characteristics. Generalizing Gardner's claim that the farm problem model is outdated seems therefore somewhat premature, at least for the EU (p.84).

the atomistic structure of many small enterprises and the public good character of innovations, agriculture will underinvest in research and development. Subsidizing certain types of agricultural research can therefore be welfare improving (Everson and Huffman, 1993). The income objective is placed after the aim of increasing productivity. Tracy argues that item *b* is in fact made subject to item *a* by its initial word 'thus'. However, it seems more in accordance with the facts to say that productivity increase is seen as the instrument to achieve items *b*, *d* and *e*. Finally, it should be noted that item *b* is referring to individual earnings. This does not prescribe global support measures, but rather suggests specific, *i.e.* group-oriented support policies[3]. Income by price support policies are only justified if *all* individual earnings to an unacceptable degree are lagging behind. A large number of people (14 million, nearly 20% of total working population) were employed in agriculture (in EC-6) when the CAP was implemented in 1962. Also, given that the price support policies are intended to 'fairly' distribute the realized productivity gains between consumers and producers, global support measures, like price support, are then understandable. But there remain reasons enough for looking for more refined alternatives.

Several conclusions can be drawn from the foregoing. Firstly, there are several arguments employed to motivate the government involvement in agriculture,a number of which have reached the status of official legislation (*cf.* Treaty of Rome, Article 39). Secondly, as the "farm problem"-model explains, agriculture is a declining sector in normally developing industrialized economies, with a continuing downward pressure on agricultural prices and related farm incomes subject to fluctuations due to the high sensitivity of the sector to supply (and demand) shocks. Besides productivity growth and increase of efficiency, income distributional concerns are therefore of primary importance (Johnson, 1991, p.4). As productivity growth proceeds, distributional concerns are likely to increase in political weight and become dominating compared to all other policy goals. Thirdly, since only gobal policy goals are specified, there is room for considering and comparing various policy alternatives which are able to achieve, or even better, achieve the stated goals.

3 *Cf.* Chambers (1988) for an illustration that different policies have different implications for low-cost and high-cost producers.

2.3 Economists and policymakers

The previous section gave a descriptive survey of reasons for government interference in agriculture. A clear definition of economic policy in general and agricultural economic policy in particular was not yet given. At this point I want to define (governmental) policy as the harmonization of all interests of the various population groups under the perspective of public justice (Goudzwaard, 1963, p.396). Although this idea of balancing diverse interests according to the principle of a maximum righteousness requires further elaboration, it should be emphasized that its focus is broader than a narrowly defined efficiency-criterion[4]. Economic policy focuses on the harmonisation of economic interests, but even then public justice and not primarily social welfare is the qualifying criterion. Derived from this, agricultural policy can be defined as the harmonisation of interests related to agriculture in its broadest sense (including ultimate food consumers and the agribusiness)[5]. Among the interests taken into account are economic ones, food safety concerns, environmental sustainability, etc. According to this definition, policy makers have the task of making synthetic judgements balancing a host of interests (Larsen, 1993, p.2). This outcome fits with the actual practice sketched in the previous section, where economic interests (productivity increase) and social concerns (a 'fair' income distribution between agriculture and non-agriculture) were balanced (*cf.* Article 39).

Following Robbins (1952, p.16), economics can be defined as "the science which studies human behaviour as a relationship between ends and scarce means, which have alternative uses". Robbins, rightly called economics an aspect-science, *viz* a science which focuses only on one aspect, sometimes denoted as the scarcity aspect, of human behaviour. Unfortunately he did not discuss how the economic

4 Elaboration of this issue goes beyond the scope of this study. For a discussion of economic righteousness based on the judeo-christian values I sympathize with see the article of Goudzwaard already referred to in the main text, and Beukes and Van Niekerk-Fourie (1993). For an application to agriculture see Van Bruchem (1991).

5 Our definition differs from that given by Josling (1974, p.229) who states that agricultural policy is defined as "those measures taken by a (central) government that are aimed at influencing, directly or indirectly, agricultural factor and product markets". The main defect of this rather descriptive definition is that it does not indicate what qualifies public policy. Agricultural policy is here understood to be broader than economic policy, but is assumed to also include social, environmental, and food safety policy as far as they are targeted at agriculture.

aspect of a human action related to other aspects (social, ethical, etc.) of human behaviour (*e.g.* Haan, 1975, p.17 a.o.; Kee, 1982). So, where Robbins definition suggests that economics only partially explains human behaviour, (by lack of external reference point) often a practice arose where the economic aspect the as only nominated one, was absolutized[6]. Accepting Robbins standard definition, however, it is clear that economics only provides partial explanations for human behaviour. As such the judgement of economics is a fragmentary judgement which selects only one aspect out of the large number which are relevant in real life (Schumacher, 1974, pp.40-41; Hennipman, 1977, p.92). This in particular holds for that part of human action which is called policy formation. Agricultural economists are thus over-asked when they are held responsible for explaining the agricultural policy formation process. Their task is a more limited one, *i.e.* clarifying the economic impacts of agricultural policies, and therewith providing information about one essential ingredient of the policy making process (Just, 1988, p.450). Policy makers may have good reasons not to follow the advice of economists, because they should make a synthetic judgement based on the knowledge supplied by various disciplines, and are free to decide to 'buy' non-economic benefits while accepting some economic costs (Josling, 1969). Moreover, just as freedom of speech does not guarantee an audience, good advice does not necessarily imply good followers (Hennipman, 1977, p.93).

Having provided some criteria to evaluate the relationship between economists and policy makers, and economic research and political action, it is time to focus on agricultural economic research, which is aimed at sustaining the policy making process. As already mentioned in the introduction, this research is mainly based on welfare economics, and, to a lesser extent, on the theory of economic policy. This branch of economics, which emanates from Pigou (1932) "stresses the reasons why the market economy fails to function properly in allocating and distributing resources, and suggests that governments intervene in the private economy in certain policy-specific ways (taxation) to correct such market failures and distributional shortcomings" (McCormick and Tollison, 1981, p.3). This approach is sometimes labeled as the social welfare maximization perspective or welfarism, and criticized

6 Even Robbins himself failed to correctly apply his own principle (*cf.* Kee, 1982, p.10-14.

for its view on the government as an omniscient benevolent dictator who interferes in the economy to correct market failures in order to increase social welfare (*e.g.* Sen, 1992; Josling, 1974, p.235; Van der Zee, 1997, pp.10, 12, 17). In particular from a public choice perspective, this is an unacceptable reduction; the government, like the private sector, consists of various actors, having their own motivations and making their own 'cost/benefit' calculations, which may not parallel the social welfare maximization objective. Moreover, market failures are not costlessly and instantly identifiable, and governments are faced with incomplete and imperfect information and subject to manipulation from private actors. Briefly, the other side of market failure is government failure. It is the merit of the public choice approach that it has contributed to an improved understanding of this latter source of failure (see Van der Zee, 1997).

Whereas the public choice criticism effectively attacks the social welfare maximisation perspective, one should be careful when drawing conclusions from this. The main error of the social welfare maximization perspective is that it absolutizes the economic aspect in taking the economic component of welfare, *viz.* social welfare, as the prime aim of government policy. This is a reduction as we saw from the beginning of this section. However, the social welfare maximisation approach is not wrong in focusing on the economic aspects of policy interference, and for searching for optimal economic allocations. That is at the heart of its task, and that is not what it should be blamed for. Nevertheless the social welfare maximization perspective is more than a straw man erected by public choice criticists in order to gain relief for their own perspective. Looking at the evolution of welfare economic theory, it should be accepted that the Pigovian welfare economics relied heavily on a social welfare maximization perspective. Its successor, Paretian welfare economics, upheld the maximization principle, but became obscured with the determination of social welfare, as it denied the possibility of interpersonal utility comparisons (Robbins, 1952, p.140). Its scope significantly narrowed, since the only discriminating criterion that prevailed was the Pareto-criterion. Unfortunately, however, since most policy interferences have both gainers and losers, its practical relevance was substantially limited as compared to its predecessor (Jongeneel en Koning, 1996, p.4). Firmly based in the logicist positivist approach to science and the utilitarian neo-classical tradition in economics, with its desire for neutrality and avoidance of value judgements, the impossibility of interpersonal welfare comparisons survived, even where its costs were high (Blaug, 1985, p.591).

The solution that emerged in the late 1930s, offered by Kaldor (1939) and Hicks (the founders of the neo-Paretian welfare economics), was to rely on (hypothetical) compensation principles. The primary question they would like economists to answer was whether a potential Pareto improvement (PPI) is possible. That means that in cases where there are winners and losers, economist should answer the question whether the winners of a policy-shift are potentially able to compensate the losers and still be better off (Kaldor), or whether the losers are not able to profitably bribe the gainers to oppose the change (Hicks). Although the neo-Paretian welfare economists focus on the possibility of compensation, they do not require compensation to actually take place. In fact the very relevance of the compensation criteria relied on compensation not taking place, for otherwise the standard Pareto criterion would suffice to establish an increase in social welfare. Although a potential Pareto improvement is just what its words say: a potential, not an actual improvement, many economists could not resist the temptation to equate a PPI with an actual improvement. Hicks (1981, p.105), for example, calls a policy change that meets the compensation principle an 'unequivocal improvement', although others picked their words more cautiously, aware of the underlying problems of such a statement (among them Chipman and Moore, 1978, pp.579-581; Boadway and Bruce, 1984; Mishan, 1981). Many economists, in particular those doing applied economic research, maintained, without making any additional suppositions, that a PPI corresponds to a social welfare improvement, and therewith propagated the earleir mentioned social welfare maximization perspective (Jongeneel and Koning, 1996, p.11).

In this study a more limited scope of welfare economics is propagated, which does not go beyound the PPI in its literary meaning. Therewith I am in line with authors like Varian (1992, p.405), Atkinson and Stiglitz (1987, pp.12, 334-335), Just *et al* (1982), and Gardner (1987, pp.176-179). The approach focuses on assessing the economic effects of alternative policies on different social categories, or on the attainment of different economic goals. This includes examining whether the analysed policy alternatives leave room for actual compensation, because this will often be information relevant for both policy makers and concerned groups. If political preferences are clear, for example because criterion-values used in policy choice are established by legislation, even the use of some kind of social welfare function-approach (SWF) might be followed. For once a system of policy goals is decided upon in politics, economists have a role in examining the most efficient way to achieve it. Normally, however, the SWF option will not be open, because at best only vaguely specified information about the policy maker's preferences is available (Just, 1988).

One of the main lessons to be learned from the past is that simple cost/benefit analysis of agricultural policies is of limited interest, unless it can be tied to the magnitude of the desired effect of the policy intended (Josling, 1969). Therefore Josling (1969; 1974) pleads for an integration of traditional welfare economics with the theory of economic policy. The theory of economic policy, initially developed by the Dutch Nobel laureate Tinbergen (1952) and further developed by Meade (1955) and Theil (1958), can best be described as an instrument-objective approach. It essentially focuses on the choice of appropriately choosing an optimal mix out of the available policy intruments in order to optimally achieve a limited number of defined policy objectives which are amendable to a quantitative interpretation. It has the advantage of explicitly emphasizing the multiple objective approach of policy makers. The approach integrating welfare economics with the theory of economic policy differs in one important respect from the traditional one. Instead of only relying on competitive efficiency, the efficiency concept is rather redefined as the optimum state of the economy evaluated according to the political preferences that matter (Just, 1988, p.451). It emphasizes evaluating alternative policy intruments to find the least cost way of achieving a particular objective or set of objectives. At the same time, accepting this framework does not necessarily require the acceptance of a social welfare function, which is highly problematic (Mishan, 1980, p.699; Just, 1988).

Several authors have worked along these lines. Besides Josling, Thomson and Harvey (1981), Newberry and Stiglitz, Gardner (1987), and Bullock (1992) can be mentioned to name a few (see Bullock *et al*, 1999 for a recent overview). Because many agricultural policies are aimed at redistribution, most approaches center around the equity/efficiency trade-off, in particular the efficiency of agricultural policies as a means of transferring income, although a broader scope is possible.

2.4 Lessons learned

When reviewing the past, most analytical work on agricultural policies was based on the standard competitive model. This model is appealing because it provides a theoretical construct which can be easily translated into a normative framework, and seems to fit well with the atomistic market structure of agriculture and the standard commodity characteristics of food (Josling, 1974, p.237; Oskam, 1996, p.130). As a consequence, policy recommendations aimed at improving societal welfare were mainly based on first-best neo-classical welfare economics[7]. This is in spite of the fact that the real world, whether the focus is on the general economy or on a specific sector like agriculture, is not a first-best world, but is 'blatantly of the second-best variety'[8] (Blackorby, 1990, p.749). Whereas agriculture largely satisfies the assumption of perfectly competitive markets (farmers are price takers, firms are usually small, output rather homogeneous) it fails to satisfy two other important assumptions, *viz* the absence of externalities, and the assumption of a complete set of (futures and risk) markets (Newbery and Stiglitz, 1981, p.207; Innes and Rausser, 1989; Oskam, 1996). The simple first-best world view is therefore seldom justified, and it would therefore be not surprising if (only for this reason) the results of such an approach are repeatedly criticized, or ignored as simply irrelevant[9]. In this section a brief overview will be given of the main results obtained from first- and second-best analysis, and their significance for agricultural economics.

The outcome of first-best welfare analysis is rather predictable, even without doing any quantitative work. Welfare will be most improved if the distortions would be completely eliminated, which is more or less a popular restatement of the First

7 Depending on the strand of literature, a first-best world is usually defined as a world in which all distortions can be removed (e.g. trade theory) and/or in which non-distortionary or lump sum taxation is possible (e.g. public finance). In applied analysis, which studies distorted markets, this usually means that it is assumed that *i)* the distortions which are analysed can in principle be completely removed, and that *ii)* in the 'rest of the economy' first-best conditions are satisfied (Ng, 1983, p.224).

8 Tyers and Anderson (1992, p.100) mention (political) reasons why within agriculture first-best policy instruments are not preferrably used. Among them are the higher informational costs to potential opponents of the sectoral assistence policy, which are associated with second-best type solutions, and the wish to make it not all too clear which transfers are made from public funds to farmers (see also Boadway, 1994, p.2).

9 *Cf.* the remarks made in the introductory chapter about the gap between economists and policy makers.

Fundamental Theorem of welfare economics. The only contribution of quantitative analysis in this case is that it provides estimates of the amount of welfare (expressed in monetary terms) that could be gained if the distortions were eliminated. According to the Second Fundamental Theorem of welfare economics, efficiency and equity issues can be dealt with separately. Distributional policy goals should be achieved by lump sum income redistribution. The main conclusion therefore is that in a first-best world, first-best (policy) rules should be used. In other words, prices should equal marginal costs. A second contribution is that it made clear that the efficiency loss increases quadratically with the height of the tariffs or taxes (see *e.g.* Boadway and Wildasin, 1984, 388). So, higher tariffs or taxes means relatively much higher welfare losses. When a government wants to raise a certain amount of tax revenue while at the same time distorting the economy as little as possible, its best option is to tax a broad range of goods at a low rate rather than at a high rate. A third result is that the welfare losses will be less the more inelastic the demand and supply relationships are. This result, formally proved by Ramsey for a general equilibrium context, states that to reach an 'optimal' taxation the taxes should be inversely related to the elasticities of demand (and supply) (Boadway and Wildasin, 1984, p.245, Atkinson and Stiglitz, 1987, pp.370 a.o., Newberry and Stern, 1987, pp.28 a.o.). From this it follows that goods classified as belonging to basic needs should be relatively highly taxed[10]. With respect to agricultural policies, the main contribution of first best analysis relates to the efficiency ranking of farm income support instruments. General price support/trade restriction measures are inefficient relative to specific subsidies/deficiency payments, which in turn are less efficient as compared to decoupled direct income payments (Josling, 1974, p.242).

An important result from second-best analysis is that policy changes which intuitively appear to be steps in the right direction, *viz.* reducing the distortions where possible, can actually reduce welfare instead of improving it. For an extensive review of the theory of second-best, formalized by the seminal contribution of Lipsey and Lancaster in the mid 1950s, and evolved since then, see Boadway (1994). If

10 From a revenue-raising perspective it seems therefore rather efficient to finance the Common Agricultural Policy via taxing the consumption of agricultural food products. The inefficiency of the CAP is more a result of the way in which producers are supported. See Newberry and Stern (1987, pp.366-386) for a more general discussion of the main issues in agricultural taxation.

the real world is of a second-best order, according to one of the basic results of second-best welfare analysis, the best response to one or more unalterable existing distortions may be the imposition of another distortion elsewhere in the economy[11]. Intuition can thus be very misleading which emphasizes the value of scrutiny in scientific analysis (Atkinson and Stiglitz, 1987, 382). In case of second-best situations, the implication of policy reforms for welfare crucially depends on demand and production interrelationships between markets in which distortions are altered and other markets in which (unalterable) distortions exist. As a consequence, in general, without quantitative analysis not much can be said[12]. Fortunately, recent advances in economic theory (duality theory) and econometrics make it possible to get detailed and consistent information about the substitution and complementarity relationships between goods demanded or supplied (Jorgenson, 1992). This at least partly reduces the empirical constraints to satisfy the informational requirements of second-best analysis[13].

One important theoretical result from second-best welfare economics is that the equity-efficiency separability-theorem of the first-best world no longer holds (Blackorby, 1990). This implies that equity and efficiency issues should be dealt with simultaneously. Although less clear cut than in a first-best world, in second-best worlds there are also no lack of economic policies that are easy to characterize and are economically intuitive, and which can be proved to be welfare-increasing (Drèze, 1991, p.194, Blackorby, 1990, 749 and Atkinson and Stiglitz, 1987, section 12-4). A number of general policy rules are derived from second-best analysis, which are identified as likely to be welfare improving[14]:

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11 For an extensive review of the theory of second-best, formalized by the seminal contribution of Lipsey and Lancaster in the mid 1950s, and evolved since then, see Boadway (1994).

12 For exceptions see Mishan (1962) who argued that given that a sector is rather isolated from the rest of the (first-best) economy, first best rules may provide reasonable policy guides. Although this argument is rather weak, exploration of separability assumptions is a promising way to get manageable problems with still meaningful outcomes (Ng, 1983, p.226). Furthermore, Mishan showed that for some types of quantity constraints only the constrained sector would need to be adjusted and a simple piecemeal policy would be sufficient to improve welfare (Mishan, 1962, p.216).

13 Ng (1977; 1983 and 1990) distinguished third-best analysis (exploring an idea already lanced by Mishan, 1962). With this he meant the approximation of second-best analysis in a world with informational scarcity (third-best world). Because of informational limits and administrative costs second-best optima are not always identified. An important part of modern second-best analysis focuses precisely on these informational aspects. Here, this extension, although adding to the realism of the analysis, will be ignored.

14 See Vousden (1990) for an application of these rules to international trade theory.

- Reduce first those distortions which are the most extreme.
- Reduce the distortions of those goods which have as substitutes goods with relatively low tariffs/taxes and as complements goods with relatively high ones.
- Reduce all distortions in a proportional way.

These rules, which have the character of partial or piecemeal policy reforms, emphasize that the strong point of second-best analysis is its contribution to the analysis of policy packages and policy reform, whereas first-best analysis may be in particular useful for policy design (Atkinson and Stiglitz, 1987, p. 358 and p.382)[15]. They further suggest that even when starting from an initial arbitrary tax/tariff structure, there is likely to exist a large number of policy reforms which can potentially raise welfare. At the same time it makes it clear that the characterization of optimal tax/tariff structures requires detailed empirical investigation.

The results of second-best analysis will usually have no wide general applicability, but are rather case-specific. This also holds with respect to agricultural economics, and therefore only some examples are mentioned. Some examples focus on the measurement of (exact) welfare effects in a second best environment, while others have the more ambitious goal of making statements about policy efficiency. One example was the incorporation of the social costs of public funds issue in the analysis of the costs and benefits of agricultural policies. Since real lump sum transfers hardly exist, the distortionary costs of the use of public means (for example needed for financing 'decoupled' direct income payments) should be taken into account (Alston and Hurd, 1990; Chambers, 1995). From Moschini and Scokai (1994) it can be concluded that in general taking into account this cost does not discredit decoupled direct income payments as an efficient income transfer device. Another example of the first group is the determination of the benefits of research in an open but distorted agriculture (Martin and Alston, 1994).

Examples under the theme of optimal policy are the social transfer efficiency and agricultural price reform approaches. The so-called social transfer efficiency (STE) approach focuses on the redistributive efficiency of various policy instruments

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15 If incomplete markets and asymmetric information play a role, even policy design should be approached from a second-best perspective (see *e.g.* Chambers, 1992). Moreover, Boadway (1994, p.3) argues that policy making as subject to principal agent-phenomena is always of a second-best nature.

(Gardner, 1983; 1987; Alston and Hurd, 1990; Bullock, 1990; 1992; 1994). One of the results from this analysis is that the redistributive efficiency of policy instruments generally depends on the magnitude of the desired transfer. So the optimal mix of policy instruments is no longer a question of qualitative (deductive) reasoning, like in the first-best world, but a function of the size of the income transfer and the underlying supply and demand conditions in concerned and related markets (OECD, 1994). Moreover, even within a relatively simple context, there appears to be no (single) policy instrument that is superior in all respects and for all purposes (OECD, 1994, p.21).

A number of studies falling under the label of 'agricultural price (and tax) reform analysis', and emanating from the public finance tradition have been done with the intent of identifying 'satisfactory policies' for developing countries (Newbery and Stern, 1987; Newbery, 1988). A central concept in this strand of literature is the social marginal costs of raising revenue. Every tax or price distortion has its own social marginal cost. The guiding principle for reform is substituting the one with the highest social costs for the one with the lowest social costs, if feasible until the social marginal costs associated with the various distortions all equall each other (Ahmad and Stern, 1984; Newbery and Stern, 1987, p.9; Newbery, 1988). In this literature often some form of 'social aggregation' is used, usually without strong pretentions of identifying unique social optima, but rather as a device for educating social judgements, and as an instrument to get insight into undominated policy subsets (Buccola and Sukume, 1993). Again most results of this analyses is rather case specific (*e.g.* Newbery, 1988, p.23). A general result of these studies is that the optimal taxes/distortions in agricultural markets are different from zero, which follows from the inelastic demand for food and the need for public revenue generating devices. Another result is that a set of uniform commodity taxes is non-optimal, except under unusual circumstances.

Although second best considerations are sometimes embraced as providing 'objective' economic theoretical support legitimizing actual agricultural policies, that conclusion is far too simple (Newbery and Stiglitz, 1981, p.237; Timmer, 1989, p.19; Beghin and Karp, 1992; Boadway, 1994, p.3-4).

2.5 Concluding remarks

This chapter started with a general description of the reasons for government intervention in agriculture. From the 'farm problem'-model it appeared that agriculture typically suffers from low and fluctuating product prices and related farm incomes. Agricultural policies have a relatively strong focus on income (re)distribution, which was explicitly confirmed by looking at the formally stated policy goals for the EU. Although from an economic point of view policies aimed at dissolving rigidities in the factor market would just as well relieve the 'farm problem', Section 3 has made it clear that economists and policy makers have different responsibilities. The balancing of social (income) and economic concerns (efficiency) by policy makers could very well lead to a certain degree of income support to smooth the adjustment of a declining sector. Qualifications have been made about the social welfare maximization approach which was judged to be incorrect in portraying the government as an omnicient benevolent maximizer of social welfare. At the same time, however, there is the need for management, or (as I would prefer) stewardship of scarce resources, which has its own normativity. As a consequence the economic aspect of government involvement in agriculture should be taken into account as at least one essential ingredient of balanced policy making process.

It is argued that modern welfare economic analysis, be it of a more limited scope then was assumed in the social welfare maximization perspective, has a role to play. To a greater extent than has been traditionally, this analysis should try to tie its cost/benefit-estimates to the desired effects of policies. In fact this is also one of the main lessons that could be learned from the theory of economic policy perspective, which plays a role in macro economic policy evaluation. As Section 4 has shown, this is also the way theory has developed. Welfare and excess burden measures for distorted economies have been developed. Moreover, the social transfer efficiency-approach linked social costs to distributional goals, while the agricultural taxation and price reform-approach linked the costs of distortions at agricultural markets to the need to generate a certain amount of public funds. In reviewing some general results obtained from welfare economic analysis, Section 4 has further shown that the results derived from first best welfare analysis, although appealing for its simplicity and clarity, are subject to serious qualification, because in reality the economy, including agriculture, is characterized as a second-best world. One consequence of this is the break down of the Second Fundamental Theorem of welfare economics, which implies that equity and efficiency issues are no longer allowed to be dealt with separately. While in a second-best world second-best rules should be applied, simple general and universally applicable rules are no longer available. What is optimal from an economic perspective can no longer be determined from simple qualitative reasoning, but requires refined quantitative analysis. However, even in a complex and often obscure second best world, there appear to exist several policy alternatives for improving 'welfare'.

With respect to this study, which focuses on the EU's GOLF-complex, and consequently deals with the income distribution within the agricultural sector, some specific remarks can be made. The GOLF-complex is comprised of a set of inter-linked markets in which several distortions exists. As such it is a primary case for a second best welfare analysis along the lines suggested before. A traditional characteristic of agricultural policies with respect to the GOLF-complex has been the imbalance between the extensive support to the arable subsector and the meagre sustenance of the feeds-based livestock subsectors (Josling, 1974, p.249). Recently, the cereals and oilseeds support programmes have been reformed (MacSharry reform), and one of the research issues raised is how this affects the inter-farm income distribution. In the next chapters the focus will be on welfare measurement, both on useful operational concepts (Chapter 3), and measurement within a horizontally and vertically related distorted market context (Chapter 4).

Chapter 3

MEASURING ECONOMIC WELFARE

3.1 Introduction

This chapter focuses on the measurement of welfare impacts. Its main purpose is to provide the basic tools that will be employed later in this study and a description of the welfare measures that are actually estimated in this study.

The oldest welfare measure, introduced by Dupuit in 1844 in a paper about the costs and benefits of constructing a bridge, is the consumer's surplus concept. The consumer surplus measures a change in utility[1] by a change in an area to the left of the ordinary or Marshallian/Walrasian demand curve. It became widely known when Marshall picked it up in his famous *Principles* (1890). Although still much used and attractive after more than 150 years, the consumer surplus measure suffers from the so-called path dependency problem, which causes it to be an inexact welfare measure when multiple prices change. In his classic article "The Rehabilitation of Consumer's Surplus", and its follow up, Hicks (1939; 1940/41; 1943; 1945/46; 1946) developed two new welfare measures, which became known as the compensating variation (CV) and equivalent variation (EV). These latter measures sucessfully overcame the deficiency of the traditional Dupuit/Marshall consumer's surplus measure. However, because the Hicksian concepts could not be linked to ordinary demand curves like the consumer's surplus concept, initially the new measures were more of theoretical than practical interest. With the duality revolution in microeconomics and the advances in empirical estimation of demand systems,

[1] For convenience sake the concepts utility, welfare and preferences will be used as synonyms. For a more refined discussion of these concepts see Ng (1979, section 1.3).

the Hicksian measures gained ground also in applied work.

Marshall also introduced the producer's surplus measure as a concept being analogous and symmetric to the forementioned consumer's surplus. Later on the economic rent-nature of this surplus was clarified (Mishan, 1968). Again with respect to the producer side, advances in economic theory (profit function) improved the applicability of the concept. Of particular significance is the conditionality of producer rents on the length of run considered. Increasing the length of run implies an increased number of previously quasi-fixed assets become variable, and larger shifts in technology result from technical change.

Marshall, when referring to the consumers' surplus, implicitly assumed that individual consumer's surplusses could be aggregated without problems. But the marginal revolution, with its reliance on ordinal (instead of cardinal) utility, caused the apostrophe to be moved one position to the left: it became usual to discuss the surplus measure in terms of a single consumer, *i.e.* consumer's surplus. However, the impossibility of inter personal utility comparisons did not prevent aggregation over households or to aggregation of the surplus measures of several groups in the economy into one overall (national) measurement concept. The usual practice is to simply aggregate welfare changes over individuals on a guilder-for-guilder basis. This raises questions regarding the exact interpretation of such measures, either in terms of social welfare changes, or in terms of hypothetical welfare changes.

Besides the aggregation-issue, this chapter will discuss the so-called balance of payments function as an operational overall welfare surplus concept. Directly related to the measurement of the impact of policy changes on welfare is the issue of appropriately measuring the excess burden or deadweight loss in an undistorted (first-best), and already initially distorted (second-best) economy.

This chapter is organized as follows: Section 2 includes a discussion of the consumer surplus measures, and their interpretation in a multiple household economy. Section 3 similarily presents the concept of the producer surplus or economic rent measure. Section 4 provides a framework for measuring and comparing welfare on a national basis, based on the eralier derived welfare measures and the so-called trade expenditure and balance of payments functions. In this context the aggregation-issue is also discussed. Section 5 focuses on the measurement of excess burden or deadweight loss, a subject directly related to the overall-measures provided in Section 4. Finally, Section 6 closes with a short summary of the main conclusions. Since there are many good references in the field of welfare economics, notably Just, Hueth and Schmitz (1982), Ng (1983), and Boadway and Bruce (1984) the discussion in this chapter will be limited to noting some highlights useful for our analysis[2].

3.2 Consumer surplus measurement

3.2.1 Consumer's surplus

Consumer welfare measures are based on the so-called preference based consumer behaviour-approach, which assumes that a preference relationship exists which 'explains' the economic behaviour of consumers. In this, welfare economics goes one step beyond positive economics, and can in principle be based on a revealed preference basis. Whereas the latter focuses on (revealed and thus observable) consumer's or producer's choices without referring to underlying mental states, welfare economics has to assume that consumers maximize something desirable or good, often denoted as utility. I do not think this necessarily requires adherence to the classical utilitarian tradition followed by the founders of welfare economics. There is no need to enquire into the reasons (motives) why certain economic choices are made, or to subscribe to a utilitarian ethics. The only requirement is to assume that there is a relationship between the availability of scarce means and economic well-being, or that all agents are 'economizers', *i.e.* follow the economic norm[3]. Moreover, it could be argued that the difference in assumptions between positive and normative economics is much less than sometimes suggested (see Mishan, 1982, Ch.1; Blaug, 1985, p.608, and, for a more formal discussion, Mas-Colell *et al* 1995, p.5 and sections 1D, 2F, 3I and 3J).

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[2] Also the better micro economic textbooks provide a discussion of consumer and producer welfare measures, although with varying detail. Examples are Varian (1992), Cornes (1992), Cowell (1987), and in particular Mass-Colel, Whinston and Green (1995).

[3] Economic normativity can be distuinguished from ethical normativity. Where the latter discriminates about morally good and bad behaviour, economic normativity provides the guiding rule for economically 'good' behaviour, like not wasting of scarce means, and efficient satisfaction of needs and preferences.

Assume a consumer's preference relationship $\geq$ is known (for example derived from empirical demand analysis). From these preferences, an indirect utility function $v(.)$ is derived which forms the basis for welfare comparisons. The welfare measure corresponding to a favourable price and/or income change should satisfy the following evaluative expression

$$v(p^1,y^1)-v(p^0,y^0)\geq 0 \tag{1}$$

indicating that the new situation characterized by prices and income (p^1,y^1) is strictly preferred to the initial situation with (p^0,y^0). In order to examine the impact of infinitesimal changes in prices or income on the utility level $v(p,y)$ is totally differentiated, which yields, after some substitution,

$$dv=\sum_{i=1}^{n}\frac{\partial v}{\partial p_i}dp_i+\frac{\partial v}{\partial y}dy \quad = \quad -\lambda\left(\sum_{i=1}^{n}x_i dp_i-dy\right) \tag{2}$$

with n representing the number of consumption goods, and λ the Lagrange multiplier (shadow price of income). If the changes in prices or income are so small that the marginal utility of income $(\lambda(p,y))$ can be treated as constant, (2) provides a marginal cost-benefit rule. The net benefit of a marginal price or income change can be determined by looking at observed variables like the vector of ordinary Marshallian demands $x(p,y)$ and income. Considering a discrete change in the price(s) and/or income variables leads to a somewhat different outcome.

$$\Delta v=v(p^1,y^1)-v(p^0,y^0)=\int_c\left(\sum_{i=1}^{n}v_i dp_i+v_y dy\right)$$

$$= \quad -\int_c \lambda(p,y)\left[\sum_{i=1}^{n}x_i(p,y)dp_i-dy\right] \tag{3}$$

where c defines some integration path between the initial and final price-income vectors[4]. The integral is a line integral defined on some path c of prices and income between an initial and final price and income vector. The first term between square brackets in (3) gives the area under the Marshallian demand curve for a change in prices $dp = dp^1 - dp^0$, while the second term represents a change in lump sum income. Note that for Δv to be completely determined, information on the marginal utility of income $\lambda(p, y)$ is necessary. This variable is unobservable, however, and to obtain a money measure of the consumer surplus, $\lambda(p, y)$ (with dimension utils/guilder) may be eliminated by simply dividing (3) by λ. This yields,

$$CS = -\int_c \left[\sum_{i=1}^{n} x_i(\mathrm{p}, y) dp_i - dy \right] \tag{4}$$

which comes down to the traditional Dupuis-Marshallian consumer's surplus measure[5]. According to this measure, the monetary value of the utility change is

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[4] In fact Silberberg (1972) was the first who, following the Marshall-Dupuit tradition, defined the consumer' s surplus concept for a multi-price changing case.

[5] Note that when one wants to evaluate the change in the consumer welfare in the *i-th* market, this should be done conditionally on all the previously considered price and/or income changes in other markets. This stands alone from the path dependency issue and holds for both approximate and 'true' welfare measures. With regard to the *CS* measure provided in (4), for example, this can be explicitly expressed by writing

$$CS = -\sum_{i=1}^{N} \int_{p_i^{t=0}}^{p_i^{t=1}} x_i(\hat{p}_i(\mathrm{p}_i), y^{t=0}) dp_i - (y^{t=1} - y^{t=0}) \tag{4'}$$

$$\text{with:} \quad \hat{p}_i(\mathrm{p}_i) = (p_1^{t=1}, \ldots, p_{i-1}^{t=1}, p_i, p_{i+1}^{t=0}, \ldots, p_n^{t=0})$$

while the superscripts $t=0$ and $t=1$ denote the initial and the final value of the variable of interest. This way of measuring welfare changes successively conditioned on previously considered price adjustments is known as the so-called sequential approach (Just et al, 1985, 338-341). This stands alone from the path dependency issue (see following) and holds for both approximate and 'true' welfare measures. Equation (4') also implies that the total welfare change in principle can be measured in one arbitrary market, *i.e.* an output or an input market, given that the appropriate price-vector is applied. The expression for the total welfare change, as measured on say market 1 is

$$CS = -\int_{p_1^{t=0}}^{p_1^{t=1}} x_1(\hat{p}_1(\mathrm{p}_1), y^{t=0}) dp_1 - (y^{t=1} - y^{t=0}) \quad \text{with: } \hat{p}_i(\mathrm{p}_i) = (p_1, p_2^{t=1}, \ldots, p_n^{t=1}) \tag{4''}$$

equal to the sum of all consumer surpluses (the first term between the square brackets in equation (4)) in the markets where prices have changed plus the income change. However, this trick is only permitted if $\lambda(p, y)$ is independent of the income and price changes. But in fact λ is not independent of income and price changes, and so the *CS* measure loses its properties of being a unique and exact measure, at least for multiple price/income changes[6]. The problem of finding different money evaluations for the same change in utility due to the changes in prices and income in different paths (even when begin and end price-income vectors are the same) is known in the literature as the path dependency problem (see among others Silberberg, 1972; Chipman and Moore, 1980[7]).

The path dependency issue can be restated in terms of a fundamental mathematical property of line integrals. Let ω be a path in the budget space Ω which is a continuous function $\omega(t) = (p(t), y(t)),\quad 0 \leq t \leq 1,$ with $\omega(0)$ equal to starting point (p^0, y^0) and $\omega(1)$ equal to end point (p^1, y^1). Assume $z = (z_1, .., z_n, z_{n+1})$ is a vector-valued continuously differentiable function of (p, y). The line integral of z with respect to ω may be denoted as (e.g. Chipman and Moore, 1980, p.934),

$$\int_0^1 z[\omega(t)]d\omega(t) = \sum_{i=1}^{n+1} \int_0^1 z_i[\omega(t)]d\omega_i(t) \tag{5}$$

According to the theory of line integrals, if all polygonal paths ω joining the begin and end points yield the same value, then there must exist a twice differentiable 'potential function', which satisfies (Chipman and Moore, 1980 equation (4) and Takayama 1987, p.609) the following expression

$$\frac{\partial L(p,y)}{\partial p_i} = z_i(p,y), \quad i = 1, \ldots, n; \qquad \frac{\partial L(p,y)}{\partial y} = z_{n+1}(p,y) \tag{6}$$

[6] As is argued by Mishan (1981, p.65), Marshall was already aware of the non-constancy of λ and became increasingly disillusioned with consumer's surplus.

[7] Hotelling already paid attention to this path-dependence issue in 1938. Had his discussion not been ignored much confusion in the later literature might have been avoided (see Burns, 1973, p.340).

such that,

$$\int_0^1 z[\omega(t)]d\omega(t) = L(p^1, y^1) - L(p^0, y^0) \tag{7}$$

Because of Youngs theorem, partial derivatives $L_{ij} = L_{ji}$, $\forall i, j$, which implies that $z_{ij} = z_{ji}$. Also the opposite is true; if there exists a twice differentiable function $L(p, y)$ which satisfies (6) then the line integral (5) is path independent and (7) holds. If the indirect utility function $v(p, y)$ is chosen as a 'potential function', for the path independency to hold, the necessary and sufficient condition:

$$\left(\frac{\partial x_i}{\partial p_j}\right)_{y=constant} = \left(\frac{\partial x_j}{\partial p_i}\right)_{y=constant} \tag{8}$$

must be satisfied[8]. Using the Slutsky equation, it can be easily seen that path independency requires

$$x_j \frac{\partial x_i}{\partial y} = x_i \frac{\partial x_j}{\partial y} \qquad \text{or} \qquad \frac{\partial x_i}{\partial y}\frac{y}{x_i} = \frac{\partial x_j}{\partial y}\frac{y}{x_j} \tag{9}$$

This implies that the income elasticities of demand must be the same for all goods whose price have changed. In other words, if path independence is to hold for any set of price changes, then this implies that each income elasticity of demand must

[8] The term 'y = constant' is added to emphasize that the Marshallian measure of consumer's surplus is generally interpreted to have reference to a demand curve for which the level of money income is held constant (Mishan, 1981, p.69).

be equal to unity. A utility function having this property must be homothetic (Deaton & Muellbauer, 1980, section 5.4)[9]. This is very restrictive and not in accordance with most empirical evidence (Deaton and Muellbauer, 1980, p.120 and p.144)[10].

3.2.2 Compensating and equivalent variations

Hicksian Compensating and Equivalent Variation represent welfare measures which do not suffer from the previously mentioned path-dependency problem. Compensating Variation (*CV*) is defined as the sum of money received by or from an individual, following a welfare change, which leaves him at his original utility or welfare level. In other words: how much money would the consumer want to receive or be willing to give up *after* a price (or policy) change to be as well off as *before* this change? The consumer has in fact a 'property right' to the 'old' or status quo situation. Equivalent Variation (*EV*) is defined as the sum of money received by or from the individual, which leaves him as well off as if he had the welfare change. In this case the individual is assumed to have a 'property right' to the 'new' or after-change situation. Formulated as a question: how much money would a consumer want to receive or be willing to give up *before* the price (or policy) change to leave him as well off as he would be *after* the change? In geometric terms *CV* and *EV* are just two different ways to measure the distance between the two indifference curves with different utility levels, say U^0 and U^1.

In order to derive an algebraic formulation for the compensating and equivalent variation, the relationship between the indirect utility function and the expenditure

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[9] A utility function U(**x**) satisfies homotheticity if there exists an increasing monotone transformation, say $\phi(U)$ such that $f(x) = \phi u(x)$ is linear homogeneous, i.e. $\lambda f(x) = \lambda \phi u(x) = \phi(\lambda u(x))$; $\lambda > 0$, $\phi'(u) > 0$.

[10] If only a subset of prices is assumed to change, the condition needs only to be met as far as that particular subset is concerned. This weakens the restrictive homotheticity condition, for now only the sub-utility function needs to be homothetic, which is not necessarily very unrealistic if 'suitable' separability assumptions are chosen (quasi-linear utility structure). Alternatively, a sufficient, though not necessary condition would be zero income effects *i.e.* $\partial x_i / \partial y = 0 \quad i = 1, \ldots, n$. This will lead to a violation of the budget constraint since at most the demand for *n-1* goods can be independent of the level of income *y*.

According to another interpretation of the path independency condition

$$\frac{\partial(\lambda x_i)}{\partial p_j} = \frac{\partial(\lambda x_j)}{\partial p_i} \quad \text{or} \quad \frac{\partial x_i}{\partial p_j} = \frac{\partial x_j}{\partial p_i} + \frac{1}{\lambda}\left(x_j \frac{\partial \lambda}{\partial p_i} - x_i \frac{\partial \lambda}{\partial p_j}\right) \tag{13}$$

as a necessary and sufficient condition $x_i \frac{\partial \lambda}{\partial p_j} = x_j \frac{\partial \lambda}{\partial p_i}; i, j = 1, \ldots n$ must be satisfied. A special case is $\partial \lambda / \partial p_i = \partial \lambda / \partial p_j = 0$, which is a sufficient, though not necessary condition for path independence. In fact λ does not necessarily need to be constant with respect to all prices, but rather it has to change at the same rate for each price change.

function $e(p, U)$ is exploited. The *CV* associated with a change in prices from p^0 to p^1 and a change in income from y^0 to y^1 can be written in terms of the indirect utility function as,

$$v(p^0, y^0) = v(p^1, y^1 - CV) = U^0 \tag{10}$$

which can be written (via inversion of $U = v(p, y)$) in terms of the expenditure function as follows.

$$y^1 - CV = e(p^1, U^0) \quad \Rightarrow \quad CV = e(p^1, U^1) - e(p^1, U^0) \tag{11}$$

After some rewriting (adding and substracting $e(p^0, U_0)$ to (11)) it follows that

$$\begin{aligned} CV &= y^1 - y^0 + e(p^0, U^0) - e(p^1, U^0) \\ &= \Delta y - \int_C \sum_{i=1}^{n} x_i^h(p, U^0) dp_i \end{aligned} \tag{12}$$

In an analogous way the *EV* (formally defined as $v(p^0, y^0 + EV) = v(p^1, y^1) = U^1$) associated with this price and income change can be written as,

$$\begin{aligned} EV &= y_1 - y_0 + e(p^0, U^1) - e(p^1, U^1) \\ &= \Delta y - \int_C \sum_{i=1}^{n} x_i^h(p, U^1) dp_i \end{aligned} \tag{13}$$

The interpretation of (12) and (13) is as follows. If there is only a change in income (prices fixed), the *CV* and *EV* are equal to one another and indicate the sum of money that must be taken from or given to the household in order to give it its initial or final utility level respectively. In this case the integral terms are equal to zero and cancell out. The integral contains the compensated or Hicksian demand functions because, for infinitesimal price changes, according to Shephard's Lemma,

$$\frac{\partial e(p,U)}{\partial p_i} = x_i^h(p,U); \quad i = 1,\ldots,n \tag{14}$$

The integral terms in (12) and (13) give the sum of areas to the left of the compensated demand curves between p^0 and p^1. As is known from the characteristics of the expenditure function, the (compensated) cross-price effects, which are equal to the Hessian, are symmetric by construction. Thus the choice of the adjustment path c is not relevant because the expenditure function $e(p,U)$ is a satisfactory twice differentiable 'potential function' $L(p,U)$ and thus the integrands are exact differentials (see equations 6 and 7). The order in which prices and/or income change may thus be arbitrarily chosen.

3.2.3 Evaluation

Unfortunately the different money welfare measures discussed up till now in general do not coincide (see note 10 for exceptional cases). See for a graphical illustration of a single price decline-case Figure 3.1 with $U^0 < U^1$ and $ABC > AB > A$, or $EV > CS > CV$. In this subsection, therefore, some evaluative and interpretive remarks are made. Subsequently the approximate *CS*, the exact *CV* and *EV* measures, and the interpretation that should be attached to the monetary equivalences of underlying welfare changes are examined.

As already noted in the introduction to this chapter, the traditional CS measure is still rather popular in applied analysis, in spite of its clear deficiencies. For in general (multiple price changes), *CS* is not a unique and sign-preserving money measure of a utility change. This implies that in situations where both prices and income are free to vary *CS* may give incorrect rankings. There are three exceptions where *CS* will provide correct rankings, namely when: (1) only one price (or income) changes and everything else remains constant; (2) the utility function is homothetic; (3) the utility function is quasi-linear and one price is fixed[11]. One reason why CS measures are still in use is because they relate to observables, whereas CV and EV relate to unobservables like utility and compensated demand functions. Another

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[11] This is equivalent to assuming homothetic demand functions (Engel curves are straight lines through the origin) or vertical Engel curves (the change in income dos not affect the demand for any commodity except for one commodity, the numeraire).

reason is that if the wealth effects of the policy changes analysed are relatively small, the marginal utility of income $\lambda(p,y)$ will be more or less constant, and the approximation error of the 'true' welfare change will be of negligable order.

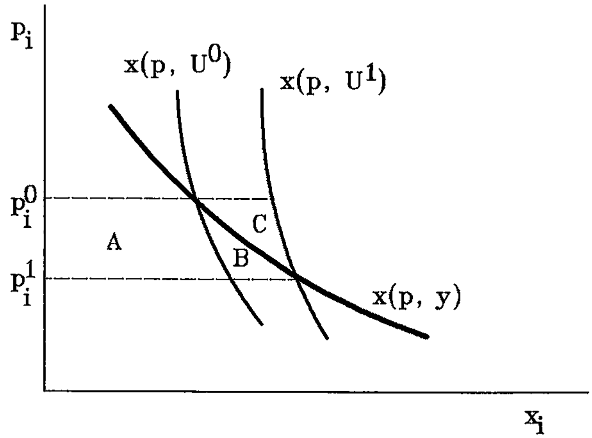

Figure 3.1: Different welfare measures

Willig (1976) systematically analysed the approximation error when using *CS* instead of true welfare measures EV and CV, and obtained the following error bounds (Willig, 1976, p.593)

$$\frac{CV-CS}{CS} \approx \frac{\eta CS}{2y^0} \quad ; \quad \frac{EV-CS}{CS} \approx -\frac{\eta CS}{2y^0} \qquad (15)$$

where η represents the income elasticity of demand. These error bounds show that the relative approximation error of *CS* is small for low income elasticities and small proportional income changes CS/y_0. Willig's analysis focused on single price changes, which from an empirical point of view, is not so interesting, but was generalized for multiple price changes by, among others, Just *et all* (1982, p.381-385). According to Willig (1976, p.595), Just et all (1982, p.379), and Shonkwiler

(1991) the approximation errors of using *CS* are of negligable order[12]. Since their simulation results are mainly based on the single price change-case, however, they are as such not sufficient for proving the general case. McKenzie (1979), for example, showed that when multiple prices change, the approximation errors may be quite large. Hartmann (1991, p.57-64), using the multiple market-approximation provided by Just *et al* (1982), ended up with more or less the same results as McKenzie, but added some qualifications[13]. Moreover, as shown by Hausman (1981, p.663), LaFrance (1991, p.1497, p.1506) and to a lesser extent by Alston and Larsen (1993, p.765), the approximation errors with regard to the measurement of the efficiency losses may be much larger than those with regard to the surplus measures[14]. As might be expected, with the commonly shared income transfer part falling away, the relative differences increase.

Summarizing so far, it can be concluded that the Willig approach and refinements thereof give a limited justification for the use of the *CS* measure. Their contribution is that they have provided much more insight into the relation between the biased *CS*-measure and the exact equivalents CV and EV. Even for multiple price change-cases they provide some guidance, although the complexity is somewhat increased. In particular, when the focus is on obtaining reliable estimates of the deadweight losses of a policy, the approximation errors remain troublesome. To this it can be added that, due to theoretical and computational advancements, the 'observables'-issue no longer plays a serious role favouring the traditional measure (*CS*)[15]. If an estimable demand system satisfying the integrability conditions exists, or demands are explicitly derived from a utility maximization framework, exact methods (*CV*, *EV*) are to be preferred to approximations. If, on the other hand,

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[12] This is not surprising, since in the case of low price and income elasticities of demand, the lion's share of the welfare effect consists of an income transfer (first order-effect), which is common to all three measures (*e.g.* Mas-Colell, 1995, p.90).

[13] Both the McKenzie and Hartmann studies used a two-good model for their simulations. Using a more general model would probably worsen the approximation still further because of the then increasing path dependency problems. Hartmann (1991, 64-72) developed some approximation refinements which yield a better performance (low errors), but have an increasing computational burden.

[14] The Hausman-result was somewhat overstated because of a computation error (*cf.* Haveman, Gabay and Andreoni, 1987), but are compensated for by the strongly significant empirical results of LaFrance.

[15] For example the work of McKenzie and Pearce (McKenzie, 1983), and Hausman (1981), which show that in principle it is possible to compute both measures using the information on ordinary demand relationships.

integrability of demand is not satisfied, the Willig type approximations do not apply since the bounds can not be determined because no recoverable compensation function exists (*cf.* Willig, 1976, p.591).

The preliminary conclusion is that exact welfare measures like *CV* and *EV* should be used, preferrably in the context of a demand system that is explicitly derived from maximizing a preference relationship. But the point remains that the *CV* and *EV* measures which differ from each other. This latter difference can be traced back to income elasticities of demand that differ from zero. Different money measures will then impute different values to one (unique) underlying utility change[16]. Although the absolute numbers obtained when computing the *CV* and *EV* of a policy change may differ, their signs are the same, and essentially that is the only thing that matters in an ordinal utility-world. So from this perspective neither of the two measures can be called the best one.

In fact there are an infinite number of 'true' welfare measures. This can be seen when interpreting the *CV* and *EV* measures as special cases of the so-called money metric welfare measure *(MM)*. Substituting the indirect utility function into the cost function gives the so-called compensation function (see Varian, 1984, section 3.5 and p.264). The compensation function $\mu(p^R, p, y) \equiv e(p^R, v(p, y))$ measures how much income the consumer would need at (reference) prices p^R to be as well of as he would be facing prices p and income y.[17] The *MM* welfare measure is then given by:

$$MM \quad = \quad \mu(p^R, p^1, y^1) - \mu(p^R, p^0 y^0) \quad = \quad e(p^R, U^1) - e(p^R, U^0) \qquad (16)$$

It can be easily verified that the money metric is a 'true' welfare measure, for the compensation function is nothing less than a monotonic transformation of the indirect

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[16] Intuitively the explanation for $EV > CV$ in Figure 3.1 is the decreasing marginal utility of money (see Ng, 1979, p.106 for a comment).

[17] Varian (1980) and King (1983) call this function an equivalent income function. Thereby 'equivalent income' is defined as the level of income which at reference prices p^R affords the same level of utility as can be attained under the given (or actual) budget constraint. The notion of equivalent income welfare measure is similar to the Hicksian equivalent variation (see Parikh et al, 1988 for an application).

utility function. The money metric utility measure MM measures the amount of money required by the consumer to purchase the change in utility resulting from the change in policy[18].

In order to make a utility comparision, an (arbitrary!) reference or base price vector p^R has to be choosen[19]. Although in principle an infinite number of reference price vectors could be chosen, all guaranteeing a reliable and 'true' welfare measure, there are certain choices which allow for a rather natural economic interpretation. Two obvious choices, which lead to the well-known Hicksian measures, are $p^R = p^1$ (*CV*), and $p^R = p^0$ (*EV*). Whereas the *EV* is a real money metric, the *CV* is only a money metric, when two but no more than two alternatives are compared (*e.g.* Chipman and Moore, 1980). This is due to the dependence of the reference price vector on the alternative that is being evaluated for the *CV* (but not for the *EV*). As such the *EV* measure (in being both a compensation and welfare measure) has a natural superiority over others.

A final point worthy of attention is the exact interpretation of the monetary equivalence welfare measures. *CV*, *EV* and *MM* measures are all based on an ordinal utility framework. The requirement they have to fulfil is that they have a positive sign if and only if the level of welfare or satisfaction increases, and vice versa. The absolute value of these measures therefore has no direct interpretation in terms of an 'amount' utility measured in monetary terms[20]. Thus, in general, it is not true

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[18] In other words, a money metric converts a change in equilibrium utility to an expenditure measure. A compensation measure calculates the (net) sum which could be extracted following a policy change while still supporting the reference utility and satisfying all budget constraints. In an already distorted economy (second-best) money metrics, and compensation measures, (like *CV* and *EV*) do not generally coincide, since the former corrects for actual changes in taxation/tariff-revenues, while the latter rely on a hypothetical measure of compensated revenue (see also sections 4 and 5 of this chapter and section 4.3 of the next chapter). Because *MM*'s add a tax revenue change due to the adjustment in (equilibrium) utility to the two compensation measure, they lose their interpretation as a real compensation measure, although remaining a valid utility indicator.

[19] As noted by Blackorby (1990, 766), at least in a multiple consumer-world, the choice of the reference price vector will influence the welfare weights attached to the various individuals, and is thus not value-free.

[20] As is shown by Mishan (1971, p.19), Ng (1983, p.105) and more formally by Takayama (1987, 611) the discrepances (differences in absolute numerical outcomes) between *EV* and *CV* can be large and increases with increasing price changes. If those values had a direct meaning and both measures are correct which one, the question which one should be used becomes more pressing. The intuition behind the potential discrepancy-issue can be understood as follows. Firstly, as is known particularly from the environmental applications, there is a distinction between willingness to pay (WTP), it's maximum being bounded by the available income, and willingness to accept (WTA). The WTA is not subject to limiting bounds and will be always greater than the WTP. Knetsch (1989) explains this by noting that individuals value a given reduction in entitlements more higly than an equivalent increase in entitlements. As Ng (1983, 106) showed, this is in fact due to the changing marginal utility of money. Secondly, note that there exists a direct relationship between WTP/WTA and *CV*/*EV*. In the case of a 'beneficial' move *CV* corresponds with WTP and *EV* with WTA, while for a 'regressive' move CV and EV correspond to WTA and WTP respectively.

that $\Delta U = \lambda CV$ or $\Delta U = \lambda EV$. As Morey (1984) argued, the introduction of a cardinal utility assumption is not very promising either in solving this conversion issue. Remaining within the ordinal utility sphere, there is a practical argument for taking, at least to some extent, the absolute values of the welfare measures into account. For, in practice, it will be usually impossible to analyse all the (economic) aspects of the policy alternatives that are studied. Although it is the minor issues that tend to be ignored, they may still alter the final outcomes somewhat if they had been included. Considering the incompleteness of empirical welfare analysis, therefore, besides knowledge about 'more or less', knowledge also about 'how much more or less' may be helpful in coming to robust conclusions (see Morey, 1984, p.170). In addition to incompleteness, data inaccuracies should also be taken into account (Ng, 1979, p.98).

Apart from these considerations, it should be emphasized that the cardinally scaled measures of gains and losses resulting from policy changes are meaningful in their own right to decision makers. Or as Currie *et al* (1971, p.786) state:

> "..the maximum sum of money an individual would be prepared to pay for the benefits of some change is a useful cardinal magnitude; whether it is obtained from an ordinal preference map is immaterial. In the simple case of a consumer who buys exactly the same quantity of a commodity before and after a price change, the change in his expenditure on the good certainly has more than an ordinal meaning".

A monetary evaluation of benefits and losses associated with alternative policies provides meaningful and interesting information. As special cases of the money metric *CV* and *EV* have an equivalent income interpretation. They denote the equivalent income necessary to compensate the consumer or producer for the welfare effects induced by a policy change. They provide, therefore, natural money measures of how a policy change affects an individual. Moreover, the (aggregated) *CV* or *EV* can be interpreted as the amount of money that is left over after compensation has been paid. If positive, this means that after compensation of the losers an amount of money is left over which can be distributed in such a way as to increase the welfare for some or all households. According to this compensation interpretation, if compensation is actually paid, positive *CV*s and *EV*s indicate desirable projects, which automatically satisfy the Pareto criterion (Mishan, 1972, p.317).

3.3 Producer surplus and economic rent

3.3.1 Producer surplus as quasi-rent

The Marshallian producer surplus (*PS*) is the area to the left of an ordinary supply curve and below the equilibrium price line. The idea behind it is that a seller as well as a buyer may receive some sort of surplus. This terminology is somewhat unfortunate, confusing and misleading. Rethinking the producer surplus concept, for example, Mishan's (1968, p.1297) suggestion to "recommend that the term "producer's surplus" be struck from the economist's vocabulary", and to replace it by the economic rent concept. Producer surplus is essentially a renumeration for the fixed factor use in the production process. As such producer surplus has no real surplus-character comparable to consumer surplus, but is a quasi-rent. Quasi-rent (*QR*), also a Marshallian concept, is defined as the gross receipts a producer receives minus the primal costs (= variable costs) he incurs. The adjective 'quasi' was added because it deals with a short-term rent (for example, due to short-run fixity of capital) which soon diminishes and disappears as time goes on. In that respect it clearly differs from the already older Ricardian rent concept which is a 'true' rent (Mishan, 1968, p.1275)[21].

In contrast with the consumer case, in the producer case the producer surplus measure coincides with the Hicksian compensating and equivalent variation measures[22]. The *CV* associated with a price increase from p^0 to p^1 is the sum of money that, when taken away from the firm, leaves it as well off as if the price did not change[23]. The *EV* for this case is the sum of money which, when given to the firm, leaves it as well off without the price change as if the price change actually

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[21] Rents are usually defined as those payments to a factor of production that are in excess of the minimum payments necessary to have that factor supplied (*e.g.* Varian, 1990, p.386). Mishan (1959, p.390 and 1969, p.636) has pointed at some ambiguities in this traditional definition of the rent-concept, since it (wrongly) suggests economic rent to be a surplus which might be expropriated without any effects on economic behaviour.

[22] This holds only if risks are not explicitly dealt with. When accounting for risk, producer behaviour will follow some form of expected utility maximization, which is rather analogous to the previously discussed consumer case, with its three distict welfare measures (*cf.* for example Chavas and Pope (1981), Pope, Chavas and Just (1983), Larson (1988) and Tsur (1993)).

[23] It is assumed that the producer is free to adjust production to the profit-maximizing quantities.

occurred. Both are exactly equal to the change in revenues over variable costs and thus coincide perfectly with the *PS*-measure. There is a direct relationship between profits and producer welfare-measures, because

$$PS = QR = TR - TVC \equiv \pi^r$$

$$\pi^r = TR - TVC - TFC + TFC = \pi + TFC \tag{17}$$

where TR, TVC, and TFC stand for total revenue, total variable costs, and total fixed costs respectively. Two profit concepts are now distinguished. Restricted profits π^r, a concept usually used in applied production analysis, is defined as total revenue minus total variable costs $(TR - TVC)$. Since it coincides exactly with both producer surplus and producer rent, it is an obvious alternative candidate for measuring changes in producer welfare. Overall profits, *i.e.* total revenues minus total (variable and fixed) costs are represented by $\pi^{surplus}$. It can be interpreted as the ultimate producer gain and may have a real surplus character[24].

Considering a profit maximizing competitive firm with a multiple input/multiple output technology, with variable outputs y, restricted outputs q, variable inputs x, and restricted (or quasi-fixed) inputs z, there exists a short-run or restricted (dual) profit function π^r, or quasi-rent function

$$\pi^r(p,w;qz) \equiv \max\{py + rq - wx\} \quad \text{s.t.} \quad (y,x) \in T(q,z) \tag{18}$$

where p represents the output price vector $(p_1, p_2, \ldots, p_i, \ldots, p_I)$, w is a variable input price vector $(w_1, w_2, \ldots, w_j, \ldots, w_J)$, q represents a vector of restricted or controlled outputs, and z is a vector which represents the quantities of fixed inputs used. $T(q, z)$ represents the restricted (outputs/inputs) transformation or production possibilities set comprising all technologically feasible combinations (y, x, q, z).

Differentiating the profit function with regard to output and input prices gives

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[24] As such it would be more appropriate to coin this producer gain area as producer surplus. It has a pure rent character, at least only as far as those profits are not an implicit renumeration for the management qualities supplied by the entrepreneur. They will have partly an incidental character, due to the normal risks associated with enterprise. Note that if the prices or rents that have to be paid by the entrepreneur for the non-owned fixed factors remain constant, a change in restricted profits changes surplus profits equally.

the Marshallian output supply and input demand functions (Hotelling's Lemma). Substituting these supply and demand functions into (18) gives the following quasi-rent function R

$$R(p,w,r;q,z) = \sum_{i=1}^{I} p_i y_i(p,w;q,z) - \sum_{j=1}^{J} w_j x_j(p,w;q,z) + \sum_{k=1}^{K} r_k q_k \qquad (19)$$

The change in quasi-rents (or producer surplus) due to (discrete) changes in variable input and output prices can be written as $\Delta R = R(p^1,w^1,r^1;q,z) - R(p^0,w^0,r^0;q,z)$. This can be rewritten as:

$$\Delta R = \int_c \left(\sum_{i=1}^{I} \frac{\partial R}{\partial p_i} dp_i + \sum_{j=1}^{J} \frac{\partial R}{\partial w_j} dw_j \right) + \sum_{k=1}^{K} q_k dr_k$$

$$\Leftrightarrow \quad \int_c \left(\sum_{i=1}^{I} y_i(\mathrm{p},\mathrm{w};\mathrm{q},\mathrm{z}) dp_i - \sum_{j=1}^{J} x_j(\mathrm{p},\mathrm{w};\mathrm{q},\mathrm{z}) dw_j \right) + \sum_{k=1}^{K} q_k dr_k \qquad (20)$$

where c is any path of integration[25]. Because (20) is the exact integral of R, there is no need to convert the money measure[26] as in the earlier discussed consumer case. There is no path dependency problem, implying that the order in which price changes are considered is arbitrary and have no influence on the overall impact on quasi-rent.

[25] Note that the Hessian of the profit function is a (negative semi-definite) symmetric matrix.

[26] In the consumer case we end up with a utility measure which has to be converted into a money measure. The rent change is already in monetary terms. It is somewhat surprising that the ordinal revolution had left one large group of economic agents (the producers) virtually unaffected.

The change in quasi-rents due to a change in restricted outputs, for example as a result of supply management policies, *i.e.* $\Delta R = R(\mathbf{p},\mathbf{w},\mathbf{r};\mathbf{q}^1,\mathbf{z}) - R(\mathbf{p},\mathbf{w},\mathbf{r};\mathbf{q}^0,\mathbf{z})$ can be written as

$$dR = \sum_{k=1}^{K} \frac{\partial \pi^r(p,w,r;q,z)}{\partial q_k} dq_k + r_k dq_k \tag{21}$$

which can be rewritten as

$$dR = \sum_{k=1}^{K} (r_k - \mu_k) dq_k \tag{21}$$

with μ_k representing the shadow price or virtual price, *i.e.*

$$\frac{\partial \pi^r(.)}{\partial q_k} = -\mu_k(p,w;q,z) \tag{22}$$

which are given by their marginal costs evaluated at the optimal output level of unrestricted outputs (*cf.* Moschini, 1988, p.320).

3.3.2 Long-run and intermediate-run supply

In the case where all production factors are variable, *viz* the long-run, the producer surplus concept breaks down. In that case the firm's long-run supply curve is in fact a locus of its minimum average cost curves, and thus necessarily includes all factor prices, and therefore all rents (Mishan, 1968, p.1278)[27]. A movement along such a long-run supply curve can be interpreted as a movement from one long-run equilibrium to another. Therefore at all points on the long-run supply curve, the competitive firms will earn normal profits, but no rents since those will already be

[27] Although this point was definitely made by Mishan, it was already mentioned by Marshall (1920) in his Appendix K on 'Certain kinds of surplus'.

incorporated in the long-run cost structure[28]. This is geometrically illustrated in Figure 3.2, panel a, where *LRS* represents the long-run supply curve, which is equal to the long run marginal cost curve. As can be seen, this curve goes through the minima of the long run average cost curves LAC^0, LAC' and LAC^1.[29] Because of this, in general, it is impossible to use the producer surplus concept in this case, and welfare propositions derived from areas above the long-run supply curves are therefore invalid[30]. There are, however, two exceptional cases. The first case is the Ricardian rent case. In this case there is one fixed production factor, which has a fixed character even in the long-run, while all other factors are perfectly elastic, *viz.* have a fixed price. In that case the long-run supply curve will be upward sloping: the more intensively this factor is used as output is increased, the higher will be its shadow price or marginal value product. Changes in producer surplus, measured as the area behind such a long-run supply curve, will have an economic rent interpretation, *i.e.* it yields the change in rents accruing to that single fixed factor (Mishan, 1968, p.1275; Harvey and Hubbard, 1984, p.571; Panzar and Willig, 1978)[31]. The second exception arises in the case of imperfect competition. If the assumption of a perfectly competitive industry is weakened, then long-run surpluses are also possible. Such a surplus can be realized, for example, if the industry analyzed has market power (not necessarily zero profits in the long-run) and can earn "monopoly"-rents[32]. Another reason may be initial costs from operation-barriers. They may lead to a non-zero profit level which must exceed a certain amount before it will be profitable for a 'new' firm to entry the industry (Blaug, 1985, 378).

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[28] As Mishan (1968, p.1278) states: "at each point on the long-period industry's supply curve "Euler's theorem" is met: the product is exhausted by paying to each of the contributing factors its full marginal product. Nothing is left as a surplus to any agent of production".

[29] The long-run average cost curves already include the rents.

[30] See the recent discussion in the *Can. Jrn. of Agr. Econ.* following an article of Veeman (1982) and further debate by Johnson, Spriggs and Van Kooten (1982), Harvey and Hubbard (1984) and Van Kooten and Spriggs (1984) regarding the confusion on this point.

[31] The Ricardian rent, due to the fixity and non-homogeneity of land, serves as a long-run incentive payment encouraging the economical use of (fertile) land, and is in that sense not functionless (*e.g.* Blaug, 1985, p.85 and his discussion of H. George's 'single tax'). The limited availability of land may suggest that it is possible to have positive long-run profits in agriculture. This idea is wrong because there are economic forces which drive those profits to zero. Finally, each production factor should be valued at its market price (opportunity costs). Substracting the appropriate cost of land, long-run profits will be zero (*cf.* Varian 1990, p.385). Nevertheless, it will be true that there are long-run rents earned by land, which are however costs to producers.

[32] *Cf.* Tirole (1988, p.65-71) for a discussion of monopoly, including the intertemporal pricing-issue and Just, Schmitz and Zilberman (1979) as an example for a number of other market imperfections.

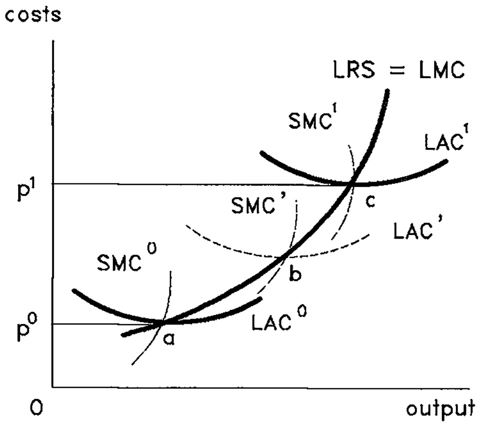

Figure 3.2 a) Long-run supply

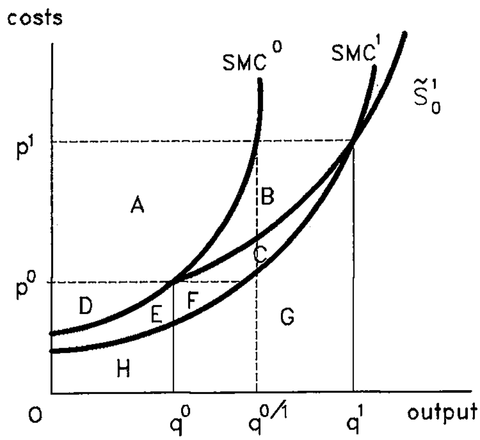

Figure 3.2 b) Intermediate-run supply

More interesting than the long run, are the intermediate run effects of policy changes and the way in which the associated welfare effects should be measured. Between the short-run (static case) and the long-run, firms can invest, and therewith change their production structure. Or their product supply may shift due to technical progress. Figure 3, panel b, which is copied from Just *et al* (1982, p.65), shows this for a simple two-period case, where (due to investments; no technical change) the supply curve shifts to the right after an initial period in which output prices increase from p^0 to p^1. In the first period the change in producer surplus (quasi-rent) is equal to area *A*. Applying the same procedure, the surplus associated with the second period is equal to area *ABCDEF* (final surplus) minus area *D* (initial producer surplus) or to *ABCEF* (is the short-run producer surplus for period 2). However, in order to achieve production level q^1 in period two, adjustment costs (investment) have been made. These adjustment costs are reflected in the intermediate run marginal costs curve $\tilde{S}_0^1$, which links the initial (p^0, q^0) and final (p^1, q^1) positions. As was proved by Just *et al* (1980, p.65 and their Appendic C), the total adjustment costs incurred to increase production from q^0 to q^1 is given by the change of the area under this intermediate marginal cost curve (area *CFG*). But this implies that the correct measure for the change in the second period's producer surplus is equal to area *AB*, *viz* the change in total revenues (area *ABCFG*) less the change in total variable costs (area *CFG*). The total welfare change of the two-period length of run is thus equal to area *A* plus area *AB*. The correct welfare measure for the price change over the two periods is not the sum of both short run surpluses, but rather the sum of producer surpluses as measured along the the variable lenghts of run marginal cost, or supply functions. Of course, while summing the amounts of money they should be properly discounted.

The investment costs can be netted out since the change in total costs is the sum of changes in normal variable costs and investment (pure adjustment costs). The change in (normal) variable costs is equal to areas *HG* minus *EH*, which equals area *G-E*. The investment then equals area *CFG* (change in total variable costs) minus *G-E*, or area *CEF*. Based on this, Just *et al* (1980, pp.422-423) suggest a procedure to indirectly measure changes in investments, even when they are unobservable in a direct sense. The investment made in the first period is simply the difference between the change in short run producer surplus for period two and the producer surplus as measured along the intermediate marginal cost or supply curve associated with period two, *viz* area *ABCFE* minus are *AB*, or area *CEF*[33]. Moreover, knowing the investment costs, it can be easily verified that the two-period welfare effect also equals the sum of the two short-run producer surpluses, less the investment costs, *viz* area *A* plus area *ABCFE* minus area *CEF*. This last result provides another rule for determining the intermediate run welfare effects. "The welfare effect of any change affecting a firm over time can be measured by the (discounted) sum of changes in short run producer surpluses minus the (discounted) sum of changes in investments" (Just *et al*, 1982, p.422). In fact it comes down to the old revenues over variable costs-measure, with the variability of costs depending

[33] This procedure is not without practical difficulties, since in principle knowledge about planned instead of actual supplies is required, and the analysis as presented by Just *et al* and here do not account for (disembodied) technical change.

on the length of run (short or long or intermediate) of the supply curve.

The intertemporal producer surplus is defined more formally as the discounted stream of profits or

$$\Pi_t^T = \sum_{k=t}^{T} \delta^{k-t} \pi_t^k \tag{23}$$

where

$$\pi_t^k = \sum_{i=1}^{I} p_i^k y_i^k - \sum_{j=1}^{J} w_j^k x_j^k + \sum_{l=1}^{L} r_l^k q_l^k - \sum_{n=1}^{k-t} \frac{1}{\delta^n} v_{k-n}^n z_{k-n}^n \tag{24}$$

It consists of a short-run surplus part, less the costs associated with (planned) adjustments of quasi-fixed inputs (investment costs), or

$$\pi_t^k = R^k - \sum_{n=1}^{k-t} \frac{1}{\delta^n} I_{k-n}^k \tag{25}$$

with R_t^k denoting the rents at k periods ahead of t. This expression is in particular useful when the focus is on *ex post* welfare analysis, since changes in investments will not be observable ex ante. The alternative measure, relying on the intermediate supply curves, is

$$\Delta\pi_t^k = \int_{\bar{p}_t^k}^{p^k} \tilde{y}_t^k \, dp^k \tag{26}$$

with $\tilde{y}_t^k(.)$ the (planned) supply curve for the k-t+1-period length of run, and the integral denoting an intermediate producer surplus, with $\bar{p}_t^k$ the shutdown price. Although this latter procedure has the advantage of avoiding the measurement of investment, it can not be used for ex ante-welfare analysis, since it relies on observing planned supply, while the available data usually reflect actual, not planned output

(Bullock *et al* 1996, p.3).

Another dynamic factor highly relevant when analysing agriculture, and leading over time to shifts of behavioural relationships, is technical change. Whereas investments might be the carrier of embodied technical change, an alternative form is (exogenous) disembodied technical change. It can be interpreted as an increase in the supply of non-rival goods, provided for free to individual producers. Several specifications of technical change have been used in the literature. The most important among these are *a*) the direct incorporation of technical variables into the profit function, and *b*) the use of a distinction between actual and effective quantities and prices (assuming output or input augmenting technical change). (See Miller *et al*, 1988; and Norton and Davis, 1981, and Alston *et al* 1994 for reviews of that literature). Under the first approach, the technical change variable(s) enters the profit function in the same way as a quasi fixed factor, except that as 'public goods' they receive a zero factor return at the firm level. The welfare effect of this kind of technical change (with τ the "quasi-fixed" technology shift-factor)

$$\Delta R = \int_c \frac{\partial R(p,w,r;q,z,\tau)}{\partial \tau} d\tau = \sum_{i=1}^{I} p_i \Delta y_i - \sum_{j=1}^{J} w_j \Delta x_j \qquad (27)$$

with $\Delta y_i = (\partial y / \partial \tau) d\tau$ and $\Delta x = (\partial x / \partial \tau) d\tau$. In case of the often used (normalized) quadratic profit function, this kind of technical change (parallel shift of supply and input demand curves) has a very simple geometric interpretation as the supply or demand shift times its corresponding price (only first-order effect).

As shown by Martin and Alston (1994), the profit or quasi-rent function has an advantage over the traditional producer surplus analysis, since the latter approach sometimes (*e.g.* in case of elastic supplies) leads to misleading surplus estimates. For a graphical illustration see Figure 3.3, where for the ease of exposition the demand side-effects are ignored (fixed prices). The rent-function measure of the technical change from τ^0 to τ^1 is given by area *abcd*, which is equivalent to area *abgh*. The traditional producer surplus estimate is area *abef*, which clearly underestimates the welfare gain of the technical change. Note that even when the quasi-rent function itself cannot be completely recovered but the relevant supplies and demand can, (as is often the case in empirical analysis), the quasi-rent function procedure can (better) be followed at the supply and demand level.

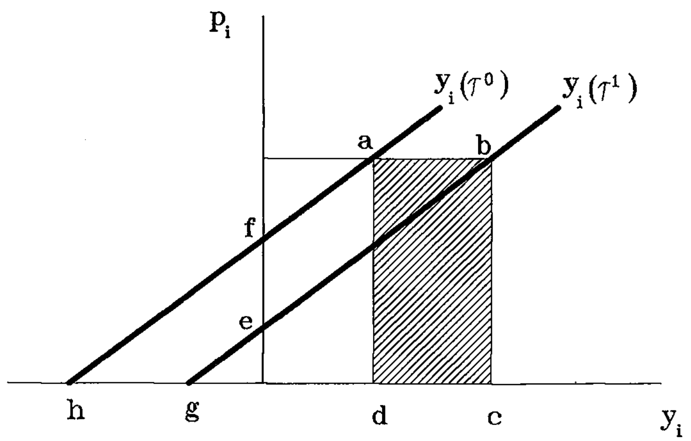

Figure 3.3 Technological change and welfare

For input or output augmenting technical change, technology is included in the price and quantity variables. For example, for input saving technical change, input demand is given by $x_j = \tau_j . x_j^*$ with x_j the actual quantity of input *j*, x_j^* the effective quantity of input *j*, and τ_j the augmentation factor reflecting the input augmenting technical change with regard to input *j*. Input saving technical change is represented by a decline in the augmentation factor τ_j thereby reducing the physical quantity of input required for one effective unit. Moreover, the input price is $w_j = w_j^* / \tau_j$ with w_j^* the effective input price of input *j*. This type of technical change implies two proportional shifts: one in the price direction (slope change) and one in the quantity direction ('intercept' change). The impact on producer rents is equal to

$$\Delta R = \int_{\tau_j^0}^{\tau_j^1} \frac{\partial R(p,w^*,.)}{\partial \tau_j} d\tau_j$$

$$= \int_{\tau_j^0}^{\tau_j^1} w_j x_j(p,w) d\tau_j = \int_{\tau_j^0}^{\tau_j^1} w_j \tau_j x_j^*(p,w^*,.) d\tau_j \qquad (28)$$

which usually consists of two terms: a first order effect (representing the welfare effect of a direct reduction in the input used), and a second order effect representing the gain from substituting input factors (Martin and Alston, 1994, p.15).

3.4 National welfare measurement

3.4.1 Aggregation

Transfers to/from domestic producers and domestic consumers are completely captured by the already discussed consumer and producer welfare measures. These transfers are important in the evaluation of the ultimate welfare effects. Also of importance is the explicit consideration of international transfers generated by policy changes if the policies analysed take place in an open economy- or supra national policy-making-context. Therefore in this section welfare measures for the evaluation of national net benefits, which explicitly deals with international financial aspects, is discussed. Since, in one way or another, this requires aggregation of various interests, this subsection starts with the aggregation issue, and the way it is dealt with in this study.

Sofar, consumer and producer welfare measures have been defined at an individual level, *viz.* the single consumer or producer. An important issue, however, is whether these measures have any significance as aggregate welfare measures. This particularly holds with respect to the utility-based consumer welfare measures. Traditionally, welfare economists solved the problem of aggregating household welfare in a rather direct manner. Assuming utility to be a cardinally measurable concept, and following Bentham's 'felicific calculus' procedure, the cardinal utilities of all households in the economy were added together. The overall evaluation criterion was based on the outcome with respect to this sum of satisfaction. This (utilitarian) aggregation of welfare rested on restrictive ethical assumptions, which not only relied on cardinality, but also required an inter-personal household comparability assumption. At the turn of the century, Pareto propagated an ordinal measurable view on utility, which became the standard in economics since the Second World War. Both cardinality and the possibility of making interpersonal utility comparions were rejected. The main achievement it yielded for evaluating overall welfare changes was the well-known and widely appealing Pareto criterion, which is central to all modern notions of efficiency in economics. Unfortunately, it appeared to be an incomplete criterion, since it could give no guidance for policy changes characterized by simultaneously having 'winners' and 'losers' (see Chapter 2 section 2.3). As already mentioned earlier, neo-Paretian welfare economics tried to 'compensate' for the lack of relevance induced by the Paretian advancement. It is not the purpose of this subsection to give an extensive proof of aggregation conditions, but only to describe the main results from this literaure as relating to this study, and the assumptions they relied on.

A discussion about overall or 'social' welfare requires the use of social welfare functions (SWF). But that is not the route followed here because our aim is much more limited than measuring social welfare in any direct sense. We rather focus on the determination of welfare impacts of policy changes on certain groups, and on issues of compensation (for example whether a potential Pareto improvement (*PPI*) would be possible). The approach chosen here is therefore, firstly, to look at the significance of aggregated *CV* and *EV* measures as compensation devices, and secondly, to examine whether representative consumers and producers exist. In that case, aggregate demand and supply functions would have welfare significance. Because the *CS* measure has been discredited, no further attention is paid to its aggregation properties.

With regard to the welfare significance of aggregated *CV* and *EV* measures, the main results are summarized by Boadway and Bruce (1984, pp.262-271), who state that " a positive (non-positive) value of the aggregated *CV* is necessary (sufficient) for the Kaldor weak test (equivalent with a PPI; R.J.) to be passed (failed) but is not, in general, sufficient (necessary) for it to be passed (failed)". Moreover, " a non-positive aggregated *EV* is necessary for the Hicks weak test (equivalent with a PPI; R.J.) to be failed but is not, in general, sufficient for it to be failed". Unfortunately, these propositions do not allow for the use of an unweighted sum of the (multiple) *CV*'s and *EV*'s as a necessary and sufficient indicator for a *PPI* (Boadway and Bruce, 1984, p.271). However, for small projects and policy changes, the aggregate measure yields a good approximation (Ng, 1979, Bruce and Harris, 1982). Aggregate variation measures have necessary and sufficienty properties in one exceptional case, the case of non-intersecting Scitovsky community indifference curves (*CIC*'s). This case is related to the assumption of a welfare maximizing policy maker, who continually redistributes money (Samuelson, 1956; Chipman and Moore, 1979).

A second way to approach the aggregation issue is to examine under what conditions a representative consumer or producer exists. If a welfare maximizing policy maker exists who maximizes a social welfare function subject to a contrained amount of wealth, then there exists an indirect utility function of a representative consumer associated with the aggregate demand function of the consumers (Mas-Colell *et al*, 1995, p.117). There is one interesting case that deserves attention here. If it is assumed that all consumers have indirect utility functions of the so-called Gorman polar form, *i.e.*

$$v_i(p,y_i) \quad = \quad a_i(p)+b(p)y_i \tag{29}$$

with $a_i(p)$ a consumer specific price index, and $b(p)$ a price index common to all consumers. The policy maker maximizes an arbitrary (!) social welfare function $W = W(v_1(p,y_1),\ldots,v_i(p,y_i),\ldots,v_N(p,y_N))$ subject to $\sum_i y_i \leq \bar{y}$. The indirect utility function associated with the representative consumer is simply

$$v(p,\bar{y}) = \sum_i a_i(p) + b(p)\bar{y}; \quad \bar{y} = \sum_i y_i \tag{30}$$

(See Mas-Colell *et al* (1995, pp.119-120) for the proof). Note, that in this case a more or less sufficient assumption is that the policy maker is concerned about the income distribution, which is reflected in the policy actions made, without, however, making a-priori assumptions about the distributional weights attached to various (groups of) individuals[34].

Aggregation with respect to the producer side is much simpler than that on the consumer side. When firms maximize profits (taking prices as given), there exists a representative producer. This implies that solution of an industry's or sector's (aggregate) profit maximization problem corresponds exactly with the aggregate profit, supplies and demands that would be obtained if each firm maximized its profit separately (Mas-Colell, 1995, pp.147-151). So, the conventional aggregate producer market demand and supply relationships have direct welfare significance.

3.4.2 The balance of trade function

In this subsection it is assumed that a representative consumer and representative producer, in the sense discussed before, exist. Now, the focus is on welfare measures from a national (or social) perspective. Although this analysis is directly linked and is parallel to the measurement of the excess burden, that issue will be postponed to the next section. Here the focus is still on compensation, but in the context of supra-national policies imposed on a state. Instead of compensation measures for certain groups (producers, consumers), the focus changes to compensation on a national scale, *i.e.* to the amount of compensation that has to be paid to the economy (from outside) in order to maintain a prespecified utility level (including all budget constraints holding). Not-surprisingly, the previously discussed *CV*, *EV* and *MM* welfare measures will also play a prominent role here. The welfare measures discussed in this subsection are based on the international trade literature, in particular on the trade expenditure function and balance of trade functions (*e.g.* Dixit and Norman, 1980; Vousden, 1990; Anderson and Neary; 1992).

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[34] In a strict sense the assumption should be added that the policy maker also succeeds in establishing the optimal welfare distribution. Policy changes, in particular relating to income distributional concerns, imply that it fails to continually achieve this.

Measuring the impact on national welfare due to an imposed policy change requires not only aggregation within groups, like aggregation over consumers and producers as discussed in the previous subsection, but also aggregation over groups. The general form of the welfare measure is therefore

$$B(p;z,U) \quad = \quad e(p,U)-R(p,z)-t'm \tag{31}$$

i.e. national consumer expenditure minus quasi-rents associated with production, which are assumed to accrue to the representative consumer, and minus the (net) revenues raised from tariffs t. The latter are also assumed to be (costlessly/lump sum) returned to the consumer. Domestic consumer and producer prices p are linked to external prices p^* by $p=p^*+t$. Net imports m are defined as $m(p;z,U)=e_p(p,U)-R_p(p,z)$ with subscripts denoting partial derivatives, and e_p a vector of domestic demands, etc. The function $B(p;z,U)$ is known as the so-called balance of trade (payments) function, or distorted trade expenditure function (Anderson and Neary, 1992, p.59; Anderson and Martin, 1994). It equals the value of demand less the value of supply, evaluating demand and supply vectors at distorted prices (p^*+t). As such it is a social budget constraint, and incorporates the government and private sector budget constraints. $B(p,U)$ is defined as the net foreign exchange required (in general equilibrium) to support a fixed utility level U, *i.e.* $p'(e_p(p,U)-R_p(p,z))-t'm=p'm-t'm=p^{*\prime}m$.

Using an exogenously specified utility level, a change in the balance of trade function can be interpreted as the amount that has to be paid to the economy from outside in order to maintain a constant level of welfare (Anderson and Martin, 1994, p.4). The (over-all) *CV* of a policy change $(t^0 \rightarrow t^1)$ is defined as

$$CV \quad = \quad B(p^1,U^1)-B(p^1,U^0) \quad = \quad B(p^*+t^0,U^0)-B(p^*+t^1,U^0) \tag{32}$$

(for the sake of convenience quasi fixed inputs are suppressed) where it is assumed that an external payments constraint exists, implying $B(p^0,U^0)=B(p^1,U^1)$. When, instead of fixed borrowing or fixed other exogenous transfers, no borrowing or transfers are allowed at all $p^{*\prime}m=0$, and the following equilibrium budget conditions hold, *i.e.* $B(p^*+t^0;U^0)=0$, or $B(p^*+t^1;U^1)=0$. In that case the *CV* measure may be further simplified as $CV=-B(p^*+t^1;U^0)$. Analogously the *EV* measure can be written as

$$EV \quad = \quad B(p^0,U^1)-B(p^0,U^0) \quad = \quad B(p^*+t^0;z,U^1) \qquad (33)$$

Both the *CV* and *EV* measures compare actual budget equilibria with hypothetical budget equilibria. In other words, they measure the amount of compensation which should actually be extracted from (or must be added to) the economy in order to maintain the representative agent as well off as in the benchmark equilibrium.

Besides the compensation measures, there exists a class of money metric welfare measures, which does not compare an actual equilibrium with a hypothetical compensated equilibrium, but compares two actual equilibrium utilities[35]. It should be noted that for a distorted economy, money metrics differ from the forementioned compensation measures. A money metric does not measure a sum which could be extracted following a policy shift while maintaining general equilibrium. In fact these money metrics measures evaluate changes in actual tariff revenues, as opposed to revenue measured at a compensated equilibrium (Auerbach, 1985; Mayshar, 1990; Anderson and Martin, 1994). Martin and Alston (1994,p.26-27) therefore call these money metrics a modified balance of trade function. They are defined as

$$MM(p;z,U) \quad = \quad E(p^*+t^i;z,U^1)-E(p^*+t^i;z,U^0) \qquad (34)$$

with $E(p;z,U)\equiv e(p,U)-R(p,z)$, and i denoting a specific tariff/price level, *e.g.* initial tariffs ($i=0$), final tariffs ($i=1$), or an arbitrary reference level (i = r). $E(p;zU)$ is the trade expenditure function, which is formally defined in the trade

[35] The balance of trade function thus relies on compensated revenue changes (since $m=m(\ldots,\bar{U})$ with utility fixed at reference level $\bar{U}$). In other words, the balance of trade measure compares hypothetical equilibria (while assuming compensation actually taking place), while the money metric compares actual equilibria and measures the hypothetical compensation. See for further discussion Chapter 4, in particular the remarks made at the end of section 4.3)

literature as the difference between domestic expenditure and 'gross domestic product'[36]. They are particularly appealing from an excess burden measurement-perspective, which is the subject of the next subsection.

So far, producer and consumer prices were assumed to be equal to each other, while exogenous external reference or border prices were assumed. However, the compensation measures developed here provide very general and theoreticallly consistent measuring devices, which allow for different producer and consumer prices, terms of trade effects, and need not be restricted to a single representative household or single producer (group). Moreover, it can handle a wide range of phenomena like market interaction (spill-over) effects, multiple price and quantity distortions, public goods and technical change, non-costless redistribution of tax revenues, *etc* (Anderson and Neary, 1992; Martin and Alston, 1994). The trade balance evaluation function, although based on behavioural relationships, can be seen as distinct from the underlying economic model. Which prices are endogenous and which exogenous (large versus small country case), and what the final (after policy-shift) equilibrium values of prices, quantities, and utility are, depend on the underlying economic model, but all of these can be viewed as exogenous in evaluating the compensation (or excess burden) measures (Martin and Alston (1994, p.27).

3.5 Measuring the excess burden

There is an extensive literature on the welfare cost of tax and tariff changes, with a sometimes confusing amount of proposed welfare measures (see Auerbach, 1985; and Mayshar, 1990 for an overview). Measures of excess burden attempt to measure, in monetary units, the decrease in the representative consumer's utility due to the imposition of a distortionary policy interference in the economy, while correcting for the revenues raised or subsidies paid by the government (Triest, 1990, p.558). Of interest is the degree to which the loss of welfare due to the policy interference exceeds the loss that would have resulted from the use of non-distortionary lump

[36] With $\pi(.)$ or 'gross domestic product' referring to the maximum value function for solving the optimal production program, whether or not decentralized. As such it differs from the empirical (macro-economic) usage of GDP.

sum taxes and/or subsidies. As in particular this latter formulation shows, the excess burden measure is usually defined with respect to a first-best world (an arbitrary Pareto optimal initial benchmark equilibrium) (Diewert, 1985, p.59). In the following, firstly the measurement of the excess burden will be dealt with, while secondly, a more refined second-best interpretation of the excess burden will be given. Therefore we will discuss some informative concepts in this respect: the marginal excess burden, and the marginal costs of public funds.

As already noted, various excess burden-measures have been proposed, which differ in how the change in the representative consumer's utility is measured and how the tax and tariff revenues *c.q.* subsidy costs are measured. With regard to the latter, Diamond and McFadden (1974), for example, choose to work with hypothetical revenue changes, whereas Kay (1980), Pazner and Sadka (1980), and Triest (1990) preferred the *EV* measure combined with actual changes in net government revenues. An excess burden measure, that combines the *EV* measures with the actual change in tax/tariff revenue $(t^0 \rightarrow t^1)$ is (Zabalza, 1982, p.357; Mayshar, 1990, p.267):

$$\begin{aligned} L(p^* + t, U^0, U^1) &= E(p^* + t^0, U^1) - E(p^* + t^1, U^1) \\ &\quad + t^1 E_p(p^* + t^1, U^1) - t^0 E_p(p^* + t^0, U^0) \end{aligned} \tag{35}$$

with $E_p(p^* + t^i, U^i) \equiv m(p^* + t^i, y)$ for $i=0,1$; *i.e.* tax revenues evaluated at ordinary or Marshallian net import demand levels. After some manipulation, while assuming that $E(p^* + t^i, U^i) + E_p(p^* + t^i, U^i) = 0$ for $i=0,1$ (budget equilibrium), it follows that

$$L(p^* + t, U^0, U^1) = E(p^* + t^0, U^1) - E(p^* + t^0, U^0) \tag{36}$$

which is equal to the money metric defined in the previous section evaluated at the initial reference price vector. For the *CV* an analogous derivation can be done (Anderson and Martin, 1994, p.10). As already noted in the previous section, the excess burden measures do not satify the compensation properties, although as money metrics they provide a perfect measure of the induced welfare change (ignoring aggregation issues[37]; Auerbach 1985, pp.79-83). The *EV* measure of excess burden or deadweight loss, decreases when a tax/tariff-reform either holds tax/tariff-revenues constant and results in a higher level of (final) utility, or keeps utility constant and results in an increased tax revenue. But the *CV* measure does not have this desirable property (Kay, 1980; Triest, 1990, p.558).

The excess burden measure provided above explicitly started from an already distorted economy ($t^0 \neq 0$) or second best context. In a first best world, this excess burden or deadweight loss, which can be seen as consisting of a net economic loss to consumers as well as a net economic loss to producers, has a familiar 'welfare triangles' or efficiency loss interpretation[38]. However, within a second-best context some comments on this traditional view of deadweight loss are in order. The basic idea behind the deadweight loss is that something must be lost when passing from a first best situation to a second best case. If the initial situation is already of a second-best nature, which will often be the case, than the traditional 'welfare triangles' do not represent deadweight losses. Starting from a second-best position, a policy change may have a positive or a negative effect on the marginal deadweight loss. Thus, the traditional deadweight loss interpretation only holds in a first-best neighbourhood (Starret, 1988, p.151). Further, it has a perfectly clear interpretation if actual situations are measured in relation to the first-best benchmark, assuming this is known[39]. As was argued in Chapter 2, however, first-best worlds do not exist. In a second-best world, even for small Δt the additional excess burden might be large because in such a context policy changes generate first order welfare effects (Auerbach, 1985, p.69). Nevertheless, even when departing from a first-best world, excess burden measures remain measures which refer to some form of 'waste' that may be inherent in distorted equilibria. Here the term 'waste' refers to the possibility

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[37] Note that there is a difference between the aggregation of compensation measures and of welfare measures. The latter do not lend themselves to easy aggregation and in fact require some kind of (implicit) social welfare function.

[38] The net economic loss to consumers represents an efficiency loss because the consumers are shifting part of their expenditures to other goods and services, from which they derive less utility. The net economic loss to producers represents an efficiency loss, because resources being pushed into the production of this output are pulled away from other activities where productivity is higher. In contrast with the traditional consumer surplus analysis, compensation and deadweight burden measures cannot generally be reduced to a triangular approximation (*e.g.* Zabalza, 1982).

[39] *Cf.* section 4 from Chapter 4 for a further discussion of this issue.

of potential Pareto improvements (*PPI*'s) or to the cost in terms of resource utilization of policy interference. The deadweight loss measure refers explicitly to the standard competitive Arrow-Debreu model, also for defining sensible excess burden measures it is necessary to refer to an explicit economic model, albeit one which accounts for the specific features of the economy under study (*cf.* Diewert, 1985, p.64).

If the world is of a second-best nature, in which governments pursue tax financed projects, like the supply of public goods and income redistribution (for example by making decoupled income payments to farmers), the social costs of public funds and the marginal excess burden are often relevant concepts. In particular, when partial equilibrium versions of the compensation and excess burden measures discussed here are used, the latter concepts are informative in defining an appropriate shadow price rule for the use of public funds. The literature on measuring excess burden, the articles on marginal excess burden and the cost of marginal funds have also yielded a number of related but different measures (see Ballard and Fullerton, 1992 for a review of this literature). Pigou already noted that taxes or more generally revenue raising creates indirect 'damage' inflicted on the taxpayers over and above the loss they suffer in actual money payment. This idea was more formally worked out by Browning (1987), who compared a distortionary tax with an equal revenue lump-sum tax, and established Pigou's conjecture that the marginal cost of public funds (*MCF*) is greater than one. Alternatively this implies that the marginal excess burden (*MEB*), defined as *MCF* minus 1, is greater than zero. Browning took into account the 'distortionary' effect, but ignored the 'revenue-effect' (which depends on income-effect generated by the tax). The general conclusion emerging from the literature is that when this latter effect is also taken into account, the marginal costs of public funds can go either way, *viz.* be greater, equal to or less than one. The *MCF* depends crucially on the nature of public funds spending and the interaction effects this generates in related (distorted) markets (Stern 1987, p.77; Fullerton, 1991; Ballard and Fullerton, 1992; Browning, 1994).

Based on this literature, the excess burden measure can be developed as follows. Assume the government has the task to redistribute income (making transfer T), while maintaining a 'balanced budget'. These features can easily be incorporated into a simple model consisting of a government budget constraint and a social budget constraint, or

$$T - t' E_p(t^* + t; U, z) = 0 \tag{37}$$

$$E(p^* + t; U, z) - T = B \tag{38}$$

(see Anderson and Neary, 1992 for the exact properties of these functions). Note that when (37) is substituted in (38) the balance of tràde function is obtained. The marginal costs for raising revenue for redistribution can now be determined as follows. Differentiating (37) holding U constant yields an expression for the change in taxes required to achieve the desired change in distributional transfers T.

$$dT - t' E_{pp} dt - E_p' dt = 0 \tag{39}$$

To solve for a unique change in the tax rate it is necessary to define a tax reform package in terms of particular weights. This makes it possible to express the intensity of use of the package required to finance the change in by a simple scalar, say τ. In other words, the change in taxes may now be written as $dt = W d\tau$, with W a (diagonal) weighting matrix specifying the marginal degree of reliance on each tax in the funding package (*e.g.* if the transfers would be financed out of personal income taxes, only 1 element in W would be non-zero). Using this (39) can be solved for the change in tax rates in terms of scalar τ as

$$d\tau = \frac{1}{E_p' W + t' E_{pp} W} dT \tag{40}$$

Firstly, this expression reflects the common sense notion that the change in the required rate of taxation is lower the larger is the base (E_p) and the less price responsive the taxed commodities are. Secondly, it shows that in general the rate (expressed in terms of scalar τ) will be dependent on the specification of the weight-matrix W.[40] A compensation based measure of the net costs of collecting (and costlessly and in a non distortive way) redistributing one unit of transfer is obtained by differentiating the social balance constraint with respect to t while holding U constant, and using the previously introduced scalar way of expression,

$$dB = -t'E_{pp}W\,d\tau \tag{41}$$

and subsequently substituting (40) into (41), which yields (Anderson and Martin, 1994, p.13)

$$dB = \frac{-t'E_{pp}W}{E_pW + t'E_{pp}W}\,d\mathrm{T} \tag{42}$$

The result is a marginal excess burden measure (based on compensated tax revenues), which is comparable to that in Fullerton (1991, p.303, column 3). The costs of direct redistributive transfers (in terms of marginal excess burden) are clearly non-zero, except for the unusual case that they are exclusively financed by taxing goods whose compensated price elasticities are zero.

The options for reform (focusing on most distortive instruments) may be illustrated by using a more general model, which takes into account the revenue and the valuation of different person's or group's welfare. The simple framework is to assume the government maximizes a social welfare function $\underset{t_i}{\mathrm{Max}}\, W[v^1(t),\ldots,v^N(t)]$ subject to a revenue constraint $\mathrm{T}(t) \geq \overline{\mathrm{T}}$. Consider an infinitemisal feasible change in (a specific) instrument t_i which has the following impact on social welfare and government revenue:

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[40] Besides transfer T also the choice of W itself influences the distribution.

$$dW = \sum_{n=1}^{N} \frac{\partial W(v(t))}{\partial v(t)^n} \frac{\partial v(t)^n}{\partial t_i} dt_i \tag{43}$$

$$dT = \frac{\partial T(t)}{\partial t_i} dt_i \tag{44}$$

with the social marginal costs of a unit of public revenue associated with change in policy instrument i, λ_i, equal to

$$\lambda_i = -\frac{\partial W / \partial t_i}{\partial R / \partial t_i} \tag{45}$$

As long as the set of variable tax instruments and the associated λ_i's differ from each other in value, in principle socially desirable tax reforms are possible (Newbery, 1988, p.5). For if the λ's are ranked as $\lambda_1, > \lambda_2, \ldots, > \lambda_N$ a revenue-neutral change which increases t_n while simultaneously lowering t_1 creates a social gain of $\lambda_1 - \lambda_N$ per unit of revenue switched. However, the variability of instruments depends usually not only on a revenue-raising perspective, but also on other goals of policy makers (*e.g.* particular forms of redistribution or public good provision). In general therefore the possibilities for policy reform depend on the feasibility-range specified by the total set of the policy maker's goals. Although there are as least as many social cost measures thinkable as there are policy instruments, when the costs of public funds concept is used in partial equilibrium studies, it is preferrable to base it on those instruments that are specifically aimed at government revenue raising.

3.6 Concluding remarks

In this chapter various welfare measures are reviewed. With respect to consumers, it is argued that the Hicksian *CV* and *EV* measures are preferrable to the traditional Marshallian consumer's surplus, because they are 'true' and exact welfare measures. Although for some applications (transfer analysis, single price movements) the approximation errors inherent in consumer surplus may be acceptable, in particular when focusing on efficiency loss measurement, they might lead to seriously biased estimates. Moreover, due to recent advances in economic theory and estimation and computation facilities, recoverability of 'true' measures is not a serious problem anymore. The Hicksian measures are essentially utility indicators, but also have their own welfare significance as cardinally scaled measures: their equivalent income interpretation makes them useful both as money measures of benefits and costs and as compensation devices. As a (general) compensation measure *EV* is superior to *CV* since it is a general money metric.

With respect to producers, it is argued that the Marshallian producer surplus is a quasi-rent rather than a surplus. Although often producer surplus along supply curves are measured, it is argued that the quasi-rent function, which is equivalent to a dual (restricted) profit function provides, a preferrable measure. In particular when focusing on the welfare effects of technical change, the traditional surplus measures may in some cases (elastic supply) lead to biased results. Since the producer rents are a renumeration for quasi-fixed factors, it is dependent on the length of run that is taken into account. Whereas in the short run all quasi-fixed inputs are fixed, when time elapses an increasing number of them will become variable (investments), while in the long run, in general, all inputs are variable. The long run supply curve is therefore not suited for surplus-analysis. Intertemporal intermediate term producer welfare analysis should account for adjustment and/or investment costs related to initially quasi-fixed factors which had become adjustable over the time period considered.

Fortunately, individual producer behaviour can be perfectly aggregated, with the aggregated market supply and demand relationships having a direct welfare significance. While a representative producer normally exists, a representative consumer requires a number of restrictive assumptions. When the indirect utility functions satisfy the Gorman polar form, and the policy maker tries to 'maximize' an arbitrary social welfare function, the consumer side can be aggregated with the market demand curves having a unique welfare interpretation. Aggregation is a prerequisite for obtaining national or social compensation measures. Exploiting the balance of trade function, the *CV* and *EV* measures appear to have an overall compensation measure interpretation. Although there is a close relationship between those social compensation measures and measures of excess burden or deadweight loss, the latter are essentially money metrics, which in general do not satisfy the compensation properties. Whenever the compensation property is likely to be important, as for example in the case of EU member state comparisons under the common agricultural policy, the compensation metrics are preferrable. It is further argued that in a second-best world, traditional deadweight loss and 'welfare triangle' analysis loses a lot of content. More informative concepts then are the marginal excess burden and the social costs of public funds. Although there are as many costs of social funds as there are policy instruments, this does not preclude the use of income and/or value added taxes as primary benchmark-cases.

We have obtained a number of operational and consistent welfare, compensation, and excess burden indicators. We have also paved the way for policy evaluation or reform analysis by introducing the derived marginal excess burden and marginal costs of public funds concepts. The next step is to elaborate more on welfare measurement within a related markets in a multiple distortions context. That is the subject of the following chapter.

Chapter 4

APPLIED WELFARE ANALYSIS IN A MULTIPLE DISTORTED RELATED MARKETS CONTEXT

4.1 Introduction

In this chapter, applied welfare measurement in a second best environment, in particular the multiple distorted related market case, is discussed. So far not much attention has been paid to the distinction between partial and general equilibrium analysis. The consumer and producer welfare measures discussed in the previous chapter were presented in a partial way. The quasi-rent function, for example, measured the quasi-rents with fixed input factors. Likewise the *CV* and *EV* measures provide formulas for computing the impact of multiple price changes on individual welfare. However, even when multiple price and/or output restrictions are allowed to change, all other prices were assumed fixed. So, the effect of interfering in one market on all other prices (related market interactions and price and quantity equilibrium adjustments) is not taken into account. The conditionality of fixed prices generates strict partial welfare measures, which have a clear interpretation, but also suffer from shortcomings as they ignore related market effects. However, nothing precludes the use of the previously presented measures in a general equilibrium (GE) setting. They can handle multiple price changes, and even the extreme case in which all prices change presents no theoretical difficulty. In the previous chapter it was noted, for example, that the balance of trade equation could be used as a welfare measure. This measure is distinct from an underlying behavioural economic model generating the required equilibrium quantities and prices. In the same way, the other welfare measures can be extended to a general equilibrium context by first predicting the initial and final equilibrium prices and quantities, and subsequently applying the Marshallian or Hicksian measures to those equilibrium price and quantity vectors.

However, recognizing that welfare measurement should take place in a general equilibrium context, is at first sight not very helpful for applied welfare analysis. Measurement following a *real* general equilibrium approach is beyond the scope of any empirical analysis. Practically estimating responses of all prices and quantities in an economy is simply intractable, regardless of the significant advances in the theory of economics and practice of econometrics. Apart from this, however, it still remains true that from a theoretical perspective the general equilibrium context is the most appropriate one. Moreover, also from a practical perspective, it is often useful to view markets as being horizontally and vertically related. Horizontal relations arise because many firms produce multiple outputs and consumers buy many processed commodities. Vertical relations arise because, for example, the markets at the farm level are related to certain markets for raw materials, and other by markets for handling, processing, distribution to the final consumer level. Any refined welfare evaluation cannot ignore these multiple market spill-over and feed back effects (Chambers, 1995). In applied welfare economics these indirect effects often tend to be ignored or there is confusion about how to integrate them in the analysis (Helmers and Harberger, 1982, Van Kooten 1990, Bullock, 1993). Several empirical studies have pointed out, however, that ignoring or incorrectly treating these indirect effects can substantially influence the welfare evaluation results. Van Kooten (1990) who analysed Canadian supply management with respect to broilers, for example, showed that the indirect benefits amounted to about one-third of the welfare loss estimated in the concerned broiler market alone. To put it differently, ignoring the indirect effects could lead to an overestimate of the social costs of supply management by 50%. Other studies emphasizing the significance of indirect welfare effects are Thurman and Easley (1992), Brannlund and Kristrom (1996), and Canning and Vroomen (1996).

The purpose of this chapter is to develop and justify a multiple market equilibrium (MME) evaluation approach, as distinct from both strict partial (back of the envelope) single market analysis and general equilibrium analysis. Moreover, this approach will be placed against the background of some of the theoretical and empirical literature in this field. Several issues emerge from this choice. Firstly, it raises the question: in what way will the MME welfare estimates differ from their 'true' GE-equivalents, and what determine their approximation properties. Secondly, there is a recent stream of literature focusing on GE-welfare measurement in a single market, a procedure which relies on the use of general equilibrium demand and supply curves. This procedure, which combines simplicity and generality, seems to make any detailed economic modelling of related markets superfluous, and therefore is preferrable to a MME-approach, which is neither simple nor general[1]. Justification of the MME-approach followed in this thesis therefore seems required. A third related issue concerns the theoretical appropriateness and welfare significance of welfare measures based on incompletely modelled consumer and producer behaviour. What interpretation do *EV*, *CV*, and quasi-rent measures based on an incomplete demand system have?

The chapter is organized as follows. The Harberger rule, which is a fundamental result in multiple distorted related market analysis, is discussed in Section 4.2. Section 4.3 presents the general equilibrium curves welfare measurement approach, which is sometimes also called the extended Harberger analysis. In Section 4.4, we discuss the MME *cum* shadow price of public funds approach. Section 4.5 handles the issue of welfare measurement in incomplete consumer demand and producer supply systems. Finally, section 4.6 provides the main conclusions, and closes the welfare theoretical part of this thesis.

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[1] To avoid confusion it is emphasized that the latter form of general equilibrium analysis should be distinguished from the general (C)GE analysis. See Gunning and Keyzer (1993) and Ginsburgh and Keyzer (1997) for a detailed discussion of this latter approach, including the related welfare economics.

4.2 Related markets: the Harberger rule

Harberger (1971) defended the applied consumer surplus methodology against the accusation of being of a partial nature. While acknowledging that in applied studies general equilibrium considerations were rarely taken into account, he showed that there were no theoretical obstacles for not taking them into account. His main conclusion was that in evaluating welfare changes for the economy as a whole, input and output changes in all markets for which prices differ from marginal costs should be taken into account. (This known as the Harberger rule). This section reproduces the Harberger result in a more rigourous way, without relying on the consumer surplus approximation he propagated.

A simple illustration of the Harberger rule can be given by assuming a very simple (closed) economy consisting of one producing entity, a consumer owned firm, and one consumer (Boadway and Bruce, 1984, pp.241-243). The number of producers and consumers can be generalized, but that is not essential to the analysis (see Just *et al* 1982, pp.445-464). N goods are distinguished, which may include basic resources as well as produced final goods. It is assumed that this N-market economy is characterized by multiple distortions, say t_n, which are for the ease of exposition assumed to be fixed (except for one), and cause a difference between the consumer and producer price. The effect of (marginally) changing a distortion Φ in market m in the economy on the consumer and producer can be determined by

$$EV = -\sum_{n=1}^{N} \int \frac{\partial e(p^d, U^1)}{\partial p_n^d} \frac{\partial p_n^d}{\partial \Phi} d\Phi \tag{1}$$

$$\Delta R = \sum_{n=1}^{N} \int \frac{\partial R(p^s, z)}{\partial p_n^s} \frac{\partial p_n^s}{\partial \Phi} d\Phi \tag{2}$$

with price p_n^j denoting the demand ($j=d$) or supply ($j=s$) price for the n-th good (*cf.* equations (13) and (20) from Chapter 3), and U^1 denoting the utility level corresponding to the after change equilibrium situation. (As before $e(.)$ is an expenditure function and $R(.)$ a quasi-rent function, which depends on quasi-fixed inputs z). Denoting netput producer supplies by $y_n(p^s, z)$, netput consumer demands by $x_n(p^d, U^1)$, the change in social welfare or excess burden $\Delta L = EV + \Delta R + \Delta T$ indicating the overall welfare impact can be written as

$$\Delta L = \sum_{n=1}^{N} \int_{\Phi^0}^{\Phi^1} [y_n(p^s)\frac{\partial p_n^s}{\partial \Phi} - x_n(p^d, U^1)\frac{\partial p_n^d}{\partial \Phi}]d\Phi + \Delta T \tag{3}$$

where ΔT represents the net changes in government revenues arising from the distortions in the relevant markets. Changing the variables of integration, (3) may be rewritten as

$$\Delta L = \int_{\Phi^0}^{\Phi^1} [y_n(p^s)dp_m^s - x_n(p^d, U^1)dp_m^d + \sum_{n=1;n\neq m}^{N} \int_{p_n^d(\Phi^0)}^{p_n^d(\Phi^1)} [y_n(p^s)dp_n^s - x_n(p^d, U^1)dp_n^d + \Delta T \tag{4}$$

where the market in which the distortion is changed (market *m*) is distinguished from all other markets. Note that the (line) integrals denote surplus measures which are general equilibrium measures, since all prices are allowed to adjust to the economy wide new equilibrium values associated with the changed distortion.

At markets *j* other than *m* at where no distortions exist $p_j^d = p_j^s$ and aggregate supply must (by definition) equal aggregate supply to be in equilibrium. For these markets

$$\int_{p_j^d(\Phi^0)}^{p_j^d(\Phi^1)} (y_j(p^s) - x_j(p^d, U^1))dp_j^d = 0 \tag{5}$$

since $y_j - x_j = 0$. But this implies that when evaluating the change in excess burden or social costs associated with changing the distortion at market *m* from Φ^0 to Φ^1, related markets which are undistorted can be completely neglected: both the producer and consumer surplus estimates cancel out each other, and the other revenue effects are clearly zero. Or as Harberger (1964, p.62; 1971, p.789) puts it: in undistorted markets, marginal costs and marginal benefits from changes in production and consumption just offset each other (*cf.* also Starret, 1988, p.158). It should be emphasized, however, that changes in undistorted markets will have distributional consequences since the quasi-rent and consumer welfare measures are in general non-zero.

In markets *h* other than *m* and *j* where distortions exist, the equilibrium condition still holds, given the assumed fixed distortions $dp_h^s = dp_h^d$. Looking at (5) but now for market *h*, it can be easily seen that the same result applies. Again private welfare effects cancel out, but now there will in general be a non-zero change in the government revenue-effect. It is to capture these latter effects that distorted related markets to good *m* cannot be neglected. To capture the revenue effect, related market *j* has to be modelled at least up to a reduced form equation which links the changes in Φ to changes in the equilibrium quantity in market *j*. The change in revenues ΔT can be written as

$$\Delta T = t_m(\Phi^1)y^s(p^s(\Phi^1)) - t_m(\Phi^0)y^s(p^s(\Phi^0)) + \sum_{n=1;n\neq m}^{N} t_n y(p^s(\Phi^1)) - y(p^s(\Phi^0)) \qquad (6)$$

Based on this, Harberger drew the following conclusions. Incorporating the general equilibrium effects implies adding to the 'standard partial-equilibrium welfare analysis' the change in net government revenues in the related distorted markets. Thus the private welfare effects due to a change in distortions in a particular market, say *m*, can be completely captured for that market by relying on welfare measures along equilibrium curves. Harberger (1971, p.791), who expresses the additional revenue term as $\sum_{n=1}^{N} t_n \Delta x_n; \forall n \neq m$, pointed out that GE-welfare analysis need not be a formidable task, since the set of distorted markets is a subset of the total set of *N* markets, while the set of related markets, characterized by $\partial x_n / \partial \Phi = /0$ represents another subset of markets. Only the intersection of these subsets is important for the analysis of the effects, and (hopefully) in most cases the number of elements in it will be of manageable size (Harberger, 1971, p.791).

Some qualifications about the Harberger rule are, however, in order. Firstly, in contrast with, for example, Just *et al* (1980) and Thurman (1991), Harberger is not completely clear about the incorporation of general equilibrium effects. Using consumer surplus and speaking about the 'standard partial equilibrium analysis', he is at least suggesting relying on Marshallian demands and on non-compensated cross price effects as indicators of market relatedness. Whether the Marshallian curve or, for example, the Baily curve is the most relevant one depends on the way of compensation (Boadway and Bruce, 1984, p.209; p.238); Thurman, 1993, p.1512). What matters regarding market relatedness are the pure substitution effects and not the uncompensated cross price reactions (*e.g.* Triest, 1990). Secondly, Harberger was not fully clear about when the appropriate measurement of private welfare effects requires that related markets are also explicitly considered. This was elaborated on by Just *et al* (1980, pp.459-462) who show that for some policy interventions in third markets, notably price floor and price ceiling policies, and distortions due to market power, measurement of equilibrium demand and/or supply responses in those markets is required. More generally, in all cases where private welfare effects do not cancel out, and/or changes in revenues or rents are not fully captured, the market should be explicitly taken into account. Recalling (5) for a target price/deficiency payments distorted third market *h*, with $dp_h^s \neq dp_h^d$, for example, gives

$$0 \quad - \int_{p_j^d(\Phi^0)}^{p_j^d(\Phi^1)} x_j(p^d, U^1))dp_j^d \quad \neq \quad 0 \tag{5'}$$

where the first term denotes the zero change in producer rents because it is assumed that the target price p_j^s is not dependent on the distortion, *i.e.* $\partial p_j^s / \partial \Phi = 0$. The second term denotes the (non-zero) change in consumer surplus. The associated change in government revenues (deficiency payments to be paid) T_j is equal to

$(p_h^d(\Phi^0) - p_h^d(\Phi^1))y_h^s(p_h^s)$.

As the foregoing example illustrates, when analysing policies which rely on price support packages simultaneously affecting several markets, in general a multi-market approach is required. However, although in that case the related markets have to be modelled, a complete GE-model is not necessary for obtaining reliable welfare estimates of the impact of policy changes. Moreover, when policy changes are considered in a number of markets, all of these markets have to be taken into account. Finally, if the interest is not only on excess burden measurement, but also on how specific producer or consumer groups (producing or consuming a particular good) are affected by policy changes, the concerned market should be explicitly taken into account, even when surpluses cancel out against each other. As distinct from the strict partial equilibrium and the general equilibrium approaches, the approach folowed in this study on the GOL-complex, is a multiple market equilibrium approach, abbreviated as MME-welfare analysis.

4.3 Extended Harberger analysis: GE-curve

Several authors have elaborated on Harberger's theme, among them, in chronological order, Schmalensee (1971; 1976), Wisecarver (1974), Anderson (1974; 1976), Panzar and Willig (1978), Carlton (1979), Just and Hueth (1979), Just, Hueth and Schmitz (1982), Thurman and Wohlgenant (1989), Thurman (1991; 1993), Bullock (1993), and Chavas and Cox (1997). This section starts with a brief overview of the main developments in this literature. Subsequently a short illustrative example of related market welfare measurement along GE curves is presented. This example is, on the one hand, used for clarification of the brief sketch of the literature, and on the other hand as a reference framework for discussing the strengths and weaknesses of the GE-approach. The section ends with some evaluative remarks.

Harberger's former assistant Wisecarver along with Schmalensee began to investigate the relationship of surplus measures in input markets with those in output markets. Anderson made some corrections to their studies, and mentioned the welfare significance of general equilibrium curves. The established result is that the welfare effects of an industry (consisting of many firms) can be equivalently measured as a demand surplus in either the (relevant) input market, or the final product market. Panzar and Willig showed that this equivalence vanishes when infra marginal firms exist due to a profit change effect. Carlton argued that when data on directly affected markets (like market *m* in Section 4.2) are unavailable, related output or input markets could be used to recapture the welfare effects. Just, Hueth and Smith integrated the forgoing contributions, and provided a general framework for welfare measurement in a multiple market context. They clarified the exact interpretation of measuring welfare along GE-curves in case of vertically and horizontally related markets. Furtheron, they rigourously proved that, under competitive conditions, general equilibrium demand and supply functions can be used to measure in one intervened-in market the sum of surplus changes in all markets due to this intervention.

Although Just, Hueth and Schmitz provided a quite general framework of what is sometimes called the (single market) GE welfare measurement methodology, a number of unsettled issues remained. Thurman and Wohlgenant offered some guide-lines for identification and consistent estimation of a GE-demand curve. Thurman (1991; 1993) and Bullock (1993) further elaborated on the exact interpretation of the GE-curves, and showed that when multiple feedback effects between markets exist, neither GE-curve, supply or demand, has welfare significance on its own, although jointly they have one. Bullock (1993) added that for an open economy, the social costs of a distortion cannot be captured by areas behind the general equilibrium demand and supply curves. Recently, Chavas and Cox (1997), elaborating on previous work of Hahn, Diewert, Heiner and Braulke, further investigated the (formal) properties of market equilibrium curves and showed (in contrast to Bullock) that for small-open economies GE-curves retain their welfare meaning. Moreover, they come up with a Slutsky type of relationship between compensated and uncompensated GE-curves (showing the role of income-effects), and accounted for the role of technical change, a factor not included in the Harberger result (Harberger, 1971, p.793). Like Chambers (1995), they show that neglecting induced price adjustments tends to provide an upward biased estimate of the welfare effects of price-distortion policies.

Empirical studies following the GE-approach include Thurman and Easley (1992), Canning and Vroomen (1996) and Brannlund and Kristrom (1996). Of these studies, Canning and Vroomen use a simple three market model calibrated on elasticity estimates of previous research, but without paying much attention to the exact nature of these previous elasticity estimates. Thurman and Easley, as well as Brannlund and Kristrom empirically estimate GE (and PE) relationships. In general the identification of the GE relationships appears to be problematic.

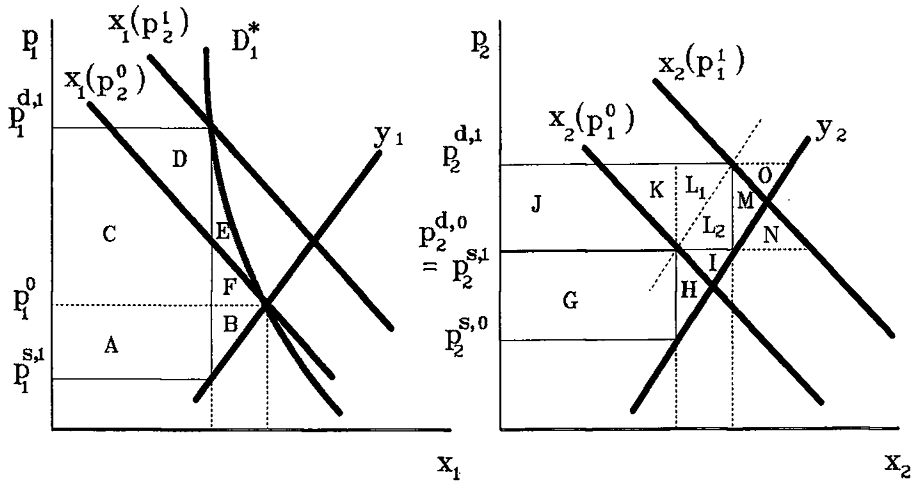

Figure 4.1 GE-curve welfare analysis

In order to give the briefly sketched developments in (single market) GE welfare measurement some relief, and as preparation for making a comparison between the GE and the MME approach, an illustrative example is given of a simple horizontally related markets case. It mainly follows Thurman (1993); the main difference being that the related market is a distorted instead of an undistorted one. Assume a simple two goods market structure, where the two goods are substitutes in demand, while being independent with respect to supply (each good supplied by one producer for example). The horizontally related market structure is graphically displayed in Figure 4.1. Market 2 is an already distorted one, while in the previously undistorted market

1 a tax is imposed. The effect on consumer welfare is calculated by computing the *CV* for this policy change, which, following a sequential measurement procedure may be written as

$$CV = e(p_1^{d,1}, p_2^{d,1}, U^1) - e(p_1^{d,1}, p_2^{d,1}, U^0)$$

$$= \underbrace{\int_{p_1^{d,0}}^{p_1^{d,1}} x_1^h(p_1^d, p_2^{d,0}, U^1)\,dp_1^d}_{-(C+F)} + \underbrace{\int_{p_2^{d,0}}^{p_2^{d,1}} x_2^h(p_1^{d,1}, p_2^d, U^1)\,dp_2^d}_{-(J+K+L+M+N)} \qquad (7)$$

where the changes in producer surplus are obtained by evaluating the quasi-rent functions for producer 1 and 2

$$\Delta R_1 = \underbrace{\int_{p_1^{s,0}}^{p_1^{s,1}} y_1(p_1^s, z_1)\,dp_1^s}_{-(A+B)}; \quad \Delta R_2 = \underbrace{\int_{p_2^{s,0}}^{p_2^{s,1}} y_2(p_2^s, z_2)\,dp_2^s}_{G+H+I} \qquad (8)$$

The excess burden from the introduction of the tax in market 1 can be determined by aggregating consumer and producer welfare losses, and subtracting the change in net tax revenues $(A+C+D)$ + (L), with $L = L_1+L_2$ in Figure 4.1. This is equivalent to $(A+B) + (C+F) + (J+K+L_1+L_2+M+N) - (G+H+I) - (A+C+D) - (L)$, which is equal to areas $(B+F\text{-}D) + (L_2+M+N\text{-}L)$.

Now consider the welfare loss calculated in market 1, based on the equilibrium demand curve and normal supply curve respectively. The GE demand curve connects the points of initial and final equilibrium (with tax imposed in market 1, and p_2^d, p_2^s adjusted to their equilibrium values). So, along the GE demand curve p_2^d continuously varies in order to maintain equilibrium in market 2 for each p_1^d value, or the equilibrium relationship $p_2^d(p_1^d)$ holds. Measuring welfare along the GE demand curve involves integrating along the equilibrium path from $(p_1^{d,0}, p_2^{d,0})$ to $(p_1^{d,1}, p_2^{d,1})$ with $p_2^{d,0} = p_2^d(p_1^{d,0})$ and $p_2^{d,1} = p_2^d(p_1^{d,1})$. In order to integrate along this equilibrium path (rather than sequentially) the consumer welfare measure is rewritten as

$$CV = e(p_1^{d,1}, p_2^d(p_1^{d,1}), U^1) - e(p_1^{d,1}, p_2^d(p_1^{d,1}), U^0) \tag{9}$$

Applying the fundamental theorem of calculus, and integrating with respect to p_1^d yields

$$CV = \int_{p_1^{d,0}}^{p_1^{d,1}} \frac{de(p_1^d, p_2^d(p_1^d), U^1)}{dp_1^d} dp_1^d$$

$$= \int_{p_1^{d,0}}^{p_1^{d,1}} \left\{ \frac{\partial e(p_1^d, p_2^d(p_1^d), U^1)}{\partial p_1^d} + \frac{\partial e(p_1^d, p_2^d(p_1^d), U^1)}{\partial p_2^d} \frac{dp_2^d}{dp_1^d} \right\} dp_1^d$$

$$= \underbrace{\int_{p_1^{d,0}}^{p_1^{d,1}} x_1(p_1^d, p_2^d(p_1^d), U^1) dp_1}_{C,+D+E+F} + \int_{p_1^{d,0}}^{p_1^{d,1}} x_2(p_1^d, p_2^d(p_1^d), U^1) \frac{dp_2^d}{dp_1^d} dp_1 \tag{10}$$

The first right hand side integral gives the demand surplus as measured along the GE demand curve in market 1, which is equal to area -(C+D+E+F) in Figure 4.1. By changing the variable of integration the second integral may be rewritten as an integral along the equilibrium path $p_1^d(p_2^d)$ in market 2

$$\int_{p_1^{d,0}}^{p_1^{d,1}} x_2(p_1^d, p_2^d(p_1^d), U^1) \frac{dp_2^d}{dp_1^d} dp_1 = \int_{p_2^{d,0}}^{p_2^{d,1}} x_2(p_1^d(p_2^d), p_2^d, U^1) dp_2^d$$

$$= \underbrace{\int_{p_2^{d,0}}^{p_2^{d,1}} y_2(p_2^d, z_2^d) dp_2^d}_{J+K+L_1} \tag{11}$$

Looking at the equilibrium path as indicated by the broken line parallel to y_2 in the right part of Figure 4.1, the integral can be seen to be equal to area (J+K+L_1). Comparing this with the equivalent area (G+H+I), its producer surplus interpretation becomes clear. Note that this producer surplus differs from the surplus given by the area $(J+K+L_1+L_2+M+O)$ in that it excludes the change in revenues $L=L_1+L_2$. From the foregoing it follows that

$$CV \quad = \quad \tilde{CV} + \Delta R_2(p_2^d) \quad = \quad CV_1(p_2^{d,0}) + CV_2(p_1^{d,1}) \qquad (12)$$

where $\tilde{CV}$ represents the GE-surplus measure, $\Delta R_2(p_2^d)$ denotes the quasi rent change for producer 2, while $CV_1(p_2^{d,0})$ and $CV_2(p_1^{d,1})$ represent the sequentially measured surpluses in market 1 and market 2 respectively. Rewriting (12) in terms of the GE demand surplus measure yields

$$\tilde{CV} \quad = \quad CV_1(p_2^{d,0}) + CV_2(p_1^{d,1}) - \Delta R_2(p_2^d) \qquad (13)$$

This establishes the main result: the GE demand surplus measure is the sum of the changes in consumer loss less the producer surplus gain in market 2. Or in terms of areas in Figure 4.1: $(C+D+E+F)$ is equal to $(C+F)$ plus $(J+K+L+M+N)$ less $(G+H+I)$, or $(C+F)$ plus (L_2+M+N). The deadweight loss measure is now equal to the welfare loss as measured by the GE consumer surplus measure and producer rent measure in market 1 less the change in tax revenues. This equals $(C+D+E+F)$ + $(A+B)$ - $(A+C+D)$ - (L) which equals areas $(B+E+F)$ less L (welfare measured along GE-curves in the concerned market plus revenue changes in 'third' markets). It can easily be seen that this is equivalent to the areas $(B+F-D)$ plus $(L_2+M+N-L)$ derived earlier by following the sequential procedure.

More generally, Just and Hueth (1979), and Just *et al* (1982, Appendix D) show that in case of horizontally and vertically related markets, surplus areas behind GE-curves capture all of the (related) multiple market effects of the considered policy distortion. More precisely, for an intermediate market in a vertically related market context, the GE consumer surplus measure is the sum of the changes in the final product consumer welfare change and the quasi rents for all industries involved in transforming the concerned product from the stage in the concerned market to the final consumption stage (Just and Hueth, 1979, p.949). Similarily, the GE producer surplus measure in that market measures the change in the surplus of the initial resource suppliers plus the quasi rents for all industries involved in transforming the raw material to its intermediate half-product level in the concerned market (Just and Hueth, 1979, p.950)[2]. The GE consumer surplus measure for an (intermediate) input market in a horizontally related market context measures the sum of the change in consumer welfare in the output market, the changes in quasi rents in the (related) input substitute markets, and the change in the profits of the concerned industry (Thurman, 1991, p.1510). Moreover, the GE producer surplus measure for this case can be shown to measure the sum of changes in consumer welfare in related (substitute) output markets, the change in producer rents in the input markets, and the change in the profits of the concerned industry[3]. For cases where horizontally and vertically related markets simultaneously occur, individual demand or supply GE-welfare measures have no clear welfare significance since the equilibrium path can no longer be traced back to surplus changes (see Thurman 1991; 1993; Bullock 1993).

The strength of the (single market) GE-analysis is that it allows to estimate the private welfare effects due to introduced policy changes by only focusing on the intervened-in market. The related market welfare effects are all captured when welfare is measured along GE supply and demand curves. This is attractive because the lack of knowledge or data often limits or even rules out directly estimating all the welfare effects in the production column. When, further on, the partial relationships are also known in this market, the impacts on welfare of the directly concerned suppliers and users and on that the rest of the economy can be distinguished (Just *et al*, 1982, pp.188-192). Some weaknesses also arise with this approach. Although it saves on detailed modelling of related markets, it requires reliable estimation procedures for the GE-curves. Unfortunately, the econometric techniques for empirically distinguishing between partial and GE relationships is still limited.

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[2] The horizontally related market case is not formally treated (only verbally) as a separate case in Just *et all* 1980). See Thurman (1991, p.1510) for a formal proof of this specific case.

[3] The proof is analogous to Thurman (1991) and was worked out in a previous draft of this chapter, but later on skipped because of space limitations.

Accounting for GE-adjustments requires including a number of conditioning variables, the amount of which easily becomes unmanageably large in number (Hueth and Just, 1991, p.1518). GE-curves are often difficult to identify, whereas the partial relationships are much less problematic (Thurman and Wohlgenant, 1989; Thurman and Easley, 1992). Apart from this, the remark made when discussing the Harberger rule still holds: when the related markets are distorted, determination of the revenue-effects of policy changes at least requires estimation of the reduced form equations for those markets. The same holds with respect to the analysis of policy-packages in a related market context. When multiple distortions are simultaneously altered for a number of related markets, direct insight into those markets is often required, at least when one is interested in detailed distributional consequences. Additional complications are that in a horizontally and vertically related market setting, multiple feed back effects will usually occur which obscure the welfare significance, at least of individual GE-curves. Further, the limits to distinguishing various distributional effects poses particular problems for the welfare analysis of open-economy cases (Thurman, 1991; 1993; Bullock, 1993).

A specific issue worth mentioning is the way in which compensation is treated. For GE welfare measures to be exact measures the underlying GE curves have to be compensated ones (*i.e.* consumer utility kept fixed). When Hicksian individual demands or compensated GE curves are used, the welfare measures are called behavioural consistent measures since they reflect the hypothetical as-if-compensation-takes-place case[4]. The compensated relationships are such that the agents in the economy behave in a manner consistent with compensation taking place. As such the behaviour consistent measures provide measures for the efficiency-effect, reduction of wealth-effect or shrinkage of (aggregate) pie-effect for the economy as a whole. In other words, like the Hicksian measures at a particular agent-level, compensated GE measures measure the economy-wide compensation (coming from outside the economy) required to compensate for policy changes (as discussed in the previous chapter). If, however, as is usually the case, compensation does not take place or is only provided to a limited extent, then the equilibrium price path which faces the economy would be different from that assumed in the beha-

[4] Consumer behaviour is consistent with the calculated compensation.

viourally consistent case. The latter is associated with an artificial equilibrium. The welfare effects measured subject to this alternative actual price path (uncompensated final equilibrium) is called the *facts consistent welfare measure*[5]. If the analysis focuses on the real effects of a policy change on various groups, this facts consistent measure is the most relevant one[6]. On the other hand, when one is interested in the amount of compensation (from outside the country) the behavioural consistent measure is the most appropriate one. It measures the welfare effects on various groups from adopting policies in a without compensation-context[7]. In fact this is precisely the way welfare measures are computed in the applied (partial) equilibrium models.

Concluding, it can be said that the GE-approach has particular relevance when the analyst is interested in determining the welfare effects arising from policy changes in a single market in an otherwise undistorted related markets context. As such it has the advantage over the (single market) partial approach of at least taking into account the multiple market-effects. However, more generally, for example when policy packages are aimed at influencing several related markets simultaneously, or in case of multiple distorted related markets, or when interest is focused on how policy changes affect different groups, the GE-approach will be less suitable. A MME-approach is then more appropriate. However, the previous remarks on compensation (derived Boadway paradox) are instructive in emphasizing that welfare measures derived from empirical (computable general/partial) equilibrium models yield facts consistent rather than behavioural consistent measures (which only approximate the attainable welfare effects). The latter issue will also affect the MME-approach.

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[5] A characteristic of the non-compensated GE-approach is that it leads to a market-version of the so-called Boadway paradox. This explains Thurman's (1991, p.1513) remark that the behaviourally consistent welfare measure do not disaggregate. In other words, the aggregated welfare changes measured in a facts-consistent way will be greater than the corresponding welfare change but now measured from a behavioural consistent perspective. This means that when the welfare effects are computed using the compensated GE-approach, they will be smaller than the welfare effect resulting from aggregating the compensating variations of actual price changes to the affected groups (Thurman, 1991, p.1514 and Hueth and Just, 1991, p.1518).

[6] Facts consistent because the price path conforms to the actual price path which is in nearly all cases a path without explicit compensation to affected parties. It is not behaviourally consistent because the behaviour (along non-compensated curves) is not consistent with the compensation ultimately calculated.

[7] The interest is no longer on the effects for the aggregate pie, but on the sum of the changes in the sizes of several group pies.

4.4 The MME *cum* shadow price approach

The preferred modelling framework for analysing the EU's GOL complex is the MME-approach, which has been shown to be more appropriate compared to a complete GE-modelling approach and a single market GE approach in the previous sections. The MME-approach is an approach somewhere in between the single market GE approach and the (complete) GE approach. Guided by Harberger's rule, in particular the distortedness-criterion and the relatedness-criterion, a subset of markets relevant for the analysis of certain policy programmes affecting those markets is explicitly modelled. For applied agricultural policy analysis, this comes down to some type of agricultural sector model, which, besides the primary agricultural sector and the interrelations therein, in principle should also include initial resource supply (*e.g.* landowners), the agribusiness (*e.g.* input supply industry and food industry) and final consumer demand. Applying the welfare rules from the Harberger analysis, and extensions, some additional remarks can be made. As there is a perfect elastic supply of initial resources or inputs (to agriculture) the producer rents or surpluses associated with these activities are zero. Vanishing producer rents also occur when industries are assumed to have constant returns to scale technologies and operate in long run equilibria with pure competition (Anderson, 1974). If this holds for the intermediate food industry focusing on final consumer demand and primary agriculture would be sufficient, at least from a welfare measurement perspective. The food industry is then only relevant as far as it influences the equilibrium price and quantity structure.

However, where the MME approach focuses on a subset of related markets which roughly comprise a certain sector, two additional complications arise. Firstly, when focusing on sectoral policy analysis, there is nearly always one important outside-linkage, and that is the use of public funds. Secondly, focusing on a subset of markets nearly automatically implies focusing on a subset of goods. But that introduces a practical problem regarding the reliability of welfare measures based on incomplete demand and supply systems.

The latter issue will be dealt with in the next section. This section focuses on the public funds-issue. It is particular the public funds issue where partial and extended partial models, like the MME models, go astray. At an empirical level, estimates of the marginal excess burden associated with public funds provided in the literature range from just under 10% to sometimes over 300% (Browning, 1987, p.21). Most estimates, however, lie in the range of 15% till 60% (Ballard *et al*, 1985, pp.136-137; Triest, 1990, p.563; Alston and Hurd, 1990, p. 149; Fullerton, 1991, p.127). Moreover, with respect to the agricultural sector, Alston and Hurd (1990) and Chambers (1995) have shown that the magnitude of the excess burden associated with raising the required public funds can be an important determinant of the ultimate incidence of farm policy programs.

Being a related distorted market (in the sense of Harberger), in principle, distortionary financing of public funds should explicitly be part of an MME approach. Thus, if policy changes in the concerned sector, say agriculture, lead to changes in the distortions in the markets used for the raising of public funds, in a strict sense these markets should be explicitly modelled and distorted markets related to them taken into account. This will soon come down to modeling the rest of the economy, and then the whole approach will loose its tractability. In the previous chapter (*cf.* Section 3.5) where the issue of the social costs of public funds was already raised at a more theoretical level, the general equilibrium character of this issue was affirmed. It also has been shown that there is no one unique social cost of public funds: every distortion is likely to influence the availability of public funds, and each has its own associated excess burden. In order to maintain tractability for applied analysis, it seems reasonable to rely on some shadow price rule, at least as far as the sectoral government interference analysed can be termed a 'small project' (Starret, 1980, p.5). The alternative would be to explicitly model the rest of the economy in a highly aggregated sense, and integrate it with the raising of public funds. Closing the model in this sense has the advantage that it can be termed a real GE-model, but its approximate-nature is clear from the outset (Browning, 1987, p.11). Of course, following the shadow price-route also introduces an approximation, but one that usually offers clarity on the key-parameters determining the excess burden, and one that allows inclusion of sufficient detail.

Browning (1987, p.18) calculates the marginal excess burden of taxes on labour as the area between a fixed gross wage rate and an approximately linear compensated labour supply curve and shows that

$$\frac{EV - dR^*}{dR} = \left(\frac{m + 0.5dm}{1 - m}\right)\left(\frac{dm}{dt}\right)\eta^c \tag{14}$$

with dR the change in actual tax revenue, dR^* the change in revenue as measured along the compensated labour supply, η^c the compensated labour supply elasticity, m the marginal tax rate, and t the average tax rate. The factor dm/dt is a measure of the progressivity of the tax structure (Browning, 1987, p.19). The approach of Browning, attractive for its simpleness and clarity, however suffers from one defect. Behind the above formula lies the assumption that the amount of money raised is used to provide a public good, which compensates the tax-payer in such a way that the income effect can be ignored, and only substitution effects matter (Ballard and Fullerton, 1992, p.124). In that case taxation must lead to a decrease in the labour supply, but taxing labour usually introduces both a substitution and an income effect, which reinforce each other. So, marginally increasing a tax rate may actually result in a negative excess burden if a dominating income effect leads to an increase in actual labour supply which in turn leads to a further increase in tax revenues from the initially existing tax. More pronouncedly: in a second-best world even a lump sum tax (due to its income effect) may generate a non-zero excess burden (Fullerton, 1990, p.304-305).

The marginal excess burden thus depends not only on the average and marginal tax rates, but also on the nature of government spending, and the existing distortions. The marginal cost of public funds estimates using the Browning formula are therefore likely to overstate the marginal costs of public funds, at least when the funds are spent on projects that have no direct effect on the taxed activities. Mayshar (1991) provides a more general formula which remedies this, relying on six key parameters. In addition to the ones already used by Browning, he uses the uncompensated labour supply elasticity η and the elasticity of the wage rate with respect to labour γ (Mayshar, 1991, p.1330):

$$MEB = \frac{\eta^c \frac{dm}{dt} - (\eta^c - \eta)}{\left[\frac{(1-m)}{m}\right](1 + \gamma\eta^c) - (1 - \gamma)\eta^c \frac{t}{m}\frac{dm}{dt} + (\eta^c - \eta)} \tag{15}$$

The latter formula includes several other marginal costs of social funds provided in the literature, and as such provides a good guiding rule for cost-benefit analysis in an MME-context[8].

4.5 Measuring welfare in incomplete demand and supply systems

4.5.1 Introduction

Although in the previous chapter correct welfare measures were defined for applied analysis, one further complication has to be considered. A common empirical practice is to estimate conditional demand systems, *viz.* demand systems which consider only a subset of goods. This subset then is assumed to be weakly separable from all other goods, with expenditure on the subset of goods tacitly assumed to be predetermined. Likewise, producer behaviour is often incompletely modelled, for example because of limited data availability and estimation problems (*e.g.* collinearity between prices) when the number of variables taken into account becomes too large. Explicitly or implicitly, separability assumptions are imposed to guarantee manageable and estimable models. Conditional consumer and producer behaviour models allow only for conditional welfare measures. In this section the relationship of conditional and unconditional welfare measures is studied. The section starts with incomplete consumer demand systems where a number of results obtained by LaFrance will be reviewed. Subsequently, incomplete producer behaviour is analysed for which some own results are presented.

4.5.2 Conditional consumer welfare measures

When using separable demand models to calculate exact welfare measures, as is repeatedly done in applied analysis (*e.g.* Van Kooten, 1990), biased results can be obtained even if theoretical consistency at the subset-level is satisfied (see LaFrance, 1992 and 1993 for a detailed discussion). The reason is that welfare measures relying

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[8] The shadow price rule still has a partial character since it only takes into account the revenue-financing effect. In a general equilibrium context also another effect, termed the tax-interaction effect is taken into account, which our rule negelcts (*cf.* Parry, 1999).

on conditional indirect utility or expenditure functions artificially limit the substitution possibilities between goods considered and the goods not explicitly measured (fixed group expenditure) and therefore are not consistent with overall utility maximization. As La France showed, the conditional compensating (equivalent) variation under (over) estimates the unconditional compensating (equivalent) variation.

To motivate this result, assume that the total set of goods is partitioned into two subsets, with $x=(x_1,\dots,x_t)$ the goods belonging to subset 1 and $x^*=(x_1^*,\dots,x_s^*)$ the goods belonging to subset 2. Corresponding price vectors are defined as p and p^* while expenditure is denoted by m. Using a system of conditional demands for a subset of separable goods, say subset 1, implies that a number of assumptions are made with respect to the structure of the utility maximization problem. In fact utility maximization can then be thought of as an artificial two-stage optimization process (Deaton and Muellbauer, 1980). In the first stage, expenditures on the different sets of goods are held fixed and demanded quantities are chosen optimally given the pre-fixed expenditures. Subsequently, in the second stage, the levels of expenditures for the groups are chosen optimally. Two-stage optimization corresponds with the goods x and x^* which are weakly separable in the direct preferences, or

$$u(x,x^*) = \tilde{u}(u_x(x),x^*) \tag{16}$$

then the indirect utility function is separable as (LaFrance, 1993, Blackorby et al, 1978, Barten and Boehm, 1983)

$$\begin{aligned} v(p,p^*,m) &= v\left(p,p^*,m_x,m_{x^*}\right) \\ &= \tilde{v}\left(v_x(p,m_x),p^*,m_{x^*}\right) \\ &= \tilde{v}\left(v_x(p,m_x(p,p^*,m)),p^*,m_{x^*}(p,p^*,m)\right) \end{aligned} \tag{17}$$

where $m_x(p,p^*,m)$ and $m_{x^*}(p,p^*,m)$ are the optimal expenditure levels for respectively x and x^* with the budget constraint $m_x+m_{x^*}\le m$ holding. Moreover,

$v_x(p, m_x)$ is an indirect subutility function for x which is the solution to

$$v_x(p, m_x) = \max_x \{u_x(x) : p'x \leq m_x\} \tag{18}$$

and corresponds to the sub system of conditional demands.

Assume prices in subset 1 change due to policy changes, while prices for subset 2 and income are kept constant. The welfare measures corresponding to the incomplete demand model can now be defined in terms of the indirect subutility function as

$$u_x^0 = v_x(p_0, m_x(p_0, p_0^*, m_0)) = v_x(p_1, m_x(p_0, p_0^*, m_0) - CV^{01}) \tag{19}$$

$$u_x^1 = v_x(p_1, m_x(p_1, p_0^*, m_0)) = v_x(p_0, m_x(p_1, p_0^*, m_0) + EV^{01}) \tag{20}$$

Note that the conditional welfare measures CV^{01} and EV^{01} so obtained treat (group) expenditure as fixed at the level associated with original or final prices and incomes respectively. The question now arises as to how these conditional welfare measures are related to the complete welfare measures. The complete or overall welfare measures $C\tilde{V}$ and $E\tilde{V}$ can be defined by exploiting (17), which yields (LaFrance 1993)

$$\begin{aligned} u^0 &= \tilde{v}\big(v_x(p_0, m_x(p_0, p_0^*, m_0)), p_0^*, m_{x^*}(p_0, p_0^*, m_0)\big) \\ &= \tilde{v}\big(v_x(p_1, m_x(p_1, p_0^*, m_0 - C\tilde{V}^{01})), p_0^*, m_{x^*}(p_1, p_0^*, m_0 - C\tilde{V}^{01})\big) \end{aligned} \tag{21}$$

$$\begin{aligned} u^1 &= \tilde{v}\big(v_x(p_1, m_x(p_1, p_0^*, m_0)), p_0^*, m_{x^*}(p_1, p_0^*, m_1)\big) \\ &= \tilde{v}\big(v_x(p_0, m_x(p_1, p_1^*, m_1 + E\tilde{V}^{01})), p_1^*, m_{x^*}(p_1, p_1^*, m_1 + E\tilde{V}^{01})\big) \end{aligned} \tag{22}$$

The link between both measures can be established in a formal way as

$$
\begin{aligned}
u^0 &= u(x_0, x_0^*) = \tilde{u}(u_x^0, x_0^*) \\
&= v(p_0, p_0^*, m_0) = v(p_1, p_0^*, m_0 - C\tilde{V}^{01}) \\
&= \tilde{v}(v_x(p_1, m_x(p_0, p_0^*, m_0) - CV^{01})), p_0^*, m_{x^*}(p_0, p_0^*, m_0)) \\
&\leq \max\left\{\tilde{v}\left(v_x(p_1, m_x), p_0^*, m_{x^*}\right): m_x + m_{x^*} \leq m - CV^{01}\right\} \\
&= v(p_1, p_0^*, m_0 - CV^{01}) \qquad (23)
\end{aligned}
$$

But then, because of monotonicity of the indirect utility function in income, it follows that $CV^{01} \leq C\tilde{V}^{01}$. The conditional CV measure understates the overall CV measure. Using the same line of reasoning it can be shown that the conditional EV measure overstates the overall EV measure. More formally

$$
\begin{aligned}
u^1 &= u(x_1, x_1^*) = \tilde{u}(u_x^1, x_1^*) \\
&= v(p_1, p_0^*, m_0) = v(p_0, p_0^*, m_0 + E\tilde{V}^{01}) \\
&= \tilde{v}(v_x(p_0, m_x(p_1, p_0^*, m_0) + EV^{01})), p_0^*, m_{x^*}(p_1, p_0^*, m_0)) \\
&\leq \max\left\{\tilde{v}\left(v_x(p_0, m_x), p_0^*, m_{x^*}\right): m_x + m_{x^*} \leq m + EV^{01}\right\} \\
&= v(p_0, p_0^*, m_0 + EV^{01}) \qquad (24)
\end{aligned}
$$

Because of the monotonicity of indirect utility in income it follows the that $EV^{01} \geq E\tilde{V}^{01}$.[9]

This formal result can be intuitively motivated as follows. Assume that price p_i of x_i decreases. The conditional CV then measures, given a fixed group expenditure m_x, how much money should be taken away from the consumer to maintain the original group utility level u_x^0. The overall CV measures the amount of money that should be taken away from the consumer in order to keep him at his original overall utility level. In terms of the direct utility function, what the latter

[9] Note that the actually observed expenditure (used to estimate the incomplete demand system) for subset 1 is equal to $m_x(p_1, p_0^*, m_0)$ and not $m_x(p_0, p_0^*, m_0)$.

allows for is substitution between $u_x(x)$ and x^*. The decrease in price for good x_i will lead to increased demand for this product, but (in the case of a normal good) also lead to a shift in expenditure in favour of group x^*. In other words, x^* will be substituted for x_i from group x. Translating this in terms of the demand diagram, the Hicksian demand for x_i conditional on a fixed group utility level is steeper than the Hicksian demand function, but now conditional on the overall utility level. As can be seen from Figure 4.2, conditional estimate A understates the overall welfare effect, which equals A+B.

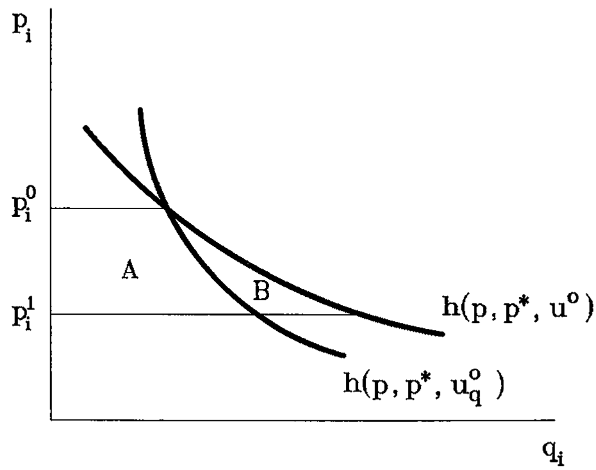

Figure 4.2 Welfare measurement in an incomplete demand system

Both the conditional measures and overall measures coincide if and only if there are no substitution possibilities between groups (Leontief type direct utility function). Fortunately, it is possible to use the partial CV measure as the lower bound for the total welfare effect. Likewise the partial EV measure provides an upper bound for the overall EV-measure. Thus, if food prices decrease due to a reform of the CAP (c.p.), the amount of money that could be taken away from the consumer is at least CV^{01}, and the equivalent gain expressed in monetary terms is at least no more than EV^{01}. Exploiting the linear expenditure model (LES), LaFrance

(1992, p.7) showed that the percentage bias in the conditional welfare measures is small if (1) the price change considered is relatively small, (2) the aggregate response to income for the goods in subset 1 is small (because then there is also little substitution between x and x^*), and (3) subset 1 makes up almost all of the consumer's budget.

4.5.3 *Conditional producer rent measures*

With respect to the producer side, weak separability is sometimes explicitly introduced to allow for two stage profit maximisation by assuming an allocatable fixed input (*e.g.* Lau, 1978; Boyle 1993). A more restrictive separability assumption is the assumption that the various activities can be comprised of disjoint technologies. This implies that the profit function is non-joint with respect to the variable input quantities and can be written as the maximum of the sum of activity related sub profit functions subject to an allocatable fixed input constraint (*e.g.* Gyomard *et al* 1996). This form of additive separability is often implicitly imposed by modelling a subset of the enterprise's total activities. Similar to the consumer case, assume that output and input price and quantity vectors are partitioned into different subsets, with $y=(y_1,\ldots,y_L)$, $p=(p_1,\ldots,p_L)$, $x=(x_1,\ldots,x_J)$, and $w=(w_1,\ldots,w_J)$ denoting the output quantities and prices, and input quantities and prices belonging to subset 1. L denotes the number of outputs in subset 1, while J the number of inputs. Moreover, it is assumed that the input quantity vector reflects the inputs used for the J activities in subset 1. Analogously the variables belonging to subset 2 are defined as $y^*=(y_1^*,\ldots,y_M^*)$, $p^*=(p_1^*,\ldots,p_M^*)$, $x^*=(x_1^*,\ldots,x_K^*)$, and $w^*=(w_1^*,\ldots,w_K^*)$. For convenience sake restricted outputs and quasi-fixed inputs are ignored, except for one allocatable quasi-fixed input, say land A. Overall profits may be written as

$$\Pi(p,p^*,w,w^*;A) \quad = \tag{25}$$

$$\max_{y,y^*,x,x^*,A}\left\{\sum_{l=1}^{J} p_l y_l + \sum_{m=1}^{M} y_m^* p_m^* - \sum_{l=1}^{L} w_l x_l - \sum_{k=1}^{K} w_k x_k \mid (y,y^*,x,x^*)\in T(A)\right\}$$

with $T(A)$ the production possibility set conditional on total land availability A. An equivalent expression is

$$\Pi(p, p^*, w, w^*; A) \quad = \quad \max_{a, a^*} \{\Pi(p, p^*, w, w^*, a, a^*) \mid a + a^* = A\} \tag{26}$$

where $\Pi(p, p^*, w, w^*, a, a^*)$ is the restricted profit function for a given area allocation of the total acreage over the two subsets of activities. Subsequently, it is assumed that the technologies associated with the two subset of activities are disjoint, which implies that the 'fixed allocation' restricted profit function is non-joint with respect to variable input quantities. The profit maximization program may then be further rewritten as

$$\Pi(p, p^*, w, w^*; A) \quad = \quad \max_{a, a^*} \{\Pi(p, w, a) + \Pi^*(p^*, w^*, a^*) \mid a + a^* = A\} \tag{27}$$

with the sub profit function

$$\Pi(p, w, a) \quad = \quad \max_{y, x} \left\{ \sum_{l=1}^{L} p_l y_l - \sum_{j=1}^{J} w_j x_j \mid y = f_1(x, a) \right\} \tag{28}$$

and $y = f_1(x, a)$ the production technology of the enterprise associated with subset 1. The optimization can now be viewed as proceeding in two stages. In the first stage the revenues or profits over the subsets are optimized conditional on a given land allocation. In the second stage, total acreage A is allocated over the two subsets of activities. The conditional quasi-rent function R_1 associated with subset 1 coincides with $\Pi(p, w, a)$, and the change in producer rents (due to for example an output price change with respect to subset 1) can be written as

$$\Delta R_1 \quad = \quad \int_{p_h^0}^{p_h^1} y_h(p, w, a) dp_h \tag{29}$$

However, the conditional rent function does not take the possible reallocation of land into account, since it is conditional on a fixed acreage allocation. But, using the envelope conditions applied to (27) it follows that

$$\frac{\partial \Pi(p,w,a)}{\partial a} = \frac{\partial \Pi^*(p^*,w^*,a^*)}{\partial a^*} = \lambda \tag{30}$$

with λ the Lagrange multiplier associated with the total acreage constraint. From this, acreage demand functions for the two subsets of activities can be solved, *i.e.*

$$a = a(p,p^*,w,w^*,A); \quad a^* = a^*(p,p^*,w,w^*,A) \tag{31}$$

which are dependent on all output and input prices, and on total available acreage A. The optimal supply for output h and variable input j in subset 1 can now be obtained by applying Hotellings Lemma to the subset specific profit function evaluated at the optimal acreage allocation, which yields

$$y_h = \frac{\partial \Pi(p,w,a)}{\partial p_h} = y_h(p,w,a(p,p^*,w,w^*,A)); \forall h, = 1,\ldots,L \tag{32}$$

$$w_j = -\frac{\partial \Pi(p,w,a)}{\partial w_j} = w_j(p,w,a(p,p^*,w,w^*,A)); \forall j, = 1,\ldots,J \tag{33}$$

Despite the non-jointness in the short-run, *i.e.* for given acreage allocations, the allocatable fixed input creates interdependence across the activities in the two subsets. The unconditional quasi-rent measure associated with subset 1 $\tilde{R}_1$ for a change in the output price of h is

$$\Delta \tilde{R}_1 = \int_{p_h^0}^{p_h^1} \left(y_h(p,w,a) + \frac{\partial \Pi(p,w,a)}{\partial a} \frac{\partial a}{\partial p_h} \right) dp_h \tag{34}$$

where the first term denotes a conditional surplus change shared by ΔR_1 and $\Delta \tilde{R}_1$.

The second term may be rewritten as

$$\int_{p_h^0}^{p_h^1} \tilde{p}_a(p,w,a)\frac{\partial a}{\partial p_h}dp_h \quad = \quad \int_{a^0}^{a^1} \tilde{p}_a(p,w,a)da \tag{35}$$

with $\tilde{p}_a(p,w,a)$ denoting a virtual price or shadow price associated with the allocatable quasi-fixed land input. It can be interpreted as the change in quasi rents due to the change in the optimal land input in the enterprise associated with subset 1. Note that this change has its counterpart in the quasi-rent change for land associated with the second subset of activities. Unfortunately no upper or lower bound criteria can be derived in this case. The conditional quasi-rent measure will usually underestimate gains and overestimate losses associated with the output price changes of activities in subset 1. With regard to input price changes, so far nothing can be said since the sign of $\partial a/\partial w_j$ is ambiguous (Moschini, 1989).

The unconditional or overall quasi rent measure ($\Delta\tilde{R}$) associated with a change in the output price h is derived from the overall profit function and the acreage constraint, which yields

$$\begin{aligned}
\Delta\tilde{R} \quad &= \quad \int_{p_h^0}^{p_h^1} \frac{\Pi(p,p^*,w,w^*,A)}{\partial p_h}dp_h \\
&= \int_{p_h^0}^{p_h^1}\left(\frac{\partial\Pi(p,w,a)}{\partial p_h}+\frac{\partial\Pi^*(p^*,w^*,a^*)}{\partial p_h}\right)dp_h \\
&= \int_{p_h^0}^{p_h^1} y_h(p,w,a)dp_h+\int_{a^0}^{a^1}\left(\frac{\partial\Pi(p,w,a)}{\partial a}-\frac{\partial\Pi^*(p^*,w^*,a^*)}{\partial a^*}\right)da
\end{aligned} \tag{36}$$

If evaluated at the optimal acreage allocation level, the second right hand side integral vanishes, like it should because the optimal allocation of acreage implies that the partial derivatives of the sub profit functions with respect to enterprise specific acreage are equal to each other. However, if only the restricted (acreage allocation) subprofit function corresponding to the activities in subset 1 is modelled and a is considered as exogeneous, the second integral will normally be non-zero, which implies a difference between the conditional quasi rent measure and the unconditional one. The difference is equal to the rent differential between the different uses of the allocatable fixed factor. More generally, comparing an (optimal) initial situation (p^0, p^*, w^0, w^*, A) and final situation (p^1, p^*, w^1, w^*, A), the difference in the conditional $(\Delta R_1, \Delta R_2)$ and unconditional $(\Delta \tilde{R})$ quasi rent measures can be written as

$$\begin{aligned}
\Delta R_1 &= \Pi(p^1, w^1, a^0) - \Pi(p^0, w^0, a^0) + \Pi^*(p^*, w^*, a^*) - \Pi^*(p^*, w^*, a^*) \\
&= \Pi(p^1, p^*, w^1, w^*, a^0, a^*) - \Pi(p^0, p^*, w^0, w^*, a^0, a^*) \\
&= \Pi(p^1, p^*, w^1, w^*, a^0, a^*) - \Pi(p^0, p^*, w^0, w^*, A) \\
&\leq \Pi(p^1, p^*, w^1, w^*, A) - \Pi(p^0, p^*, w^0, w^*, A) \quad = \quad \Delta \tilde{R} \qquad (37)
\end{aligned}$$

which affirms the earlier mentioned rule that a conditional quasi rent measure will underestimate the rent gains and over estimate the rent losses as compared to the unconditional one. So the conditional measure provides an underbound of beneficial policy changes, and an upper bound of (unfavourable) policy changes. As can be seen from closer inspection of (36) the difference will be usually of second order, since it is the product of a change in a shadow price and a change in the acreage. Therefore, in general the conditional measure is expected to give a rather close approximation to the unconditional one.

4.6 Summary and conclusions

The focus of this chapter is on applied welfare analysis in a multiple distorted related market context. It started with a deliberation on GE and PE analysis. While from a theoretical point of view a general equilibrium approach is the proper one for welfare analysis, this approach was discarded because construction of empirically estimated GE-models is in general not feasible. Simultaneously the limitations of a strict partial analysis were recognized. Markets are usually vertically and horizontally related and in several ways distorted, which precludes the welfare analysis of isolated markets. Typically such analyses tend to systematically overstate the benefits and social costs of government intervention. The Harberger rule showed that for reliable welfare measurement it is in priciple sufficient to look at the concerned market and all distorted markets related to this market. Private welfare effects can be determined for the market considered, while related distroted markets should be taken into account only to account for changes in (government) revenues. The attractiveness of this result is that only a subset of markets need to be considered.

Subsequently a number of refinements of this result were considered, in particular regarding the measurement of private welfare effects in related distorted markets and the measurement of welfare along GE-curves. The welfare significance of surplus areas measured along GE curves was shown with an illustrative example, while the general results were also presented. It was argued that single market GE-welfare measurement is attractive because it may yield complete welfare estimates even in cases where lack of knowledge or data rule out to direct estimation of all the welfare effects. Its weaknesses were the identification and reliable estimation of GE-curves, its limits when the focus is on analysing policy packages affecting more than one (related) market, the impossibility of disaggregating distributional impacts of policy changes on various (more than two) groups, the obscured welfare significance of GE curves when multiple feed back effects are relevant, and the problems of GE-measures in an open economy-context. Further, the review of the 'extended Harberger analysis' literature was clarified with respect to the issue of compensation (facts-consistent and behaviourally consistent compensation measures).

Given that the focus is on a policy analysis of the EU's GOLF-complex, it was judged that a multiple market equilibrium (MME) seems the most appropriate way to proceed. Although this allows us to focus on a subset of related markets which more or less comprised the agricultural production column, one important outside linkage could not be neglected: the use of public funds. Instead of explicitly taking into account revenue raising markets, a shadow price approach was defended as an approximation to the marginal costs of public funds. A final topic elaborated on was welfare measurement in incomplete consumer demand and producer supply models. Interestingly, conditional *CV* (*EV*) measures appear to provide a lower (upper) bound of the total welfare effect of policy changes affecting consumers. With regard to producer rents, the conditional measure provides a lower (upper) bound for (un)favourable policiy changes affecting producers.

Having developed a general theoretical framework for applied welfare analysis of the EU's GOLF-complex, and given insight into the nature and consequences of the approximations this requires, the main challenge lies in the empirical field. The next part of this study therefore focuses on the structure and estimation of an MME-model of the GOLF-complex.

PART II

MODELLING THE EU's GOLF-SECTOR

Chapter 5

INTRODUCTION TO GOLF-MODELLING

5.1 Delineation of the Grains, Oilseeds, Livestock, and Feed-complex

The grains, oilseeds, livestock, and feed-complex represents a bundle of related economic activities, which will be further specified now. The label 'complex' is used to indicate that the interest is in a set of related markets. In the geographical literature, the label complex is usually used to define a set of activities ranging from the supply of original inputs, the production of primary products, the handling, trading, distribution, and processing of these products into final (consumer) goods, and the distribution of those goods to the final users (Post *et al*, 1987, p.13). In this description of a complex, it is the vertical rather than the horizontal linkages which play a central role. An agricultural complex is seen as a part of the agricultural production column, often based on a primary output of agriculture, for example, potatoes, cereals, dairy, etc. (*cf.* Post *et al* 1987). In the literature focusing on sector analysis, complex is often used in a somewhat broader sense, with a focus on industries rather than on products, and with an emphasis on functional relationships between activities (Roelant, 1986, p.93, Peerlings, 1993, p.6). Sometimes the word conglomerate (vervlechtingsconglomeraat) is used. In this case functional relationships, whether they are vertical or horizontal, are at the center of the definition. When looking at dairy, for example, according to this latter definition not only should milk and its derived products be taken into account, but also beef and veal since they are joint products with milk. It is in this latter sense that complex is used here. In particular the economic relatedness-criterion that emerged from the discussion of the Harberger rule in the previous sector plays a central role in the delineation of the GOLF-complex. As such the demarcation criterion used here differs from the product based definitons like that of Post *et al* (1987) and industry based definitions like that of Roelant (1986) and Peerlings (1993).

The related market activities included in the GOLF-complex are graphically shown in Figure 5.1. Starting from below, the arable sector provides some basic feed ingredients, namely cereals and oilseeds, which after processing into compound feeds are used by the two livestock sectors, the intensive livestock sector and the cattle/dairy sector, into meat and dairy products. Subsequently the meat and dairy products, jointly with some other products like vegetable fats and oils, potatoes, and sugarbeets are further processed, handled and traded by the 'food' industry, which transforms them into final products suited for use by consumers. Figure 5.1 provides only a rough description of the GOL-complex. Whereas the main actors are characterized, the are markets left out for clarity of exposition. Nevertheless, even without including those markets, the figure already illustrates the horizontally and vertically linkages within the GOL-complex. Examples of horizontal relatedness are the multiple output industries and also consumer demand. The vertical relatedness is selfevident from the upstream and downstream linkages between the various industries. Of course several markets are implied, and recognizing them brings in some further linkages. For example, looking at the market for compound feed ingredients (see Figure 5.1 circled *M* and Figure 5.2), open economy phenomena like the net import of oilmeals and feed grains come into the picture. When focusing on EU member states, a member state's net imports should be further split up into net imports derived from other member states and those imported from outside the Union. Moreover, the complication of direct on-farm feeding shows up, which generates feed ingredient streams generally not registered in the market.

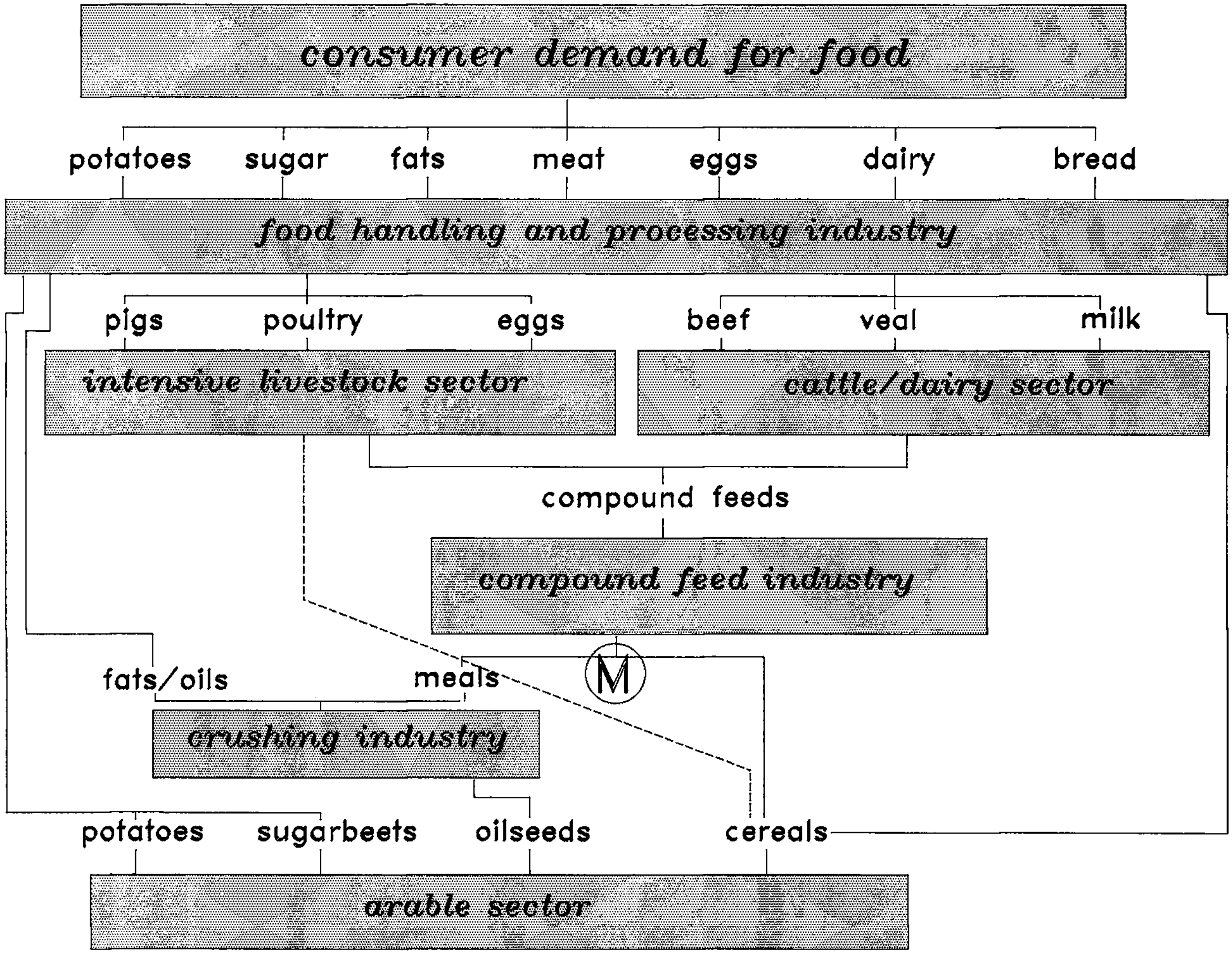

Figure 5.1 The GOLF-complex

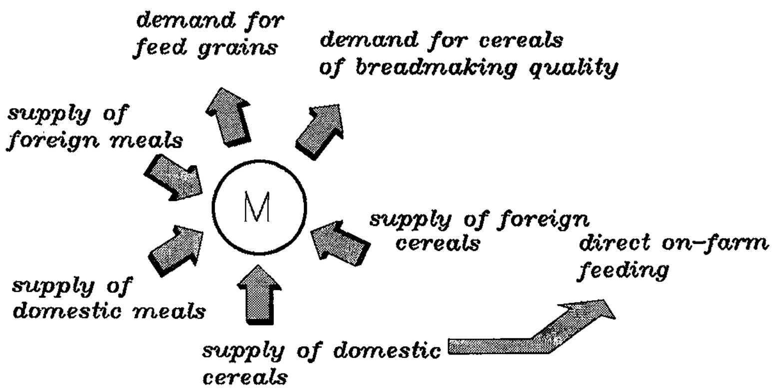

Figure 5.2 The market for compound feed ingredients

Another point not reflected in Figure 5.1 is that the various industries use other inputs besides the mentioned agricultural inputs. The arable and cattle/dairy sectors, for example, are intensive land users, while all sectors apply labour and capital inputs in their production processes. Taking all linkages into account results in a very complicated model. In the following, therefore, a number of simplifying assumptions are made to guarantee that a tractable model is preserved. Before going into the modelling approach, the next section first sets the GOLF-complex in perspective.

5.2 The GOLF-complex in perspective

The GOLF-complex is not only a primary example of related market case, but also at the heart of the EU's common agricultural policy (CAP). In 1990 the GOLF complex accounts for about 55% of the total CAP budget expenditures, of which 37% was spent on export subsidies, 16% on storage costs, and 40% on price support. Moreover, since the growth perspectives for agriculture are bad, the conflicting interests between various groups of farmers may intensify and places issues of income redistribution, both within agriculture and between agriculture and the rest of the economy, on top of the policy agenda. In this section therefore some general characteristic of the GOLF-complex and its historical evolution are discussed (sector specific details are provided in the subsequent chapters).

Table 5.1 Share of GOLF-complex in agriculture's final product value

	EU-9		EU-10		EU-12
	1975	1980	1985	1990	1995
Cereals	10.5	12.6	10.4	11.1	8.7
Oilseeds	0.3	0.6	1.6	2.3	1.2
Rootcrops	5.7	4.6	4.0	4.6	5.5
Milk	18.7	19.2	19.2	18.1	17.3
Beef and veal	16.3	15.8	14.1	13.1	11.9
Pig meat	13.1	11.5	11.4	10.3	10.1
Poultry meat	4.1	4.2	4.4	4.5	4.7
Eggs	3.8	3.4	3.0	2.5	2.3
Share of GOL-products	66.8	67.3	64.1	61.9	56.2
Total value [Bill. Ecu]	70.9	117.9	157.8	202.0	194.1

Source: The Agricultural Situation in the EU (various years)

In fact the GOLF-complex can be artificially separated into a number of activities usually labeled as agriculture, another set of activities comprised under the heading of agribusiness, and finally consumer demand. Starting with agriculture, Table 5.1 gives the share of GOLF-sector's agriculture in the final value of EU's agriculture. For completeness the value of rootcrops (sugarbeet and potatoes) is added as a separate row. As Table 5.1 shows, the GOLF-share in total agricultural output value is still over 55%, although there seems a slight tendency for the share to decline over time. The dairy and pig sectors are by far the most important ones, with the arable sector and the chicken sector in relatively minor positions.

When disaggregating the numbers over member states for 1990, a picture as presented in Table 5.2 arises. What it shows is that different member states have different interests in the GOLF-activities. France, Germany, Italy and the UK, for

Table 5.2 Share of EU member states in final value of GOLF-sector products in 1990

	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
Cereals	0.9	1.2	39.3	11.1	13.9	4.1	0.9	13.8	1.1	9.7	3.8
Oilseeds	0.3	0.2	36.6	15.8	16.6	6.3	0.0	11.6	0.5	12.0	0.3
Rootcrops	10.6	4.9	19.2	16.7	13.4	2.5	1.5	11.3	2.9	13.2	3.8
Milk	10.5	2.9	22.0	20.4	13.4	4.7	4.0	12.3	1.4	5.8	2.4
Beef and veal	6.9	5.0	26.0	17.5	14.6	2.3	6.6	11.1	1.7	7.0	1.2
Pig meat	12.7	6.4	14.0	22.2	11.4	9.2	1.1	6.4	1.8	13.5	1.3
Poultry meat	5.9	2.1	28.8	6.5	23.0	1.3	1.5	13.8	2.9	11.7	2.4
Eggs	9.7	3.6	15.4	16.1	18.8	1.2	0.6	12.4	2.0	15.5	4.7
All agr. prod.	7.9	3.2	22.7	13.3	19.3	3.2	2.0	9.2	1.9	12.9	4.4

Source: computed from The Agricultural Situation in the EU, 1991 and 1992 Reports.

example, are heavily engaged in cereals production. At a higher level, however, France, Germany, Italy, but also The Netherlands, Denmark, and Spain are active in pigmeat production. The latter three countries are known for their significant reliance on feedstuff imports from the rest of the EU, but also from outside the EU (*e.g.* soybeans from US and Latin America).

Table 5.3 provides some numbers on the public expenditures made on the GOL-products because of the CAP, in particular the expenditures under the Guarantee-heading[1]. As Table 5.3 shows, the total share of GOL products in the EAGFF Guidance-expenditures is still more than 50%, with the share showing a decline over time. Looking at subsectors, in particular the arable sector (cereals and also oilseeds and sugarbeets) and the cattle/dairy sectors are the beneficiaries of these policy programs. The intensive livestock sector, with its known light structured policy programs, involves much less expenditure. After 1985, with the introduced milk quota the expenditures on diary show a marked decline. Expenditure on the arable sector seems rather stable over time, although there is a significant shift in

[1] The Guarantee-branch includes all expenditures on market and price policy, while the Orientation-branch relates to expenditures with a socio-structural character.

Table 5.3 EAGFF Guarantee expenditures on GOLF-products

	1975 Mio Ecu	%	1980 Mio Ecu	%	1985 Mio Ecu	%	1990 Mio Ecu	%	1995 Mio Ecu	%
Cereals	620.9	15.9	1666.9	15.1	2310.2	11.8	3856.0	15.5		0.0
Oilseeds	231.4	5.9	687.3	6.2	1110.6	5.7	1033.3	4.1		0.0
Rootcrops *)	309.2	7.9	575.2	5.2	1804.5	9.2	1391.0	5.6	1831.0	5.2
Milk	1149.8	29.4	4752.0	43.1	5933.2	30.4	4971.7	19.9	4028.7	11.5
Beef and veal	979.9	25.1	1363.3	12.4	2745.8	14.1	2833.2	11.4	4021.1	11.5
Pig meat	53.8	1.4	115.6	1.0	165.4	0.8	1452.3	5.8	143.3	0.4
Poultry meat	8.4	0.2	68.0	0.6	45.0	0.2	145.2	0.6	171.9	0.5
Eggs			17.5	0.2	18.2	0.1	33.1	0.1	28.6	0.1
Gol-products	3044.2	77.9	8670.6	78.7	12328.4	63.2	14325.0	57.4	8393.6	23.9
Total **)	3906.1	100.0	11016.4	100.0	19517.2	100.0	24935.5	100.0	35110.0	100.0

Source: computed from The Agricultural Situation in the EU (various years).

the composition of expenditures on relating to this sector. After 1990 (introduction MacSharry-reform) expenditures related to traditional price support declined and expenditures because of direct income support increased.

Table 5.4 shows the per capita consumption by consumers in terms of derived agricultural GOL-products demand. The lower part of the Table provides the self sufficiency rates as provided by the Commission, which links the value share numbers provided in Table 5.2 to derived demand for agricultural products at member state level. As the Table shows, there are marked differences in per capita consumption levels. Generally southern countries have a relatively high cereals consumption (pasta products) as compared with northern countries. The latter rely relatively more on potatoes. Vegetable oils consumption includes olive oil, which is particularly used in the Mediterranean member states. Average total meat consumption in the EU in 1990 is 80 kg. per capita, and varies from 62 kg/cap. in Portugal to 95 kg/cap. in Denmark. The composition of the meat menu varies, with Denmark and Germany the leading pig meat consumers, and France and Italy having strong positions in beef and veal consumption. Poultry meat consumption is dominant in Spain, the UK and Ireland. Variations in food menu can be traced back to differences in food

Table 5.4 Per capita consumption and self sufficiency for GOL products in the EU (1990)

	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.	EU-12
Consumption in kg./capita												
Cereals	52	72	77	91	120	70	95	77	85	72	106	83
Veg. oils	38	33	22	27	31	44	23	30	23	30	33	27
Sugar	40	40	33	35	29	40	39	41	29	27	30	36
Potatoes	87	97	71	75	39	57	*144*	99	107	*106*	89	78
Milk *)	245	272	358	274	183	302	233	207	211	90	212	234
fresh	136	82	101	93	75	145	187	129	90	92	*54*	100
cheese	14	14	23	17	15	15	5	8	6	4	*23*	14
butter	3	6	7	5	2	5	3	3	5	0	*2*	4
Beef&veal	20	20	30	22	26	19	18	19	15	13	23	22
Pig meat	46	45	37	58	32	64	35	24	29	49	21	39
Pltry.meat	19	17	22	12	19	12	22	20	18	23	17	19
Eggs	10	14	15	15	10	14	10	13	7	16	12	13
Self sufficiency **)												
Cereals	31	51	215	114	80	117	*100*	119	43	91	93	120
Veg. oils	33	33	82	64	42	99	59	34	30	80	117	70
Sugar	197	246	*235*	151	89	259	166	53	1	*90*	92	128
'Milk'	295	202	206	205	103	455	896	180	143	128	31	182
Beef&veal	160	159	114	120	65	208	903	91	71	102	29	108
Pig meat	280	161	87	86	67	366	129	69	94	97	69	104
Pltry.meat	187	98	137	58	98	58	107	93	98	137	96	105
Eggs	338	126	108	71	95	104	92	62	101	97	98	103

Source: The Agricultural Situation in the EU, 1992 Report, Tables 3.7.2 and 3.7.3 (Italic numbers relate to adjacent years)

**) Computed from converting products into milk equivalents using average conversion coefficients*

***) 'Milk self sufficiency' computed as deliveries to dairies divided by human consumption (excludes non-human consumption, includes on-farm consumption; see main text).*

cultures between member states, while abolute consumption levels to a certain extent also reflect national wealth levels.

The lower part of Table 5.4 shows the self-sufficiency levels for various products. France, Germany, Denmark and the UK are more than self sufficient in cereals, while, except for Greece (for olive oil), non of the member states are self-sufficient with respect to vegetable oils. At EU level the average self sufficiency rates for cereals and vegetable oils are respectively 120 and 70%. Also for 'processed cereals' products (meats and eggs) the self sufficiency rates are over 100%, although for individual member states the situation might be rather different. Ireland and Denmark have the most pronounced surplus of production in excess of consumption for beef and veal. Denmark, The Netherlands, Belgium and Ireland have significant pig meat surpluses. The Netherlands, Spain and Ireland are in excess supply with respect to poultry meat, while The Netherlands and Belgium have dominant surplus-positions in eggs. The numbers given for diary products need careful interpretation. In fact they significantly overestimate the 'self sufficiency' rate for milk, because non-human consumption or industrial uses are neglected. A more realistic self sufficiency rate number is obtained when the total milk production is divided by domestic Community demand (excluding special disposure measures), which yields an estimate of about 127%. These differences emphasize the different interests EU member states have with respect to the CAP programs on GOLF products. Several examples could be mentioned to illustrate this. The policy part is, however, not dealt with here, but is discussed in Part III.

5.3 Modelling approach

A synthetic modelling approach is chosen, which on the one hand relies on sample data (time-series) and on the other hand makes intensive use of previous research. For consumers and agriculture (arable sector, intensive livestock sector, and cattle/dairy sector) direct behavioural models are estimated at the member state level. These models generate (derived) demands and supplies for inputs and outputs and final consumer products. The agribusiness is treated somewhat differently. The compound feed industry, which forms the main link between arable and animal farming, is explicitly modelled. The crushing industry is not explicitly taken into account, but is considered as a serving-hatch that can be represented by some simple technical equations. The food industry (including trading, grading and handling) is modelled as a two input-one output industry, with one agricultural input and one non-agricultural input (representing marketing and processing services and the like) producing one final consumer output. As such this construction is flexible in that it allows for substitution and a variable farm-retail price spread. So-far, market power and imperfect competition phenomena are not accounted for, although they can in principle be incorporated into the model. A problem that arises is the availability of reliable data to make any sensible assumptions here. As a simplifying assumption a constant returns to scale technology was assumed, which implies a zero profit condition. Nevertheless, this approach provides a device to construct a derived consumer demand for agricultral products, which is in reality a rather tricky issue. Edible fats, for example, are used in a host of final food products, and it is difficult to disentangle these component demands into a direct edible fats demand.

The economic models used are micro-based and strongly rely on duality approaches, *i.e.* expenditure functions, and profit functions. While for the consumer side the Almost Ideal Demand model specification is chosen, for the producer side usually normalized quadratic profit or cost functions are specified. These duality relationships have the advantage of easily allowing for multiple output, multiple input technologies, and of being able to easily handle restrictions imposed on inputs (quasi-fixed inputs) and outputs (production quota). Moreover, as became already clear from Part 1 of this study, they are good candidates for operational welfare measures. The empirically estimated models are the ingredients for a simulation model, which is used for policy simulations in Part 3 of this study.

Except for the consumer demand model, all behavioural models are empirically estimated. For the consumer demand side, a large empirical study by Michalek is available, which estimated AID/LES-demand models for the EU-10. These results, togeteher with some individual country studies for other member states (Spain, Greece) are translated into elasticity matrices, which forms the basis for calibrating the consumer demand model for all EU-12 member states. The behavioural models are estimated roughly for the period 1973 till the early 1990s. Also here a lot of existing emperical work was reviewed and taken into account by means of a mixed estimation procedure. The general concept of this procedure is the subject of the next section. Further details on the behavioural models will be provided in the subsequent chapters.

5.4 Mixed estimation procedure

This section discusses the so-called mixed estimation (ME) procedure used to estimate the agricultural subsector models. The mixed estimation procedure was developed by Durbin (1953), Theil and Goldberger (1961), and Theil (1963) already in the early 1960s. Theil (1974) generalized the ME estimator for the case prior when information and sample information are not independent, while Mittelhammaer and Conway (1988) provided a frequentist based justification for applied ME-work. Although most econometric texts do mention it, it has not become very popular in applied agricultural economic analysis[2]. This may partly be explained by criticisms of the approach by, for example, Judge *et al* (1988, p.819) and Swamy and Metha (1983, p.369). Nevertheless the procedure has several attractive characteristics. It allows us to include a type of *a priori* knowledge in the inference procedure which is not included in the standard OLS or GLS estimators. In the standard approach this 'omitted' prior information often plays a somewhat confusing role in that it forms an *ex post* criterion to respecifying estimated models until desired signs and magnitudes of parameters are obtained. It is well-known, however, that the exact probability statements underlying the estimation procedure no longer hold when such data mining practices are followed (Leamer, 1983). Although it will probably always remain difficult to completely ban this common *ad hoc* practice in applied analysis, the mixed estimation approach, by allowing for inclusion of such *a priori* information is at least a logically more consistent procedure to follow. Other attractive points of the mixed estimator are its claimed potential for producing estimates that are superior in mean squared error to the usual OLS (and GLS) estimators, its power to mitigate the effects of multicollinearity in the data, and its simplicity (straightforward to program and inexpensive to compute) (Mittelhammer and Conway, 1988, pp.859-860). Although the mixed estimation procedure focuses on the same subject of combining prior and sample information as the Bayesian estimation procedures, it is more in the classical realm of econometrics.

In the rest of this section, the general structure of the mixed estimator and some

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[2] Examples are Theil (1971), Koutsoyiannis (1977) and Judge *et al* (1980; 1988).

of its properties are discussed. Since the models considered in this study imply systems of behavioural equations, a systems estimator will be considered which allows for contemporaneous correlation between disturbances of different equations. Moreover, besides the normal non-sample information derived from economic theory (and imposed as exact restrictions, *e.g.* symmetry and homogeneity), also uncertain prior information concerning signs, and plausible value ranges for at least some parameters are taken into account in the form of stochastic restrictions. The result will be a restricted mixed seemingly unrelated regressions (RM-SUR) estimator.

Models consisting of a set of equations can be represented in a general way by the following set of M seemingly unrelated regressions (Zellner 1962) with T observations each. This can be written as

$$\begin{pmatrix} y_1 \\ y_2 \\ . \\ y_M \end{pmatrix} = \begin{pmatrix} X_1 & 0 & . & 0 \\ 0 & X_2 & . & 0 \\ . & . & . & . \\ 0 & 0 & . & X_M \end{pmatrix} \begin{pmatrix} \beta_1 \\ \beta_2 \\ . \\ \beta_M \end{pmatrix} + \begin{pmatrix} u_1 \\ u_2 \\ . \\ u_M \end{pmatrix} \tag{1}$$

or more compactly as

$$y = X\beta + u, \quad E[u_i] = 0, \quad E[u_i u'_j] = \sigma_{ij} I, \quad i,j = 1,2,\ldots,M \tag{2}$$

Every X_i matrix contains K explanatory variables. The $(MT\text{x}MT)$ covariance matrix of the disturbance term, which allows for contemporaneous correlation between disturbances of different equations, can more conveniently be written as $E[uu'] = \Phi = \Sigma \otimes I$ with $I = I_T$ the T dimensional unit matrix, and Σ defined as

$$\Sigma = \begin{pmatrix} \sigma_{11} & \sigma_{12} & . & \sigma_{1M} \\ \sigma_{21} & \sigma_{22} & . & \sigma_{2M} \\ . & . & . & . \\ \sigma_{M1} & \sigma_{M2} & . & \sigma_{MM} \end{pmatrix}$$

Usually there is, at least for a number of parameters, some form of quantitative information available about the ranges within which the value of the coefficients are expected to lie. For example, assume β_1 is expected to be equal to p_1. This information can be formulated as

$$p_1 = (1, 0, .., 0)\beta + v_1$$

or more generally as

$$p = P\beta + v \tag{3}$$

with p a *(Jx1)* vector and P *(JxMK)* dimensional matrix[3]. The uncertainty about the quantitative information is expressed by the added disturbance terms v_1 and v respectively[4]. They are assumed to have a zero expected value and a *(JxJ)* variance matrix V, or $E[v] = 0, E[vv'] = V$. One criticism of the ME-approach concerns the interpretation and genesis of this prior estimator. When interpreting p as a vector of the researcher's best guesses, it can also be argued that p is in fact a non stochastic fixed constant (Swamy and Metha, 1983). Consistency clearly requires p to be random and therefore the prior information on $P\beta$ should be expressed in terms of a subjective probability distribution (Mittelhammer and Conway, 1988, p.860). In this line Theil and Goldberger (1961, p.73) remark that the distribution of p is of the subjectivist or personalist type, since it is the researcher who formulates the prior point estimate and its associated sampling variance.

If the quantitative prior information is obtained from previous quantitative research, estimates of expected values and standard deviations will often be known and can be used to determine the prior distribution. Obtaining information about covariances will be much less easy since complete covariance matrices are usually not publicized. If there are only some subjective beliefs about the range in which a coefficient is expected to lie, the usual procedure is as follows (*eg.* Koutsiannis

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[3] Within the Bayesian approach (3) would be interpreted as inducing a prior distribution on β.

[4] Thus β is here thus assumed to be fixed, while p is a stochastic vector of estimates from previous research.

1977). The information about the plausible range is firstly 'translated' by interpreting it as a *confidence interval*. The mid-value of the range is taken as the point estimate of the coefficient, say b_i. Next it is assumed that with a certain probability (usually a 95 per cent probability) the true value of b_i will lie between the lower and upper values of the range. Then applying the confidence interval formula, the standard error of the coefficient can be obtained as (applying the two sigma-rule)[5]

$$st.dev.(b_i) = \frac{(b_i \pm \text{boundary value})}{2} \tag{4}$$

Having specified the prior distribution, observations on p can in principle be obtained by applying standard random number generation procedures. However, in practice usually an 'easier route' is followed by using the expected value as the relevant point estimate. As Mittelhammer and Conway (1988) show, this latter leads to a prior integrated ME (PIME), which dominates the random-drawings ME and gives the ME a sound statistical basis.

Subsequently, the uncertain prior information is coupled with the sample observations. Combining the stochastic restrictions of (*3*) with the system of *M* equations (*1*) yields

$$\begin{pmatrix} y \\ p \end{pmatrix} = \begin{pmatrix} X \\ P \end{pmatrix} \beta + \begin{pmatrix} u \\ v \end{pmatrix}, \qquad E\begin{bmatrix} u \\ v \end{bmatrix} = 0, \quad Var\begin{bmatrix} u \\ v \end{bmatrix} = \begin{pmatrix} \Phi & 0 \\ 0 & V_0 \end{pmatrix} \tag{5}$$

The sample and prior information are assumed to be independent, which causes the block-diagonal character of the covariance matrix. Before GLS can be applied to this model, knowledge of the variances and covariances of the disturbance terms $u_1, .., u_M$ are required, which are usually unknown. Estimated residuals can be

[5] For an alternative approach assuming a continuous uniform distribution see Kmenta, 1971, pp.434-435).

generated from first round OLS regressions of the M individual equations, with $b_i = (X_i'X_i)^{-1}X_i'y_i$. Consistent estimates of the variances and covariances can then be computed as[6]

$$\hat{\sigma}_{ij} = \frac{1}{T-K}\hat{u}'_i\hat{u}_j \quad = \quad \frac{1}{T-K}\sum_{t=1}^{T}\hat{u}_{it}\hat{u}_{jt} \tag{6}$$

with T-K the number of degrees of freedom. These estimates can be used to build up $\hat{\Sigma}$ and $\hat{\Phi}$ respectively. The unbiased (feasible GLS) estimator, known as the so-called *mixed estimator* can now be written as (Theil, 1971, p.349)

$$b_M = \left[(X\,P)\begin{pmatrix}\hat{\Phi}^{-1} & 0\\ 0 & V^{-1}\end{pmatrix}\begin{pmatrix}X\\ P\end{pmatrix}\right]^{-1}(X\,P)\begin{pmatrix}\hat{\Phi}^{-1} & 0\\ 0 & V^{-1}\end{pmatrix}\begin{pmatrix}y\\ p\end{pmatrix} \tag{7}$$

or equivalently as

$$b_M = (X'\hat{\Phi}^{-1}X + P'V^{-1}P)^{-1}(X'\hat{\Phi}^{-1}y + P'V^{-1}p) \tag{8}$$

or

$$b_M = [X'(\hat{\Sigma}^{-1}\otimes I)X + P'V^{-1}P]^{-1}(X'(\hat{\Sigma}^{-1}\otimes I)y + P'V^{-1}p) \tag{9}$$

The *(MT+JxMT+J)* covariance matrix of b_M is approximated by the first right hand side term

$$V_M = (X'(\hat{\Sigma}^{-1}\otimes I)X + P'V^{-1}P)^{-1} \tag{10}$$

with on its diagonal the squared standard deviations of the estimated parameters.

Belonging to the class of restricted estimators, the ME can be shown to have

[6] If the seemingly unrelated regressions have individually different numbers of explanatory variables another 'degrees of freedom correction' may be more appropriate (*cf.* Judge 1988, p.451).

a superior precision matrix as compared to the unrestricted SUR estimator, irrespective of whether the stochastic restrictions are actually correct or incorrect. However, in general the ME estimator is biased $(\delta = p - P\beta \neq 0)$, since it cannot reasonably be assumed that the researcher's prior distribution or best guess will coincide with the unknown $P\beta$. Evaluating the final performance of ME-estimators thus involves the classic trade off between variance reduction at the cost of bias increase. To assess the accuracy of the estimator, its risk or mean square error-properties are important. If δ is 'small enough' the ME can be proved to be strong mean square error superior to the unrestricted GLS estimator (Mittelhammer *et al*, 1980, p.202; Mittelhammer and Conway, 1988, p.862). Therewith a second criticism of the ME-approach is met. While in general restricted GLS estimators (including ME) have smaller risk than GLS, this only holds under appropriate conditions, which depend upon the true but unknown parameter values. If the prior estimates are not 'sufficiently close' to the true ones, risk improvement may not be realized since restricted estimators have unbounded risk functions, *i.e.* the larger is δ the larger the risk (*eg.* for example Judge, *et al*, 1988, pp.812-819). In this study it is throughout assumed that if prior information is imposed, it is of such a quality that the closeness-criterion is satisfied.

The issue of compatability of prior and sample information is not explicitly dealt with in this study, although there are test statistics available. The problem is not the computation of these statistics, but rather their interpretation. An outcome of a test statistic indicating that prior and sample information are not mutually compatible, for example, does not necessarily disqualify the prior information in favour of the sample. The prior information is, for example, partly of a theoretical nature, and rejecting this information may imply rejecting that farmers are profit maximizers. Moreover, prior estimates conforming to the 'true' model may be evaluated against (biased) sample estimates of a known inadequately or misspecified model. Nevertheless, it is still informative to obtain some general idea of how the sample and prior information determine the final precision. Analogously to Theil (1974, p.39), α_p indicating the share of the prior information in the posterior precision is defined as

$$\alpha_p = \frac{1}{J.K} \text{ trace } [(X'(\hat{\Sigma}^{-1} \otimes I)X + P'V^{-1}P)^{-1}(P'V^{-1}P)] \tag{11}$$

which is zero for a non-informative prior, and approaches 1 as the influence of the prior information gets stronger.

The next step is to modify the estimator to also incorporate the theoretical restrictions, *i.e.* the restrictions known with certainty. In order to do, that the combined model (see equation (*6*)) is rewritten as

$$z = Z\beta + e \tag{12}$$

with

$$z = \begin{pmatrix} y \\ p \end{pmatrix}, \quad Z = \begin{pmatrix} X \\ P \end{pmatrix}, \quad e = \begin{pmatrix} u \\ v \end{pmatrix}, \quad E\left[\begin{pmatrix} u \\ v \end{pmatrix}\begin{pmatrix} u \\ v \end{pmatrix}'\right] = \begin{pmatrix} \Phi & 0 \\ 0 & V \end{pmatrix} = \begin{pmatrix} \hat{\Sigma} \otimes I & 0 \\ 0 & V \end{pmatrix} = \hat{\Psi}$$

where z and e are *(T+J)*x*1* vectors, Z is an *(T+J)*x*K* matrix and Ψ a *(MT+J)*x*(MT+J)* dimensional covariance matrix.

The quantitative-theoretical prior information is assumed to be formulated in a set of restrictions which have an exact and linear character. They can be written algebraically as

$$R\beta = r \tag{13}$$

with R a *(Q*x*MK)* matrix containing the Q independent restrictions on the parameters. Notice that they have a strict and non-stochastic character (no disturbance term added). The restricted mixed estimator, which is again a restricted GLS estimator, should yield the β that minimizes the particularly weighted sum of squared residuals subject to restriction (*13*)

$$\min.\{(z - Z\beta)'\Psi^{-1}(z - Z\beta)\} \tag{14}$$
$$s.t. \quad R\beta = r$$

with Ψ approximated by the estimated variance matrix from (*12*). Solving this optimization problem gives the restricted mixed SUR-estimator which can be written as[7]

$$b_M^* = b_M + (Z'\Psi^{-1}Z)^{-1}R'[R(Z'\Psi^{-1}Z)^{-1}R']^{-1}(r - Rb_M) \tag{15}$$

with b_M the unrestricted mixed estimator

$$b_M = (Z'\Psi^{-1}Z)^{-1}Z'\Psi^{-1}z \tag{16}$$

The estimated variance of b_M^* is approximated by

$$\begin{aligned} Var(b_M^*) \;&=\; (Z'\Psi^{-1}Z)^{-1} - \\ &(Z'\Psi^{-1}Z)^{-1}R'[R(Z'\Psi^{-1}Z)^{-1}R']^{-1}R(Z'\Psi^{-1}Z)^{-1} \end{aligned} \tag{17}$$

a result that is a natural extension of Judge et al (1988, p.457). Of course it is possible to write an iterative version of the GLS/SUR estimator.

Summarizing, the RM-SUR approach is presented here as an attractive estimation procedure for quantitative agricultural economics analysis. Not only do researchers have prior beliefs, but often reliable prior information (at least for some parameters) is available from previous economic or agronomic research. Such prior information from an efficiency perspective should, as far as possible, be included in the inference procedure. If the probability nature of the prior-information is explicitly recognized, and prior information is only used if it is reliable in the sense of satisfying the closeness-criterion, the criticisms leveled at the ME-approach can be downplayed. The procedure will in general lead to smaller risk or lower mean

[7] The derivation is in essence analogous to the derivation of the restricted least squares estimator (*cf.* for example Judge, 1988, pp.236-237.

square error-loss than the pure sample estimator, while its statistical consistency is guaranteed. The frequently occurring multicollinearity in agricultural time series only further emphasizes the value of the ME-procedure.

5.5 Outline

Having provided a delineation of the GOL-complex and discussed the general modelling and estimation approach, this section sketches a brief outline of the rest of this study. In the next chapter (Chapter 6), the consumer demand model, including the derived demand for agricultural products (accounting for the food industry) is examined. Subsequently, the modelling results for agriculture are presented: the arable sector (Chapter 7), the cattle/dairy sector (Chapter 8), and the intensive livestock sector (Chapter 9). Finally, in Chapter 10 the compound feed industry is discussed. The general structure of the subsequent chapters is follows. Each chapter starts with an introduction reviewing the main sector-specific characteristics, followed by a specification of the economic model, a discussion of the prior information used, and then a presentation of the estimation results. In Part III of the study, these estimation results will be used for the calibration of a simulation model. The modelling of the CAP and model closure (relationships with the rest of the world) will be also discussed there.

Chapter 6

Consumer demand for food and the derived demand for agricultural products

6.1 Introduction

This chapter starts with a brief overview of the levels and main trends in EU food consumption. Moreover, some characteristics of the food industry are presented. Subsequently, the Almost Ideal Demand model and the calibration routines used for the parameterization is discussed (Section 2). Section 3 focuses on the data and calibration results. Section 4 deals with the food industry and the determination of the derived demand for agricultural products. Finally, section 5 closes with some concluding remarks.

One of the most famous results in consumer food demand analysis is Engel's Law, *viz*. the tendency for consumer expenditure on food to decline as a proportion of total expenditure when the income level rises. As shown in Figure 6.1, this phenomenon is also relevant for EU food consumption. The horizontal axis shows the average income per capita (expressed in 'purchasing power parity' US$ for comparison), while at the vertical axis gives the percentage of food expenditure in total expenditure. Although there are clear differences in national attitudes, the income shares decline over time as the welfare levels increase (*e.g.* Trail, 1997, p.394). Table 6.1 shows some main indicators characterizing human consumption patterns in 1990. The first row gives total consumption expenditure in Ecu per capita. The next row indicates the share of the group 'foods, drinks and tobacco' in total consumption expenditure. The third row shows the amount of expenditure on the

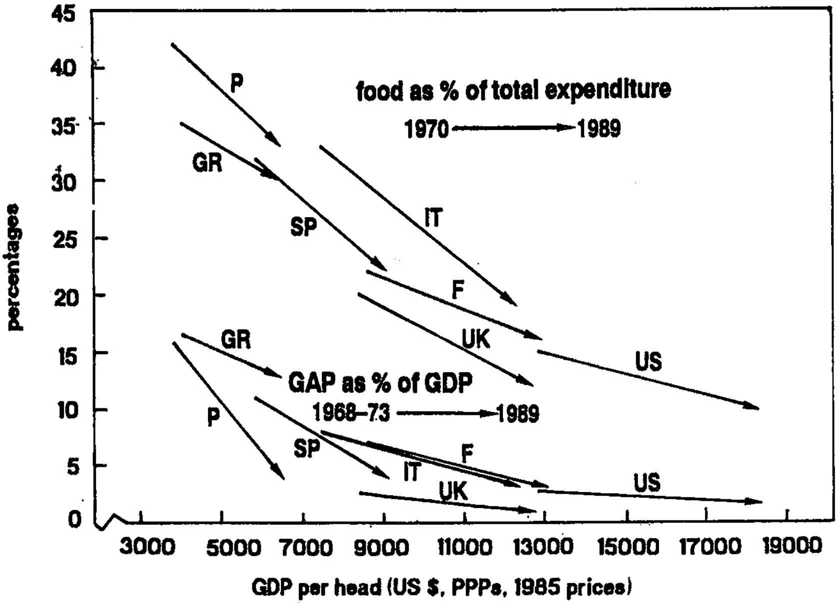

Figure 6.1 Food expenditure and economic development
Source: Tracy (1993, p.135)

food products distinguished in the model. It should be noted that these products are valued at consumer-level prices. For each country, the number of inhabitants, the number of households, and the income elasticities for total food demand are given. As can be seen from Table 6.1, the demand for food is inelastic in all EU member states, with the wealthier countries having relatively lower than average income elasticities. The income elasticity of Portugal is set equal to that of Spain. Those of Greece and the United Kingdom are somewhat surprising, the first being somewhat high and the latter is somewhat lower than expected.

In order to obtain some idea about dynamic developments, in the second part of the table numbers about expenditure and population growth are provided. With respect to consumption expenditure and consumer prices, average compound growth rates over the period 1981-1990 have been computed. For population growth the same has been done over the period 1980-1990. Since population growth is very low, its contribution to the yearly increase in food consumption is rather low. For

Table 6.1 Some basic characteristics of EU food demand (1990)

	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
Tot. cons exp. *)	8697	94732	10058	10023	9248	10154	5977	8251	2264	5939	3843
Share fds&drinks **)	15.51	19.08	18.12	22.16	20.73	21.31	34.71	21.35	37.15	21.93	37.90
Food exp. *)	1346	1807	1822	2221	1917	2164	2075	1762	841	1303	1456
# Inhabitants ***)	14892	10326	56304	62700	57576	5134	3499	57327	10335	38925	10046
# Households ***)	6011	3929	21644	27211	20766	3011	1060	22902	3301	11444	3449
Fd.exp. elasticity	0.14	0.31	0.55	0.23	0.62	0.34	0.67	0.03	0.88	0.88	0.97
Inc. growth **)	5.46	5.88	5.63	6.87	11.4	6.66	8.98	6.12	3.32	9.61	5.37
CPI **)	1.99	4.21	5.53	2.22	8.76	5.28	6.36	5.28	16.80	8.73	18.43
Real inc. grwth. **)	3.47	1.67	0.10	4.65	2.64	1.38	2.61	0.84	-13.48	0.87	-13.06
Pop. growth **)	0.51	0.10	0.52	0.09	0.09	0.02	0.31	0.23	-0.01	0.39	0.46

*) Ecu per capita; ***) in per cent; ***) in thousands.

Source: OECD: National Accounts (detailed tables, Vol.II) 1980-1992, Paris, 1994 (various tables); Eurostat: Basisstatistieken van de Gemeenschap, Table 3.13, Luxemburg, 1992; and own estimates based on literature survey (elasticities) and trend regressions.

Germany, population growth was computed on a non-unification base. The unification caused an increase in the German population of about 17 million people. Except for Greece and Portugal, there is significant expenditure growth in all the EU member countries ranging from 0.1 for France to 4.7 percent a year for Germany.

Table 6.2 provides the shares of a selected number of individual food products in total consumption expenditures. Because at this level of disaggregation no data for 1990 is available data from 1988 has been used. Further, the expenditure shares of other consumption categories are given. On average the EU countries spent 25.5% (19.6) of their income on food and drinks (food). The picture emerging from Figure 6.1 that countries with relatively high per capita income have relatively low food expenditure shares is confirmed.

With respect to individual foods, the calculated inter-country variation is largest for fish and potatoes (coefficients of variation (c.o.v.) of respectively 0.87 and 0.79 against an average of 0.50). (Not reported in table). Within the drinks category (which itself shows considerable variation), alcoholic drinks show the strongest inter-country variation (c.o.v of 1.06). The expenditures with respect to the other non-food items, in particular medical care and health expenditure, show unusual variation (c.o.v. of 0.71 against an average of 0.29). As can be seen by comparing

Table 6.2 Allocation of consumption expenditure in EU-12 (in %)

Product	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
FD.&DRNKS	18.65	19.70	19.61	16.41	24.58	22.29	40.56	17.09	37.15	26.06	38.19
NON-DRNKS	14.60	16.06	15.98	12.17	19.10	15.21	22.70	12.11	32.65	23.51	31.08
Crls.&bread	2.20	2.08	2.16	1.91	2.39	1.94	3.80	1.90	4.49	2.58	1.80
Meat	3.54	5.57	5.25	4.66	5.77	4.32	6.54	3.12	10.24	6.79	8.76
Fish	0.42	1.05	0.87	0.66	1.26	0.56	0.97	0.49	4.51	2.66	2.50
Milk&Eggs	2.64	2.14	2.43	1.41	2.83	2.26	3.25	1.76	4.37	3.97	5.28
Oils&fats	0.54	0.79	0.62	0.47	0.76	0.59	0.88	0.35	1.39	1.23	1.50
Fruit&veget.	2.58	2.27	2.42	1.84	4.52	1.98	2.74	1.87	4.75	4.30	7.04
Potatoes	0.30	0.18	0.18	0.14	0.20	0.43	1.34	0.53	1.00	0.37	0.84
Sugar	0.19	0.16	0.11	0.10	0.26	0.23	0.31	0.12	0.58	0.24	0.31
Coffee, thee & cocoa	0.75	0.45	0.40	0.34	0.48	0.69	0.52	0.43	0.55	0.56	0.50
Other foods	1.42	1.36	1.53	0.64	0.63	2.20	2.35	1.55	0.76	0.80	2.55
DRINKS *)	4.05	3.64	3.63	4.24	5.48	7.08	17.87	4.99	4.50	2.55	7.10
Non-alcohol.	0.58	0.51	0.49	0.53	2.74	0.62	1.43	0.89	0.24	0.37	0.94
Alcoholic	1.82	1.38	1.98	2.15	1.13	3.54	11.54	1.71	1.93	1.03	2.65
Tobacco	1.65	1.75	1.16	1.56	1.61	2.92	4.90	2.39	2.32	1.16	3.52
NON-FOOD	81.35	80.30	80.39	83.59	75.42	77.71	59.44	82.91	62.85	73.94	61.81
Cloth. & ftwear	7.08	7.28	6.72	7.80	9.38	5.82	6.47	7.01	10.26	7.41	9.15
Gross rent, fuel & power	18.63	17.13	18.72	18.40	13.97	26.16	10.98	19.33	4.95	14.26	11.67
Furn. & hh.-equipm.	8.17	10.61	8.15	8.69	8.48	7.10	7.38	6.79	8.61	7.09	8.35
Medic.care & health-exp.	12.61	10.84	9.20	15.02	5.92	1.98	3.37	1.30	4.50	3.56	3.63
Transp. & commun.	11.08	12.92	16.76	14.58	12.46	15.62	11.95	17.25	15.36	14.81	12.29
Recr.,educ.& cult.	9.72	6.41	7.41	9.06	8.41	10.00	10.41	9.24	5.74	6.59	6.49
Misc. gds. & serv.	14.06	15.12	13.44	10.04	16.80	11.02	8.88	21.99	13.43	20.22	10.25

*) *Drinks include beverages and tobacco.*

Source: Computed from Eurostat: National Accounts ESA (detailed tables by branch) 1980-1988, Brussels, 1991 (various tables). For Germany the individual food shares are obtained from Michalek (private information) and for Spain the total expenditure on food is decomposed on the basis of the 1985 food expenditure shares.

Tables 6.1 and 6.2 the shares of food not only show considerable variation across countries, but also over time. Somewhat surprisingly, the variation over time remains when one looks at absolute nominal or real expenditure levels. The coefficients of variation reflect only the inter-country variation for one specific year (1988), and do not take into account the variation over time.

With regard to the food industry, some general information is available but it is difficult to obtain product specific information (*e.g.* Zuurbier *et al*, 1996). From Tracy (1993, p.60) and Van Leeuwen and Verhoog (1995, p.59) it can be deduced that on average the farm value as a percentage of the final consumer expenditure lies somewhere between 25 and 35 per cent. For 'individual' products (subgroups) there is significant variation which is for a large part due to the variation in processing and transformation for different products. Highly processed and transformed foodstuffs show relatively high margins in comparison with less or low processed products (*cf.* Tracy, 1993, p.58-61). Moreover, Oskam and Van Dijk (1984, p.467) concluded that there is no indication that increasing or decreasing throughput leads to systematically lower or higher margins, reflecting the long-run constancy of margins in the food industry.

The first column in Table 6.3 shows the share of the domestic market supplied by home production of food and beverages products. Except for Belgium and Greece, on average more than 80% of domestic food and beverages consumption is home-based (for UK no data is available). This emphasizes the local and/or regional nature of food consumption and production. Nevertheless, within the food sector, trade in processed food products has shown rapid growth rates (9.4% per annum between 1961 and 1990), while over the same period trade in (agricultural) bulk commodities grew only by 2.1% (Trail, 1997, p.394). This confirms the idea that less processed food products, which are bulky, perishable, and thus costly to transport are relatively immobile. The second and third columns of Table 6.3 show the Lloyd-Grubel measures for intra industry trade (trade in various types of similar products), with a zero value indicating absence of intra industry trade and a unit value indicating that the entire trade is intra industry trade (see also note in Table 6.3). It can be concluded that processed food products have generally a significant and increasing inter industry trade nature.

The following columns of Table 6.3 illustrate that agricultural markets (with

Table 6.3 Trade characteristics in EU food industry

	Home-based food consumption share (%)	Intra industry trade in food, drink and tobacco industries *)		Intra-EU 1992 trade shares for total products and dairy products (%)			
				total trade		dairy products	
Country	1990	1980	1992	imports	exports	imports	exports
Netherlands	87.5	0.54	0.56	43.1	76.2	97.5	56.9
Belgium	54.1	0.57	0.58	63.5	73.2	98.4	86.9
France	82.5	0.49	0.54	38.2	66.8	96.3	78.2
Germany	81.2	0.53	0.58	35.7	58.0	91.8	89.9
Italy	78.6	0.32	0.38	20.8	41.6	98.1	67.4
Denmark	74.2	0.37	0.39	25.0	44.3	94.7	37.0
Ireland	82.3	0.36	0.45	51.7	79.9	95.2	79.9
United Kingdom	n.a.	0.45	0.49	28.4	51.9	85.1	73.9
Portugal	93.5	0.19	0.28	38.4	69.3	98.1	75.7
Spain	91.2	0.27	0.47	23.3	49.3	98.8	38.6
Greece	56.4	0.13	0.24	24.1	43.0	98.0	75.7
EU-12		0.38	0.45				

Source: National consumption of home produced foods Eurostat, Statistical Yearbook '97, p.382), intra industry trade data from Trail (1997, p.396) who cites them from Gomes da Silva, and the intra-EU trade share data from Pieri et al (1997, p.414).

*) The Grubel Lloyd-index for bilateral trade between countries *i* and *j* for specific product *f* is defined as $GL^f_{ij} = \frac{[(X^f_{ij}+M^f_{ij})-|X^f_{ij}-M^f_{ij}|]}{(X^f_{ij}+M^f_{ij})}$ with X^f_{ij} and M^f_{ij} denoting respectively the exports from country *i* to country *j*, and imports from country *i* from country *j* for a specific product category *f*.

dairy as an example) are relatively highly integrated at the European level as compared with the general average (*cf.* intra-EU trade shares in total products). The intra-EU trade shares for dairy exports are significantly lower than those for imports, which reflects the typical surplus-character of EU dairy products.

6.2 The Almost Ideal Demand Model

6.2.1 The AID model

Consumer demand for food products is explained by the Almost Ideal Demand System, originally developed by Deaton and Muellbauer (1980; 1983) and intensively used in applied food demand analysis (*e.g.* Edgerton *et al*, 1996 and references cited therein). This theory-based demand system has several nice characteristics (*cf.* Deaton and Muellbauer (1980, p.312)). *i*) It satisfies the axioms of consumer choice exactly. *ii*) It gives an arbitrary first order approximation to any demand system. *iii*) It has a functional form which is consistent with previous household budget data. Moreover, *iv*) in its linear approximate form it is simple to estimate. Finally *v*), taking into account a number of evaluative criteria (goodness of fit, plausibility of estimated price and income elasticities, information inaccuracy of simulated budget shares), the AID-system performs reasonably well (*e.g.* Barten 1989). Moreover, the theoretical consistency of the AID model implies that the so-called integrability conditions are satisfied (recoverable expenditure and (indirect) utility functions exist), which is a prerequisite for any sensible welfare measurement.

The AID-system is a dual representation of consumer behaviour. Instead of maximizing their utility subject to a budget constraint, consumers are assumed to minimize their expenditures given a certain utility level. The expenditure function associated with the AID-system [*e.g.* Deaton and Muellbauer (1980 and 1983, 75)] is

$$\ln C(p,U) = a(p) + U.b(p) \tag{1}$$

with

$$a(p) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \ln p_i . \ln p_j \quad ;$$

$$b(p) = \beta_0 \prod_{i=1}^{n} p_i^{\beta_i} \tag{2}$$

where $\gamma_{ij} = \gamma_{ji}$. $C(p, U)$ represents expenditure as a function of prices p and conditional on a utility level U. This expenditure function has a so-called Gorman polar form where $a(p)$ can be interpreted as a base level of expenditure (for a 'poor' individual with zero utility) and $b(p)$ represents the marginal costs of utility[1]. Like other models, such as for example the Rotterdam or the Translog model, the AID-system can be thought of as a second order approximation to any arbitrary unknown cost function or as a first-order approximation to the general unknown relation between (shares) w_i, natural log of income $\ln m$, and the logs of the prices $\ln p_j$ (see below).

From this expenditure equation, via Shephard's lemma the expenditure share (demand) equations are derived, which have the following general form [Deaton and Muellbauer (1983, p.75)]:

$$\frac{\partial \ln C}{\partial C} \frac{\partial C}{\partial p_i} \frac{\partial p_i}{\partial \ln p_i} = \frac{1}{C} q_i p_i =$$

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \beta_0 \prod_{k=1}^{n} p_k^{\beta_k} U \tag{3}$$

The γ_{ij} parameters express the change in the budget share i due to a percentage change in the price of good j (with all other factors held constant).

Inversion of the expenditure function yields a closed form expression for the indirect utility function $v(p, m)$[2] or

$$U = v(p, m) = \frac{\ln m - a(p)}{b(p)} \tag{4}$$

which is used to substitute for U in the share equations and allows them to be written in terms of only observables as

[1] It may seem somewhat strange that $\partial^2 C / \partial U^2$ is equal to zero. This restriction is not so strange because it can be interpreted as following from a particular normalization of the relationship between U and m. (Ordinal utility functions may be subjected to any monotonic transformation.)

[2] The indirect utility function has also a Gorman polar form character with the property that uncompensated demands exist which are linear functions of prices and income (Roy's identity) [*cf.* Cornes (1992, p.53)].

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{m}{P}\right) \tag{5}$$

where m represents total expenditure and $\ln P$ denotes a price index defined by:

$$\ln P = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \tag{6}$$

The β_i parameter represents the change in budget share *i* due to a percentage change in real income (with all prices held constant).

The incorporation of the price index makes the system non-linear in the parameters. Although this is no longer an insurmountable problem, in applied analysis the index is often approximated by Stone's price index $\ln P^{Stone} = \sum_{i=1}^{n} w_i \ln p_i$, which allows simpler linear estimation procedures. This approximated version of the AID-model is indicated as LA/AIDS, *i.e.* the linear approximate AID-system [Blanciforti and Green (1983)]. Using this approximation (which is very popular), however, may give rise to some problems, at least when the Stone-index provides a poor approximation to the real index. In a strict theoretical sense it is not known whether the LA/AID-system has the same satisfactory theoretical properties as the AID-system (Green and Alston, 1994, p.442).

The theoretical restrictions associated with utility maximization and expenditure minimisation apply directly to the parameters and are given below.

$$(1) \quad \sum_{i=1} \alpha_i = 1, \qquad \sum_{i=1} \beta_i = 0, \qquad \sum_{i=1} \gamma_{ij} = 0 \quad ; \quad \forall j \tag{7}$$

$$(2) \quad \sum_{j=1} \gamma_{ij} = 0 \quad ; \quad \forall i \tag{8}$$

$$(3) \quad \gamma_{ij} = \gamma_{ji} \quad ; \quad \forall i, j \tag{9}$$

The first restriction is the adding-up condition and will be automatically satisfied. The second restriction guarantees homogeneity of degree zero for the share equations (and homogeneity of degree one in prices of the cost function)[3]. The last restriction is the so-called symmetry restriction[4]. The homogeneity and symmetry restrictions will only be satisfied following a restricted estimation or calibration procedure.

6.2.2 Model calibration

Econometric estimation of the AID-systems is a time and energy consuming process, which is beyond the scope of the current research. In particular if the number of goods distinguished increase, say to more than four, reliable estimation with aggregate time series data becomes a cumbersome task. Because a number of empirical studies on consumer demand were available, an alternative procedure has been followed here. AID models have been calibrated based on this research and base year data on prices and quantities. Within a calibration procedure the parameters of the AID-model are computed given income, price and quantity data from the base year and known information about relevant uncompensated price and income elasticities. Therefore it is necessary to first establish the price and income elasticity-parameter relationships with respect to the AID-system. The general definition of uncompensated price elasticities of demand with respect to the AID-model is[5]

$$\eta_{ij} \quad = \quad \frac{d\ln q_i}{d\ln p_j} \quad = \quad -\delta_{ij} + \frac{d\ln w_i}{d\ln p_j} \tag{10}$$

with δ_{ij} representing the Kronecker delta ($\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ when $i \neq j$). More specifically this implies[6]

[3] The economic interpretation is that consumers react to relative prices (no money illusion).

[4] Symmetry does not express a direct economic logic, but follows directly from cost minimisation (concavity of the cost function) (Deaton and Muelbauer 1983, pp.44-45).

[5] This follows from rewriting $w_i = p_i q_i / m$ as $q_i = w_i m / p_i$. Taking logarithms gives $\ln q_i = \ln w_i + \ln m - \ln p_i$ which yields (10) after logarithmically differentiating.

[6] Follows from $d\ln w_i / d\ln p_j = (d\ln w_i / dw_i).(dw_i / dp_j).(dp_j / d\ln p_j)$.

$$\eta_{ij} = -\delta_{ij} + \frac{1}{w_i}\left\{\gamma_{ij} - \beta_i \frac{d\ln P}{d\ln p_j}\right\} \qquad (11)$$

In order to find the correct expression for the AID-model, the correct expression for the differential of the group price index with respect to the price of good *j* has to be obtained and substituted into (11). This differential is

$$\frac{d\ln P}{d\ln p_j} = \alpha_j + \sum_{k=1}^{n} \gamma_{kj} \ln p_k \qquad (12)$$

Substituting this into (11) yields

$$\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i}\left(\alpha_j + \sum_{k=1}^{n} \gamma_{kj} \ln p_k\right) \qquad (13)$$

Note that the sign of the elasticities depends on the relative magnitudes of γ_{ij}, β_i and $\alpha_j + \sum_k \gamma_{kj} \ln p_k$.[7] With regard to the linkage of the own price elasticity and its budget share, it is expected that as the budget share w_i decreases, the own price elasticity will become more inelastic (Blanciforti and Green 1983, p.5). The derivative of the own price elasticity with respect of its budget share is

$$\frac{\partial \eta_{ii}}{\partial w_i} = -\frac{-\gamma_{ii} + \beta_i\left(\alpha_i + \sum_{k=1}^{n} \gamma_{ik} \ln p_k\right)}{w_i^2} \ \overset{>}{\underset{<}{?}}\ 0 \qquad (14)$$

[7] Using (5) the term between brackets in (13) may be rewritten in terms of the share and real income or more specifically $w_j - \beta_j \ln(m/P)$. This implies that except for the determination of the Stone price index, no prices are needed to calibrate an LA-AID-model, but that information about the Marshallian price and income elasticities is sufficient.

Although this expression is expected to be less than zero, this cannot be strictly guaranteed a priori[8].

The general expression for the income elasticities with respect to the AID-model is[9]

$$\eta_{i,m} = \frac{d\ln q_i}{d\ln m} = 1 + \frac{d\ln w_i}{d\ln m} = 1 + \frac{1}{w_i}\left(\frac{dw_i}{d\ln m}\right) \tag{15}$$

Since $dw_i/d\ln m = \beta_i$, the correct income elasticity relationship is

$$\eta_{i,m} = 1 + \frac{\beta_i}{w_i} \tag{16}$$

Within the AID-model there is no a-priori restriction on β_i, which may be either positive or negative. A positive β_i mathematically implies that $w_i\eta_{i,m} > w_i$, which requires the income elasticity to be higher than 1. In other words, when the marginal propensity to consume $w_i\eta_{i,m}$ is greater then the average propensity to consume w_i, the income elasticity is greater than 1[10]. A positive β_i indicates a luxury good while a negative β_i indicates a necessity. The AID-model thus allow for the

[8] Alternatively (14) may be simplified as

$$\frac{\partial\eta_{ii}}{\partial w_i} = -\frac{\gamma_{ii} + \beta_i^2\ln(m/P)}{w_i^2}$$

The sign of (14) can be directly translated in terms of $\partial\eta_{ii}/\partial q_i$ or $\partial\eta_{ii}/\partial p_i$ since $\partial w_i/\partial q_i = p_i/C(1-w_i)$ and $\partial w_i/\partial q_i = q_i/C(1-w_i)$ which are both positive. Moreover,

$$\frac{\partial\eta_{ii}}{\partial q_i} = \frac{\partial\eta_{ii}}{\partial w_i}\frac{\partial w_i}{\partial q_i} \quad \text{and} \quad \frac{\partial\eta_{ii}}{\partial p_i} = \frac{\partial\eta_{ii}}{\partial w_i}\frac{\partial w_i}{\partial p_i}.$$

[9] Again using the fact that $\ln q_i = \ln w_i + \ln m - \ln p_i$ and $d\ln w_i/d\ln m = (d\ln w_i/dw_i)(dw_i/d\ln m)$.

[10] Note that the marginal propensities to consume are variable or non-constant. This in contrast with the Rotterdam-model where they are constant [Barten (1989, p.446)].

expenditure elasticity of necessities to decrease with respect to a decrease in the budget share ($\beta_i < 0$).

The calibration procedure can now be summarized in the following four steps:

1) The first step is to determine the *n* income parameters β_i.
2) The second step is the determination of the n^2 γ_{ij} price parameters.
3) Given the gammas and betas and using the known shares, in step 3, the *n* constants of the share equations are computed.
4) Step 4 is the determination of the β_0 parameter of the cost function.

For the determination of the income parameters, equation (19) can be used, or

$$\beta_i = w_i(\eta_{i,m} - 1) \tag{17}$$

Given the (known) income elasticities, the equations can be solved for the β_i parameters, of which only *n-1* are independent. This can be easily seen from the so-called Engel-aggregation condition[11] according to which

$$\sum_{k=1}^{n} w_k \eta_{k,m} = 1, \tag{18}$$

For the calibration of the γ_{ij} parameters (step 2) equation (13) is used, which after some manipulation can be written as[12]

$$\gamma_{ij} = w_i(\eta_{ij} + \delta_{ij}) + \beta_i(w_j - \beta_j \ln(m/P)) \tag{19}$$

As with the income elasticities, there are still a number of dependencies within this set of calibration equations. Firstly, there are the symmetry conditions (guaranteeing

[11] The Engel-aggregation condition follows directly from differentiating the budget constraint with respect to *m*. It also holds if an incomplete model is rewritten as an artificial complete one. If a real incomplete demand model is calibrated, the adding-up property does not hold at the observed goods level. Direct information on all the income elasticities of the goods concerned will then be usually required.

[12] *Cf.* also footnote 12. Substituting $(\alpha_j - \sum_k \gamma_{jk} \ln p_k)$ by $(w_j - \beta_j \ln(m/P))$ allows us to get rid of the α_j's in (13).

integrability) which, when formulated in the elasticity version of the Slutsky equation, state that [derived from rewriting Deaton and Muellbauer (1983, 45) equation (4.6)]

$$[\eta_{ij} + \eta_{i,m} w_j] w_i \quad = \quad [\eta_{ji} + \eta_{j,m} w_i] w_j \tag{20}$$

Exploiting these symmetry conditions[13] reduces the n^2 free price parameters to $1/2n(n+1)$ independent parameters. Furthermore there is a homogeneity restriction, which can be expressed either as (*cf.* Deaton and Muellbauer 1983, p.16),

$$\sum_{k=1}^{n} w_k \eta_{ki} + w_i = 0 \quad \text{or} \quad \sum_{k=1}^{n} \eta_{ik} + \eta_{i,m} = 0 \tag{21}$$

This further reduces the number of independent elements sufficient for completely determining the $[\gamma_{ij}]$-matrix to $1/2n(n-1)$.

Given knowledge of the price and income parameters and the base year data, the constants (α_i) (Step 3) can be determined from

$$\alpha_i \quad = \quad w_i \quad - \quad \sum_{j=1}^{n} \gamma_{ij} \ln p_j \quad + \quad \beta_i \ln\left(\frac{m}{P}\right) \tag{21}$$

Step 3 concerns the determination of the constant for the price index (*cf.* α_0 in equation 6). This is done by assuming $\ln P$ equal to $\ln P^{Stone}$ for the base year. So the constant is given by

$$\alpha_0 \quad = \quad \ln P^{Stone} \quad - \quad \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \tag{23}$$

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[13] For calibration a more useful form of (30) is

$$\eta_{ji} \quad = \quad w_i \left[\frac{\eta_{ij}}{w_j} + (\eta_{i,m} - \eta_{j,m}) \right].$$

Finally, Step 4 is the determination of the β_0 parameter of the expenditure function. For this parameter, the AIDS expenditure function is exploited, *i.e.*

$$\beta_0 = \frac{(\ln C - \ln P)}{\prod_{k=1}^{n} p_k^{\beta_k}.U} \tag{24}$$

with U set equal to an arbitrary value expressing the initial utility level. Thus the calibration of the AID-system is completed.

As a final remark it is noted that when a complete set of Marshallian price and cross price, and income elasticities is available, the model is overdetermined. In order to guarantee that the theoretical dependencies hold, only a subset of the elasticities can be used. If the base year price and quantity data would coincide with the data (sample means) from the empirical studies from which the elasticities were derived, then it does not matter which subset of elasticities would be selected. In general this is not the case, however, and the selection introduces some arbitrariness, since the final parameters are not insensitive to the elasticity-choice. If the base year is rather close to the sample data from which the elasticities are estimated, and/or price, quantity (and expenditure shares) are rather stable over time, the arbitrariness may be of negligible order, but there is no way to really solve this issue. If compensated price elasticities were available (or recoverable), there would of course be no problem, since the latter satisfy the symmetry conditions.

6.3 Data and calibration results

In order to calibrate both the consumer demand and food industry models, a base year data set has been constructed for 1990 and information on elasticities etc. has been gathered from previous research studies. The final AID demand system distinguishes between the following ten (aggregated) products: *1)* bread and cereals, *2)* oils and fats[14], *3)* potatoes, *4)* sugar, the three meat categories *5)* beef and veal,

[14] On fats-basis; includes fats derived from oilseeds and animal fats (lard, tallow and grease) but excludes fish oil and butter-fat.

6) pork and *7)* poultry, and *8)* dairy (raw milk), *9)* eggs and finally *10)* all other foods. The latter category *(10)* is used to create an artificial complete food demand model, which is, however, still incomplete from an overall-perspective, since non-food expenditures are ignored. It consists of food products like fish, other meats (mutton), olive oil, vegetables and fruits, and some drinks like coffee and tea. It is in particular with respect to these latter products that the composite commodity assumption is somewhat dissatisfying since it restricts the specific substitution possibilities to a general average.

With respect to the consumer demand system, fortunately the work of Michalek and Keyzer (1990), who have built the human demand component of the ECAM-model, could be relied upon. From this model, which was estimated for 9 EC countries and covered the period 1970-85, the information for a large number of the elasticities was derived. Although the our AID model basically follows the ECAM-model, it has a different structure. The ECAM-model relies on a two-stage budgeting structure, which is modelled by a combined AID/LES-model, whereas we choose for a one-stage AID model-structure[15]. Moreover, the meat and milk & egg groups of Michalek and Keyzer (1990) were further disaggregated for this study. Elasticities for the subgroups meat and dairy (LES-models) were computed from unpublished information, which was kindly provided by Michalek[16]. Moreover, the definition of products has been adjusted to our requirements[17]. The category 'all other goods' has a miscellaneous character. With the exception of the income elasticities, little information about the cross price elasticities of this group with food products is available. In this case, the parameters have been obtained on the basis of plausibility and theoretical consistency. For Greece and Spain fortunately other empirical studies are available (*e.g.* Mergos and Donatos, 1989, and Molina, 1994). These latter studies, however, are insufficient to recapitulate the complete elasticity matrix. Where required, in the same way as before, additional information

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[15] Michalek and Keyzer looked for a model which could be empirically estimated. Reliable results can only be obtained if the number of goods in the AID model is limited (4-6). Incorporating more goods usually requires the imposition of more restrictions on the model (2-stage budgeting, Linear expenditure systems). When one wants to calibrate a model there is no reason not to choose a one stage AID-model, which incorporates all goods.

[16] The derivation of a one-stage elasticity structure from a two-stage budgetting AID-LES-model follows Laurila (1994).

[17] See the end of this section for more discussion on this issue.

has been added. For Portugal no information is available and an elasticity matrix has been created on the basis of the elasticity structures from Spain and Greece, (Gil *et al*, 1995, p.394 provides some evidence for assuming similarity between food consumption patterns between those countries).

As noted in Section 2 (*cf.* equations 18 and 21), there are a number of dependencies between income and price elasticities. So at least one income elasticity and a larger number of price elasticities have to be determined endogenously. As noted at the end of the previous subsection, this introduces some arbitraryness into the calibration procedure. With respect to the calibrated demand models for all countries the following general remarks can be made. The (total) income elasticities for food products are all smaller than 1[18]. All income elasticities are positive, implying that there are no 'inferior goods' among the individual foodstuffs. Even the basic foodstuffs like bread and cereals and potatoes show significantly positive income elasticities although they are sometimes classified as inferior goods in other studies (Tracy 1993, p.92 (UK) and Mergos and Donatos, 1989, p.183 (Greece)). With the elasticities lying between zero and one they can be characterized as necessities (implying negative β_i's). In 8 of the 11 cases the aggregate compound good 'all other goods' is income elastic (luxury good). Although in general the income elasticities are rather low, the effect of income changes on food consumption should not be neglected. As table 1 showed there is a positive expenditure increase for most countries. In fact income growth still plays an important (dominant) role in explaining the changes in consumption. Looking at price responses, it appeares that relatively low per capita GDP-countries have a tendency to show relatively high own price elasticities.

Looking at the Marshallian elasticity matrix, the (uncompensated) cross price elasticities are in all cases small and often negative. The conclusion is that cross price effects are generally weak. With regard to the 'substitute' or 'compleme-ntary'-character of the individual food products, the Marshallian cross price-effects give only limited information. Although they suggest that a lot of individual food

[18] The expenditure elasticities for individual commodities (defined with respect to total expenditure on food excluding drinks and beverages) are usually inelastic with respect to sugar, cereals & bread, oils & fats, potatoes and eggs. Demand for meat and dairy products shows the highest expenditure elasticities, being elastic in 20 of the 44 cases.

products have a complementarity character, this is not true. In the underlying Hicksian or compensated cross-price elasticities or substitution matrices, positive values clearly dominate, which indicates that in general net substitution prevails.

6.4 Modelling the intermediate 'food industry'

6.4.1 The one-output/two inputs-model

This section focuses on the link between the AID consumer demand system and the derived demand for primary agricultural products. The case we want to analyse is a classical example of derived demand behaviour. This topic was already analysed by Marshall (*cf* Friedman, 1976 for a simple discussion of Marshall's model), and a number of others, among which Muth (1964), Gardner (1975), Heien (1980) and Wohlgenant (1989). Basically, this approach considers the farm-retail linkage to be composed of a single sector, which is assumed to be characterized by perfect competition. From Holloway (1991) it can be concluded that this is not a bad working hypothesis since his study, which allowed for imperfect competition, did not lead to a rejection of the perfect competition hypothesis. However, a number of qualifications relate to his result, which stimulated others to study imperfect competition regimes (see among others McCorriston et al 1997; 1995; McCorriston 1996; Perlof 1992, and Schroeter and Azzam 1991). The conceptual insight from these studies puts additional emphasizis on the need to take the price transmission elasticity between farm prices and consumer prices into account. The empirical basis of this approach is still weak, although casual observation is in favour of imperfect competition. Although a theoretical model is developed that allows for imperfect competition (except in one conceptional scenario), limited attention is paid to this phenomenon.

Following the more standard literature, the basic framework chosen to approximate the 'food industry' (defined here in a very broad and rough way including food processing and food retailing) is the one product (food), two input (agricultural input, and marketing and processing input)-model. With respect to the nature of the technology of the processing sector, 'variable proportions' are allowed, i.e. there is a potential for substituting other non-agricultural inputs for the agricultural input. As a number of studies have shown, even small values of the elasticities of substitution between the agricultural and non-agricultural inputs may considerably influence the distributional impacts of exogeneous shocks to the food chain (see Alston and Scobie 1983, Mullen, Wohlgenant and Farris 1988, and Lemieux en Wohlgenant 1989). Furthermore, Wohlgenant's (1989) empirical study led to a firm rejection of the 'fixed proportions' (no substitution-hypothesis) assumption. More specifically, it is assumed that food is produced with a two inputs CES technology, implying constant substitution elasticity between the agricultural and non-agricultural inputs. Assume that the food product q_i is produced according to the CES technology

$$q_i = f_i(\cdot) = A_i\left(a_{i1}x_1^{-\rho_i} + a_{i2}x_{i2}^{-\rho_i}\right)^{-\frac{1}{\rho_i}} \tag{25}$$

where x_{i1} represents the agricultural input associated with food product i and x_{i2} represents the composite non-agricultural input. Moreover, A_i represents the efficiency parameter, and a_{i1} and a_{i2} represent the two distribution parameters. Finally, ρ is a parameter related to the possibilities for substitution. Since it is assumed that the food processing industry is characterized by a constant returns to scale technology, generally speaking, the profit maximization problem is ill-defined. Fortunately, the dual cost minimisation problem can be solved as

$$\begin{aligned} C_i(w_{i1}, w_{i2}, q_i) &= \text{Min}\{w_{i1}x_{i1} + w_{i2}x_{i2} \quad \text{s.t.} \quad q_i = f_i(\cdot)\} \\ &= \frac{q_i}{A_i}\left(a_{i1}^{\sigma_i}w_{i1}^{1-\sigma_i} + a_{i2}^{\sigma_i}w_{i2}^{1-\sigma_i}\right)^{\frac{1}{1-\sigma_i}}; \qquad \sigma_i = \frac{1}{\rho_i + 1} \end{aligned} \tag{26}$$

The conditional inputs demands can now be derived by (differentiating $C_i(.)$ with respect to input prices (Shephard's lemma)) as

$$x_{i1}(w_{i1},w_{i2},q)=\frac{q_i}{A_i}\left(\frac{a_{i1}}{w_{i1}}\right)^{\sigma_i}\left(a_{i1}^{\sigma_i}w_{i1}^{1-\sigma_i}+a_{i2_i}^{\sigma}w_{i2}^{1-\sigma_i}\right)^{\frac{\sigma_i}{1-\sigma_i}} \tag{27}$$

$$x_{i2}(w_{i1},w_{i2},q)=\frac{q_i}{A_i}\left(\frac{a_{i2}}{w_{i2}}\right)^{\sigma_i}\left(a_{i1}^{\sigma_i}w_{i1}^{1-\sigma_i}+a_{i2_i}^{\sigma}w_{i2}^{1-\sigma_i}\right)^{\frac{\sigma_i}{1-\sigma_i}} \tag{28}$$

Returning to the profit maximization-context, in the case of constant returns to scale two points deserve attention. Firstly, if the profit function has a maximum, this maximum is necessarily zero. The existence of a positive input bundle (x_{i1}, x_{i2}) which maximizes profits is equivalent to non-contradicting marginal productivity equations. This latter special case is characterized by the so-called price function[19]. This price function $P_i(w_{i1}, w_{i2})$ relates input prices and output price to each other and is given by the solution to the well-known marginal cost pricing condition

$$p_i=\frac{\partial C_i(.)}{\partial q_i} \tag{29}$$

which for this case yields the following price function

$$P_i(w_{i1},w_{i2})=\frac{1}{A_i}\left(a_{i1}^{\sigma_i}w_{i1}^{1-\sigma_i}+a_{i2}^{\sigma_i}w_{i2}^{1-\sigma_i}\right)^{\frac{1}{1-\sigma_i}} \tag{30}$$

So a positive input/output bundle maximizing profits only exists if the price function holds. This existence condition uniquely determines the relation between prices at consumer and farm level. It is rather easy to reconcile that the price spread $(p_i - x_{i1})$

[19] This price equation gets little attention in micro-economic textbooks, which contrasts with the importance of constant return to scale-technologies both in theory and practice (computable GE-models). For a detailed discussion with formal proofs see Van Mouche (forthcoming).

depends on, among others, the substitution elasticity σ_i, the distribution parameters α_j, the efficiency parameter A_i, and on the input prices. $P_i(.)$ can be used to rewrite the conditional demand functions as

$$x_{i1}(w_{i1}, w_{i2}, q_i) = q_i a_{i1}^{\sigma_i}\left(\frac{p_i}{w_{i1}}\right)^{\sigma_i} \tag{31}$$

$$x_{i2}(w_{i1}, w_{i2}, q_i) = q_i a_{i1}^{\sigma_i}\left(\frac{p_i}{w_{i2}}\right)^{\sigma_i} \tag{32}$$

As is known with constant returns to scale, there is no sub-division problem. Expenditures on agricultural inputs and non-agricultural inputs add up to total costs, which in turn equal total revenues or the value of outputs.

Following Holloway (1991) and McCorriston et al (1997) the assumption of no market power which is implicit in (29) can be relaxed. The first order condition for profit maximization of the 'food industry' is then modified to

$$p_i\left(1 + \frac{\Theta_i}{\eta_i}\right) = \frac{\partial C_i(.)}{\partial q_i} \tag{33}$$

where η_i is the absolute value of the (own) price elasticity of consumer demand, and Θ_i is the market power-parameter[20]. The marginal costs are equal to price relationship (30). For the standard case analysed in this study Θ_i equals zero which corresponds to the competitive behaviour of the food industry (equation 33 then reduces to 29). Θ_i equal to zero can also be interpreted as implying that the firms in the food industry exhibit Bertrand-Nash behaviour (competitive bidding). Θ_i has an upper limit of unity when firms operate collusively (cartel and/or monopoly). Intermediate values of Θ_i reflect Cournot-Nash firm behaviour. Thus, $\Theta_i \in [0, 1]$

[20] See Holloway (1991, p.980) for a conjectural elasticity-interpretation of Θ_i. Alternatively Θ_i can be interpreted as the average market share of the (assumed identical) firms producing food i (see for example Varian, 1990, pp.452-453). Since the consumer demand elasticities for food are rather low (inelastic), monopoly-behaviour is in general not consistent (would imply negative marginal revenues). However, some kind of oligopoly behaviour might still be possible, since increasing the number of firms lowers the elasticity-constraint (Varian, 1990, p.398). In order to calibrate a reliable imperfect competition model, one should have information about either market shares or mark-up factors.

provides a convenient index of competition, encompassing a broad spectrum of behavioural strategies of firms in the food industry, and offers an alternative to the more formal conjectural variations approach (*cf.* Holloway, 1991, p.980).

6.4.2 Model calibration

As already indicated in the introduction, it is difficult to obtain product specific information on margin behaviour and product components. As a consequence, the linkage of EU final food consumption to the derived demand for agricultural products is difficult, in particular for highly processed products. Using various sources (in particular supply balances), a base year table has been constructed with agricultural input and final good output for the food industry. Implicitly it is assumed that consumers buy from the (artificially constructed) home-based food industry, while, if relevant, the industry imports primary inputs. As empirical analysis on derived elasticities for the US shows, farm level elasticities might be rather close to consumer level elasticities, or sometimes even more elastic (*cf.* Wohlgenant (1989, p.250), in particular his Tables 3 and 5). However, if the elasticity of substitution is zero ($\sigma_i = 0$) then farm level demand is always less elastic than final consumer level demand. Most studies analysing price spreads use the so-called fixed-proportions-model, which comes down to zero substitution elasticities or exploiting a Leontief production technology (Heien, 1980; Lyon and Thompson, 1993). There is evidence, however, that the substitution elasticity between agricultural and non-agricultural inputs is in general non-zero (Wohlgenant, 1989; Kinnucan and Forker, 1993). The results found in the latter studies, although based on non-European data, were used to determine the range of the substitution elasticities σ used in the current model. The values used ultimately are provided in the right hand side column of Table 6.4, which also shows the base year farm shares in the final product value.

Calibration of the 'food industry' models is done as follows. Firstly, using various sources (in particular supply balances), a base year table has been constructed with agricultural input and final food output for the food industry. As already indicated in the introduction, it is difficult to obtain product specific information on margin behaviour and product components. As a consequence, the linkage of EU final food consumption to the derived demand for agricultural products is a difficult and complicated matter, in particular for highly processed products. Given the

Table 6.4 Some indicators (farmer's share and substitution elasticity) on the 'food industry'

	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.	σ
Sugar	0.128	0.118	0.136	0.112	0.055	0.071	0.113	0.195	0.097	0.110	0.115	0.10
Crls&bread	0.182	0.219	0.113	0.107	0.164	0.130	0.209	0.203	0.245	0.210	0.508	0.25
Oils&fats	0.284	0.133	0.129	0.101	0.146	0.098	0.111	0.268	0.295	0.160	0.253	0.50
Potatoes	0.455	0.555	0.438	0.519	0.536	0.183	0.326	0.339	0.673	1.099	0.609	0.15
Beef&veal	0.544	0.182	0.293	0.210	0.209	0.352	0.371	0.396	0.280	0.164	0.443	0.70
Pork	0.467	0.342	0.381	0.168	0.388	0.326	0.374	0.616	0.478	0.523	0.253	0.35
Poultry *)	0.616	0.347	0.260	0.229	0.283	0.304	0.944	0.699	0.561	0.504	0.719	0.25
Dairy	0.539	0.396	0.474	0.449	0.406	0.599	0.604	0.691	0.533	0.234	0.411	0.80
Eggs **)	0.406	0.436	0.622	0.371	0.329	0.499	0.432	0.589	0.647	0.676	0.757	0.10

*) Excluding other birds; **) Total domestic use.

Source: Own computations and guesstimates based on Wohlgenant (1989).

available information on quantities and prices at the farm level and the output value of the food industry, cost shares of agricultural input and non-agricultural input in total costs (equal to total revenues if no mark-up pricing is assumed) have been derived. Measuring all quantities in farm equivalents allowes us to further split up consumer expenditure and expenditure on the non-agricultural input into prices and quantities. (See also Table 11A-3 for more details). Moreover, when working with farm-equivalent quantities, the distribution parameters could be directly obtained because they are then equal to the corresponding cost shares. Given these assumptions it can be easily verified by looking at the production function that the efficiency parameters are equal to 1.

6.5 Concluding remarks

In this chapter food consumption patterns has been briefly described. Moreover the main characteristics of the EU food industry have been outlined. Final consumer demand models were calibrated. The results indicate that although the various food groups are substitutes, cross price reaction are generally weak. Variations in (real) income (rather than in prices) is the main economic determinant of long-run changes in per capita food consumption. For total food consumption, the population growth factor also matters, but this growth has been low. Somewhat artificially constructed intermediate 'food industry' models have been derived, which account for substitution between agricultural and non agricultural inputs in food processing. Although not without complications, the models have also been calibrated.

Given the nice theoretical charateristics of the AID-model, Hicksian consumer welfare measures can be directly formulated in terms of the known expenditure function. Following the assumptions of constant returns to scale for food processing technology and competitive markets, the profits in the intermediate food industry will be zero, and no quasi-rent changes have to be considered. A way has also been outlined to relax these assumptions (allowing for imperfect competition), but given the lack of data it is impossible to achieve a realistic operational model.

Chapter 7

THE ARABLE SECTOR

7.1 Introduction

In this chapter, models for the EU arable sector are developed, estimated and discussed. Section 1 provides some background information (sector characteristics, evolution of production, and policy regime). Producer behavior will be modelled by the (dual) profit function approach. The arable sector is assumed to be restricted with respect to one of its outputs, *i.e.* sugar beet production. Section 2 discusses the restricted output approach, which will not only be used with respect to this sector, but also with respect to the cattle/dairy sector (in next chapter). Section 3 provides an overview of the prior information used in the mixed estimation procedure. The estimation results are presented and discussed in Section 4. Section 5 closes with some concluding remarks.

From the perspective of the GOLF-sector, cereals and oilseeds are the most important products of the arable sector and so should be included in the study. These latter products (or derived by-products) are important ingredients of compound feeds used by the livestock sectors (about 60% of cereals is used as animal feed). Also potatoes and sugarbeets may be partly used in animal feeds, although they are less important. The same holds with respect to crops like peas and beans (protein source), whose main use is as animal feed, but which are ignored here. The crops included in the study are the mowing crops cereals and oilseeds, and the root crops sugar beets and potatoes. Since the early 1970s the production of all these crops has increased considerably. For the EU-10, cereals output rose from 70 million tonnes in 1960 to 124 million tonnes in 1983, 151 million tonnes in 1984, and then fell to around 130 to 140 million tonnes between 1985 and 1988. Over the period 1973-1990 the average annual rate of increase increase of cereals output was 1.7%. A more rapid growth was shown by oilseeds, which over the same period grew by about 14% per annum. For the other crops the comparative growth rates were 3.3% (white sugar) and 0.9% (potatoes). In 1990 the production of cereals in the EU-12 was 158.5 million tonnes, and the production of white sugar, potatoes and oilseeds respectively 15.9, 45.6 and 12.6 million tonnes. The total value of these crops in 1990 was 36.4 million Ecu, and accounted for 18% of the total value of agricultural output (Commission, 1991, various tables).

The EU arable sector is supported by common market organisations (CMOs) for various products with the following general structure. The standard model is the CMO for cereals which supports farmers mainly through frontier protection and price support. Target prices are established as a basis for determining both intervention prices and threshold prices at the common frontier. Variable import levies ensure that imports do not enter into the EU at below threshold level prices and export refunds are granted to export domestic surpluses to the world market at a competitive price. Surplus production in excess of domestic demand usually causes prices of cereals to stay close to intervention price levels. In order to curb the growing budget outlays, guarantee thresholds were introduced in the early 1980s (co-responsibility levy if production exceeded the guaranteed quantity), while in 1988 'stabilisers' were put in place. They result in an effective reduction of prices and some voluntary set-aside. The CMO applying to sugar includes the same basic element as cereals, but also a production quota system is added. Each producer is entitled to the full guaranteed price only for a basic so-called A-quota, while for an additional B-quota a levy is applied, which can be up to about 40%. Any sugar produced in addition, labelled C-sugar, is not eligible for support. The CMO with respect to oilseeds is basically a deficiency payment policy. Imports are subjected to only small tariffs, while domestic growers were ensured a return comparable to that of cereals by paying processing subsidies on home-grown seeds. For potatoes no CMO exists, although it indirectly benefits from the other CMOs. Under the recent "MacSharry" reforms (agreed on by the Council in 1992) the CMOs have been significantly modified. Direct compensatory payments (on a per hectare basis) and (obligatory) set-aside have gained a prominent role. Since the period used for model estimation is 1973-1990, their effects are beyond the scope of this chapter.

7.2 Economic model

In order to deal with a restricted output, starting from the general profit function $\Pi(p,w,z,t) \equiv \max(py - wx \mid (y,x) \in T(z,t)$, which is the solution to the profit maximization problem, given the (quasi-fixed input and technology) restricted production possibility set $T(z,t)$, the output vector and the corresponding price vector are partitioned as $y = (y_0, y_1)'$ and $p = (p_0, p_1)'$ with y_1 and p_1 representing quantity and corresponding price vectors of the n_1 freely adjustable outputs y_i. The restricted profit function can now be written as

$$\Pi(p_0, p_1, w, z, t) \equiv \max\{p_0 y_0 + \pi(p_1, w, y_0, z, t)\} \tag{1}$$

with the output-restricted profit function $\pi(p_1, w, y_0, z, t)$ defined as

$$\pi(p_1, w, y_0, z, t) \equiv \max\{p_1 y_1 - wx \mid (y_1, x) \in T(y_0, z, t)\} \tag{2}$$

with $T(y_0, z, t)$ the conditional production possibilities set. $\pi(p_1, w, y_0, z, t)$ satisfies the regular properties of restricted profit functions[1]. The output-restricted profit function is non-increasing in the restricted output, and for obvious reasons no longer necessary satisfies the non-negativity property (in contrast with for example $\Pi(p,w,z,t)$ and $\Pi(p_0, p_1, w, z, t)$).

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1 See Chambers, 1988, p.124 for a discussion of these regularity properties.

$\Pi(p_0, p_1, w, z, t)$ represents the total revenue from output y_0 and the sum of returns for all other outputs (y_1) over variable costs. Note that the supply of output y_0 is still optimal. If the maximum output of y_0 is effectively restricted, the profit function becomes

$$\Pi(p_0, p_1, w, y_0, z, t) = p_0 y_0 + \pi(p_1, w, y_0, z, t) \tag{3}$$

with $\pi(p_1, w, y_0, z, t)$ an output-restricted profit function identical to (2).

The output-restricted profit function $\pi(p_1, w, y_0, z, t)$ can be used to provide information whether or not the output of y_0 is effectively restricted. This can be seen as follows. Applying the derivative property of profit functions (Hotelling's lemma) output supply and input demand relationships can be derived as (Chambers 1988, p.126 and p. 146)

$$\frac{\partial \pi(p_1, w, y_0, z, t)}{\partial p_i} = y_i(p_1, w, y_0, z, t) \quad \text{and}$$

$$\frac{\partial \pi(p_1, w, y_0, z, t)}{\partial w_j} = -x_j(p_1, w, y_0, z, t) \tag{4}$$

with i and j denoting the i-th element of the non-restricted output price vector and the j-th element of the variable input price vector. These variable output supply and variable input demand relationships are conditional on the level of the constrained output y_0 (and of course on the level of quasi-fixed inputs). The demand for the quasi-fixed inputs and the supply of the restricted output are known exogenous variables.

If the supply of y_0 is not restricted (for example because a quota is in place but is not binding) the behavioural relationships should be obtained by applying Hotelling's lemma to $\Pi(p_0, p_1, w, z, t)$ (*cf.* equation (2)). This gives the following conditions for the variable output supply relationships

$$\frac{\partial\Pi(p_0,p_1,w,z,t)}{\partial p_i} = \left[p_0\frac{\partial y_0}{\partial p_i}+\frac{\partial\pi(p_1,w,y_0,z,t)}{\partial y_0}\frac{\partial y_0}{\partial p_i}\right] + \frac{\partial\pi(p_1,w,y_0,z,t)}{\partial p_i} \tag{5}$$

which differ from (4) by the term between the square brackets. However, given that the supply of y_0 is now not restricted but can be freely (*i.e.* optimally) chosen, invoking the envelope theorem, it can be shown that the term between square brackets vanishes. For the inputs the same reasoning could be followed, and the conditions of (5) and reduce to those of (4).

If the output y_0 is not effectivily restricted, it is possible to derive its optimal magnitude using what is known from the estimated profit function. So the first order condition of non-output-constrained profit maximization should be exploited, which is

$$\frac{\partial\Pi(p_0,p_1,w,z,t)}{\partial y_0} = p_0 + \frac{\partial\pi(p_1,w,y_0,z,t)}{\partial y_0} \equiv 0 \tag{6}$$

As such this condition may look not very informative. In order to gain more insight, the output-restricted profit function can be rewritten as

$$\pi(p_1,w,y_0,z,t) \equiv \max\{p_1y_1 - C(y_1,y_0,w,z,t)\} \tag{7}$$

with *C(.)* representing a (restricted) cost function. From this it directly follows that

$$\frac{\partial\pi(p_1,w,y_0,z,t)}{\partial y_0} = \left[\sum_{i=1}^{n_1} p_i\frac{\partial y_i}{\partial y_0} - \sum_{i=1}^{n_1}\frac{\partial C}{\partial y_i}\frac{\partial y_i}{\partial y_0}\right] - \frac{\partial C}{\partial y_0} = -\frac{\partial C}{\partial y_0} \tag{8}$$

with the term between square brackets vanishing and where the latter term represents the marginal costs of y_0 evaluated at the optimal level for all other outputs. Moreover p_0 in (7) represents marginal revenue, which should equal marginal costs in order to guarantee that profits are maximized. From this term the optimal supply of y_0 as a function of $p_0, p_1, w, z,$ and t can be derived.

Beside the intuitive interpretation of marginal costs equalling marginal revenues, the derivative of the output-restricted profit function with respect to y_0 can be interpreted as a shadow value or virtual price μ, which reflects the impact of the imposed constraint, *i.e.*,

$$\mu(p_1, w, y_0, z, t) = -\frac{\partial \pi(p_0, w, y_0, z, t)}{\partial y_0} \tag{9}$$

The shadow price $\mu(p_1, w, y_0, z, t)$ should be equal to zero by definition if the constraint on output y_0 is non-binding. Note that in the case of binding constraints, $\mu(p_1, w, y_0, z)$ is no longer equal to p_0 (see Figure 7.1, $\bar{y}_0$). If p_0 is higher than the shadow price, producers receive windfall-transfers (see Figure 7.1 shaded area) which, since they do not influence the producer's optimization problem, are comparable to direct income transfers [*cf.* Guyomard and Mahé (1994, pp.10-11)].

As shown by Fulginiti and Perrin (1993, pp.99-100), the virtual price line coincides with the output supply function if the restricted profit function is evaluated at the actual supply price. Moreover, the restricted supply follows from the unrestricted profit function, but is now evaluated at the virtual price. Figure 7.1 illustrates the shadow price function, which may be interpreted as an aggregate supply relationship based on a theoretical representative-firm assumption. However, as Alston (1981), Burell (1989) and others have argued, when a quota is imperfectly transferrable the aggregate supply function will shift, with the shift depending on the quota distribution over firms. As far as limits exist on the transferrability of production rights, the shadow price relationship is not equivalent to the pre-quota supply but looks rather like the broken line OABC (see Figure 7.1). In general, without using a real micro approach, it is difficult to obtain consistent econometric estimates of supply functions under quota regimes (*cf.* Bureau et all, 1996, 25). Rent measures associated with changes in quota or rationed output price changes may

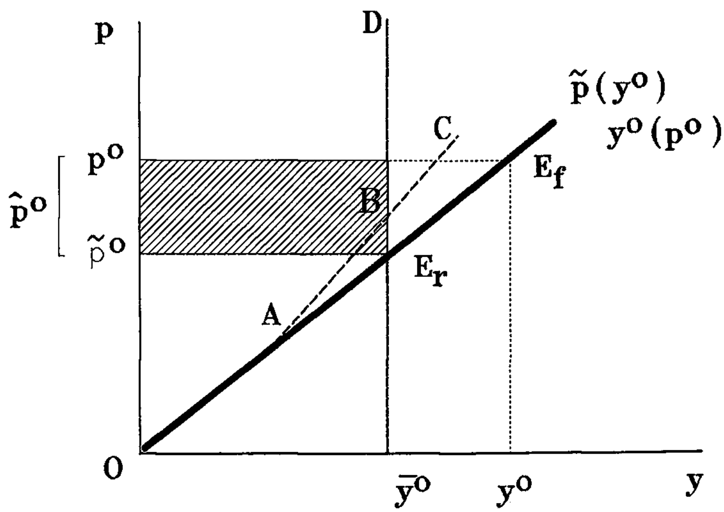

Figure 7.1 Producer supply response

therefore overestimate the real effects if extrapolated pre-quota supply is used rather than the real conditional shadow price relationship (conditioned on limited quota tradability).

Choosing a normalized quadratic restricted output profit function, and considering four outputs, *i.e.* cereals, oilseeds, potatoes, and (restricted) sugar beets, and one variable input, the model to estimate is

$$\frac{\Pi}{w} = \alpha_0 + \sum_{i=1}^{3} \alpha_i \left(\frac{p_i}{w}\right) + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} \alpha_{ij}\left(\frac{p_i}{w}\right)\left(\frac{p_j}{w}\right) +$$

$$\sum_{k=1}^{3} \beta_k z_k + \frac{1}{2}\sum_{k=1}^{3}\sum_{l=1}^{3} \beta_{kl} z_k z_l + \sum_{i=1}^{3}\sum_{k=1}^{3} \gamma_{ik}\left(\frac{p_i}{w}\right) z_k \qquad (10)$$

$$y_1 = \alpha_1 + \alpha_{11}\left(\frac{p_1}{w}\right) + \alpha_{12}\left(\frac{p_2}{w}\right) + \alpha_{13}\left(\frac{p_3}{w}\right) + \gamma_{11}z_1 + \gamma_{12}z_2 + \gamma_{13}z_3 \quad (11)$$

$$y_2 = \alpha_2 + \alpha_{21}\left(\frac{p_1}{w}\right) + \alpha_{22}\left(\frac{p_2}{w}\right) + \alpha_{23}\left(\frac{p_3}{w}\right) + \gamma_{21}z_1 + \gamma_{22}z_2 + \gamma_{23}z_3 \quad (12)$$

$$y_3 = \alpha_1 + \alpha_{31}\left(\frac{p_1}{w}\right) + \alpha_{32}\left(\frac{p_2}{w}\right) + \alpha_{33}\left(\frac{p_3}{w}\right) + \gamma_{31}z_1 + \gamma_{32}z_2 + \gamma_{33}z_3 \quad (13)$$

with p_1 the price for cereals, p_2 the price for potatoes, and p_3 the price of oilseeds[2]. The restricted input sugarbeets is represented by $z_1(=y_0)$, while land and technology are represented by z_2 and $z_3(=t)$ respectively. From a statistical point of view, the system can be interpreted as a set of seemingly unrelated regressions. Estimation therefore requires an appropriate (GLS/SUR) systems estimator. An aggregate variable input (fertilizers, plant protection products) is used, and its price w is used to normalize the model. Unfortunately, data with respect to the input of capital and effective labour units are not available. This implies that some mis-specification has to be accepted, which may introduce some bias in the estimated coefficients.

7.3 Prior information

After adding disturbance terms to the model equations derived above, the model can be estimated using a mixed estimation procedure, as discussed in Section 5.4. Because only a limited number of observations are available and there are multi-collinearity problems in the data, only the output supply equations (and not the profit function) are finally estimated (*e.g.* Oskam, 1986). This section focuses on the prior information used in the inference procedure.

The sample information consists of time-series data at aggregated member state level. Price and quantity data are available for the period 1973-1991 for eight member

2 Prices are expected prices, which are generated by using a simple moving average scheme. As already indicated, prices and profits are normalised by the variable input price.

states: the Netherlands, the United Kingdom, Ireland, Danmark, Germany, Belgium/Luxembourg, France and Italy. For Greece (and partly also for Ireland) the information is incomplete but could be constructed for the period 1978-1991.

The sample information is combined with two kinds of prior information: 1) prior information derived from economic theory, labeled 'qualitative' prior info, and 2) prior information derived from previous economic, or non-economic research, labeled 'quantitative' prior-information. The first concerns theoretical restrictions like homogeneity, convexity and symmetry. Symmetry implies that the following parameter constraints should hold:

$$\alpha_{ij} = \alpha_{ji}; \quad \forall i, j \tag{14}$$

while homogeneity is guaranteed by normalisation. Convexity is not directly imposed, but it is assumed that the 'quantitative' prior information will take into account that to a sufficient degree already.

Table 7.1 Economic 'quantitative' prior-information

Country	Germ.	UK	Denm.	France	Italy	Nethrl.	Belg. *)	Ireland	Greece
price elasticity									
p_1	0.50	0.60	0.60	0.60	0.30	0.25	0.15	0.15	0.30
p_2	0.22	0.10	0.10	0.22	0.60	0.05	0.05	0.15	0.60
p_3	1.00	2.50	2.50	2.50	1.50	1.30	1.30	1.50	1.30

*) Belgium stand for Belgium Luxembourg Economic Union (BLEU) and thus includes Luxembourg.

Source: Constructed on basis of Blom (1995), Guyomard, et al (1994), Oude Lansink and Oskam (1995), Jongeneel (1991), Krebs and Weindlmaier (1990).

The quantitative prior-information is partly derived from other studies and is partly created on the basis of external information on yields and biological technical progress. The information from other studies (usually in the form of price elasticities) is used mainly to form prior-ideas about the α_{ij} - or price parameters. Table 7.1 gives a summary of this prior-information, presented in elasticity form. With respect to the cross-price elasticities, less information is available. The results that are found suggest rather low elasticities. For all countries, the cross-price elasticities between potatoes and cereals and potatoes and oilseeds are set equal to -0.05 and those between cereals and oilseeds to -0.10. Because there are different degrees of certainty between the beliefs about own- and cross-price elasticities, different variances are imposed on own and cross price priors: own price priors are assumed subject to 50% confidence bounds and cross price priors to 100% confidence bounds. A 50% confidence bound for the own price of cereals for Germany, for example, implies a confidence interval of 0.50 ± 0.25, or a 95% probability of an own price elasticity within the range $[0.25, 0.75]$.

In order to develop the prior beliefs on γ_{ij} - or the land and technology parameters, (non-economic) information about yield evolution and agronomic studies is used. The γ_{i2}-parameter, for example, may be written as

$$\frac{\partial y_i}{\partial z_l} = \gamma_{i2} = YLD_i \frac{\partial z_{l,i}}{\partial z_l} = YLD_i . s_i \qquad (15)$$

with YLD_i representing the yield of crop i in tonnes per hectare and s_{li} the land-share of crop i in total arable land. Given the relatively stable land-shares, (individual country) sample averages are used to obtain the desired prior-information. Using this condition presupposes that *i)* the s_i's are rather stable over the estimation period, and *ii)* that the 'marginal' land change reflects a change in land of average quality. Because over the period considered, changes in land allocated to a specific crop were not due to participation in set-aside but took place within a normal crop rotation-context, the average-quality assumption seems justified. When using the model to account for set-aside a correction for slippage should be introduced. Assuming land share constancy is reasonable with respect to cereals and potatoes, but less satisfactory for oilseeds for which the share increased over the estimation period.

Moreover, a change in t generates an increase in output due to mainly (biological) technical progress, or

$$\frac{\partial y_i}{\partial t} = \gamma_{i3} = \frac{\Delta YLD_i}{year}.HVA_i \qquad (16)$$

with HVA_i denoting the harvested acreage of the i-th crop. The change in farm crop yields can be roughly decomposed into three components: *viz* genetic gain in crop yield potential, other genetic gains (*e.g.* disease resistance, reduced lodging, tolerance to environmental constraints), and management or technological gains (improved cultivation practices, better fertilizer and biocides applications, more efficient mechanization) (Slafer, 1994, p.5; Evans, 1993, p.23-26). For cereals the contribution of pure genetic improvement is estimated at approximately 50%, or roughly 1% farm crop yield increase per year (Slafer, 1994, p.53, J.Goudriaan personal communication). For other crops, in particular for potatoes where a relatively high number of old cultivars are in use, this contribution might be lower (Caldiz, 1994, pp.365-366), but it will in general be non-negative.

No reliable prior information is available with respect to the restricted output-coefficients. Since the output constraint is binding, relaxing the constraint will probably lead to additonal acreage allocated to sugar beets while the acreage allocated to other crops will be diminished. Based on this reasoning, the signs of the γ_{i1} - parameters might be expected to be negative. Whether this will be true for a particular individual crop depends, among others, on possible induced changes in the crop rotation scheme. The 'technical' prior information is summarized in Table 7.2.

The development of the yield per hectare-growth is determined by computing the growth-trend over the period 1972-91[3]. The results in general correspond with more refined agronomic yield analyses, which report an average crop yield increase for cereals of approximately 100 kg/ha/year (Slafer *et al*, 1994, p.188). For oilseeds (sunflower) and potatoes yield, increase estimates of 1.17% (ca.33kg/ha/yr) and 0.50% per year (ca. 160kg/ha/yr) are reported (Slafer *et al.* 1994, p.288; p.366).

3 With the exception of Ireland and Greece where the period is 1978-91.

Table 7.2 Non-economic prior-information (sample averages)

Country	Germ.	UK	Denm.	France	Italy	Nethrl.	Belgium	Ireland	Greece
Yield (YLD)					tonnes/ha				
Cereals	5.5	5.8	5.6	5.8	3.6	6.5	6.2	5.8	2.8
Potatoes	36.0	35.0	36.0	30.0	30.0	41.0	36.0	22.0	21.0
Oilseeds	3.4	3.0	2.8	2.5	2.1	3.5	3.0	3.5	1.7
Beets	48.8	37.3	42.9	52.8	46.9	51.9	50.5	41.2	61.3
ΔYLD					kg/ha				
Cereals	121	134	114	139	53	149	128	139	82
Potatoes	498	582	876	589	-134 (160)	385	405	-224 (160)	462
Oilseeds	51	52	51	41	75	31	124	4	54
Beets	604	753	707	1 653	274	987	666	319	573
Harvested acrage					1000ha				
Cereals	5001.6	3848.9	1698.6	9563.3	4727.5	215.5	414.5	372.7	1507.2
Potatoes	295.9	198.1	33.9	227.8	136.5	165.1	48.3	36.3	56.6
Oilseeds	210.6	197.3	149.3	974.5	218.6	10.2	2.7	205.0	32.8
Beets	396.3	198.7	72.7	513.7	269.0	127.1	110.6	33.8	39.4

Source: Own computations (including trend regressions) and estimates based on Slafer et al (1994).

Given these estimates, some strange results (negative growth rates, albeit not significant) are obtained with respect to potatoes in Italy and Ireland. For the latter two countries, a conservative prior estimate of 160 kg/ha/yr is used, based on an average yield of 31,9 tonnes and a 0.5% annual growth-rate. For the 'technical' priors 25% confidence intervals are assumed.

7.4 Estimation results and discussion

Before finally estimating the EU country arable models, first an expected price series is generated, since it is reasonable to assume that farmers maximize expected profits.

The prices for program products (cereals and oilseeds) are regressed on lagged prices and institutional prices (intervention prices). The expected price for potatoes is based on own lagged prices. For cereals and oilseeds, a rather high R^2 is found, while for potatoes, with highly fluctuating prices, the explained variance is rather low (*cf.* Appendix 7A for details). Usually, the lagged prices are most significant, except for those cases where information about institutional prices (target prices) has to be used to construct an incomplete farm price series (oilseeds for Ireland and United Kingdom).

The added quantitative and theoretical prior information significantly improved the results. As can be concluded from the remarks and comments from various previous studies, estimating agricultural supply on individual country time series data is often not without problems. In a number of cases the unrestricted estimator generated wrong signs of own price reactions in conflict with the non-imposable convexity requirement. Adding the prior information is still not sufficient to solve all problems. With respect to France, the United Kingdom and Ireland, negative own price parameters are found for cereals. For Germany the same happens with respect to the oilseeds-own-price estimate. Because the convexity requirement is considered extremely important, these country models have been re-estimated with halved prior variances for the coefficients for the Germany, the UK and Ireland and the variance of the French coefficient has been divided by four. The final estimation results are presented in Appendix 7A[4].

Table 7.3 presents the estimation results in elasticity-terms. From the 81 estimated price coefficients 14 are found to be not significant at the 95% confidence level (but nearly all are at the 90% level). The price-coefficients do not require much discussion since they more or less correspond to initial expectations. However, comparing the results of Table 7.3 with the elasticity priors from Table 7.1 shows that considerable deviations are possible. For example, the (posterior) own price elasticity of cereals for Germany is only 8% of the prior estimate given in table 1, *i.e.* a 92% deviation. A general indication of the contribution of prior information to the final estimate precision is given by α_p (see lowest row of Table 7.3). In

4 The prior elasticities and variances are real *prior*-estimates, *i.e.* they are all chosen before any regressions have been run. This is essential both from a viewpoint of integrity in research and also to make a sound interpretation of the final results possible (avoidance of data-mining). See Oskam (1992) for a borader discussion.

Table 7.3 Final estimation results (in elasticity form)

Country	Germ.	UK	Denm.	France	Italy	Nethrl.	Belgium	Ireland	Greece
Cereals									
p1	0.060	0.506	0.769	0.341	0.339	0.180	0.153	0.025	0.538
p2	-0.005	-0.015	-0.006	-0.003	-0.008	-0.037	-0.018	-0.035	-0.017
p3	-0.015	-0.015	-0.021	-0.018	-0.009	-0.008	-0.002	-0.002	-0.008
y0	-0.449	0.569	0.691	0.073	-0.019	0.125	0.151	0.339	-0.298
y1	1.028	1.156	1.291	1.122	0.993	0.717	1.188	1.060	0.846
y2*)	3.952	2.570	1.840	3.069	1.524	1.126	2.146	3.187	2.484
Potatoes									
p1	-0.024	-0.052	-0.053	-0.036	-0.050	-0.012	-0.049	-0.058	-0.083
p2	0.263	0.062	0.075	0.089	0.040	0.023	0.035	0.339	0.154
p3	-0.022	-0.025	-0.074	-0.064	-0.036	-0.001	-0.003	-0.001	-0.019
y0	-0.840	0.213	0.756	-0.597	0.127	-0.036	0.252	0.017	-0.074
y1	1.409	1.158	1.021	1.077	1.072	1.043	1.090	0.972	1.209
y2*)	0.405	1.102	2.998	1.531	-1.122	0.976	1.334	1.576	1.192
Oilseeds									
p1	-0.248	-0.189	-0.169	-0.177	-0.114	-0.130	-0.241	-0.119	-0.259
p2	-0.078	-0.093	-0.063	-0.053	-0.068	-0.039	-0.109	-0.049	-0.123
p3	-0.299	0.818	1.938	0.362	2.409	0.356	0.162	0.520	2.487
y0	1.525	2.095	1.414	1.667	0.802	-0.501	0.700	-0.383	-1.194
y1	1.038	0.923	1.041	1.140	0.721	0.878	1.013	0.960	0.951
y2*)	3.183	2.426	3.185	2.297	3.109	0.783	5.688	0.133	3.125
α_p	*0.580*	*0.599*	*0.496*	*0.578*	*0.550*	*0.505*	*0.630*	*0.475*	*0.593*

**) Expressed in terms of average autonomous output growth in percentage per year.*

Legend: p1 = price cereals, p2 = price potatoes, p3 = price oilseeds, y0 = quantity sugarbeets, y1 = amount of land, y2 = time shifter.

Source: Own computations

general the prior information and the sample information are almost of about the same importance, with the prior's share slightly dominating. Given the collinearity in the price variables in the sample, the role of the prior in co-determinating the final parameter estimates of single variables is not really surprising.

In order to test the restricted output specification for sugarbeets, it is interesting to look at the elasticities for the y_0 variable. As can be seen from the table, they are positive in 17 of the 27 cases. This is in contrast with the previously suggested negative sign of this coefficient, although this expectation is not based on a good premise.

Rapeseed and sugarbeets are from the same biological species, which imposes limits to their combined rotation. So for countries with a narrow crop rotation and a considerable share of rapeseed in oilseed production, a negative sign might be expected. This is found to be the case in only the Netherlands, Ireland and Greece. Moreover, there are constraints to the amount of root crops in the rotation schemes, since they require specific soil cultivation. One would therefore expect more negative signs with respect to potato output than is currently the case.

Perhaps the results found are partly due to the use of imbalanced prior-information. No prior-information with respect to the restricted output has been imposed, while it is for all other coefficients (except the intercepts). Moreover, when the models are estimated in an unrestricted way, the y_0-coefficients are significant only in 25% of the 27 cases. It can therefore be concluded that both the sample and the prior information are rather inconclusive about this variable. As a consequence the final parameter estimate can easily take any sign, positive or negative.

With the exception of two strange results, one for Italy and one for Ireland, all y_1 and y_2 coefficients have the appropriate sign. The elasticities with respect to arable land use (y_1) closely follow the prior estimates for all three crops.

The results with respect to y_2-variable, which represents biological technical progress, are somewhat high for cereals and oilseeds. With regard to oilseeds, it was earlier found to be difficult to give a satisfactory explanation for its strong growth since the early 1970s. The growth-rates found are therefore probably partly due to biological technical change (the phenomenon y_2 is assumed to measure) and partly due to the rapid adoption of a profitable crop by farmers (learning-effect). Other factors increasing output growth above its biological technical growth rate are soil improvements and innovations in plant care and plant protection.

Table 7.4 represents average elasticities for the EU-10. The individual elasticities are weighted by the 1990-output shares of individual countries in the various products. The table not only provides a summary 'statistic', but will also be used to construct arable supply modules for the missing countries Spain and Portugal. Unfortunately, hardly any (sufficient and reliable) empirical or prior information is available for these two countries.

Table 7.4 EU-10 average elasticities *)

Crop \ price	*cereals*	*potatoes*	*oilseeds*	*quantity sugarbeets*	*land*	*annual shift*
Cereals	0.341	-0.007	-0.015	0.083	1.095	2.840
Potatoes	-0.036	0.107	-0.026	-0.179	1.158	0.927
Oilseeds	-0.177	-0.066	0.849	1.468	1.003	2.700

*) *Weighted averages using 1990 output shares. The annual shift of sugar beet output was 1.935 (estimate based on prior information).*
Source: Own computations

7.5 Concluding remarks

In this chapter, models for the EU arable sector have been estimated for 10 countries. Since not all crops are taken into account, arable supply is incompletely modelled, although the included crops are by far the most important ones. Prior information based on previous economic research and non-economic sources is used to increase the efficiency of the estimation procedure. Own price elasticities are low (inelastic) for cereals and potatoes, with oilseeds the most price sensitive. Cereals and oilseeds showed comparable farm crop yield growth rates of about 2.7% per annum, while potatoes lagged behind with a yield growth rate of less than 1%. Sugarbeets are expected to compete with potatoes in intensive crop rotation systems, and to compete with grains (and oilseeds) in extensive crop rotation systems, although no strict sign restrictions could be derived. The role of the rationed quantity of sugar beets in the free crop supplies, however, showed no clear pattern, and its parameter estimates might be sensitive to errors in the procedure.

Appendix 7A Estimation results

In this appendix the final estimation results are presented. Firstly, the estimates of the expected prices are presented. Secondly, the mixed-SUR estimates of the behavioural model follow.

Table 7A-1 represents the econometric estimates of the estimated expected prices. The general structure of the regression equations is that p_t is regressed on p_{t-1} and (if available) on the institutional price $p_t^{inst.}$ which is assumed to be (more or less) known at the planting stage. If necessary a dummy variable is included to 'correct' for the extreme drought in 1976. The estimated prices, *viz.* $\hat{p}_t (= p_t - \hat{e}_t)$ (with e_t the estimated residual), are used as a (predicted!) proxy for the final expected prices.

Table 7A-2 represents the final parameter estimates which are subject to the theoretical conditions and based on the empirical prior-information noted in the main text. A column of weighted averages is added, which will be used for the calibration of the models for Spain and Portugal.

Table 7A-1 Estimates of expected price-regressions

Country	Germ.	UK	Denm.	France	Italy	Nethrl.	Belgium	Ireland	Greece
Cereals price									
intercept	-0.964	1.557	19.709	12.129	1543.800	7.611	182.900	1.802	72.122
	(0.10)	(3.02)	(2.35)	(2.38)	(2.46)	(1.29)	(2.22)	(2.95)	(1.22)
lagged price	0.908	0.615	0.818	0.942	0.634	0.983	0.640	0.061	0.791
	(4.27)	(3.71)	(3.72)	(4.53)	(2.82)	(6.19)	(2.38)	(0.29)	(3.49)
intervention	0.113	0.234	0.040	-0.038	0.383	-0.155	0.103	0.621	0.270
price	(0.31)	(1.36)	(0.17)	(0.23)	(0.29)	(0.85)	(0.44)	(3.55)	(1.49)
R-squared *)	0.77	0.94	0.91	0.93	0.98	0.77	0.68	0.89	0.99
Potatoes price									
intercept	19.152	4.243	57.775	27.634	4688.300	20.497	250.76	5.307	-187.570
	(5.51)	(3.49)	(2.65)	(2.60)	(1.21)	(5.92)	(4.60)	(2.25)	(0.72)
lagged price	0.134	0.375	0.338	0.470	0.838	0.077	0.105	0.542	1.288
	(0.98)	(2.39)	(1.40)	(2.61)	(5.31)	(0.62)	(0.69)	(2.65)	(11.29)
dummy '76	31.701	9.862	66.140	61.218	14778.0	50.298	596.380	3.173	196.230
	(6.01)	(2.34)	(1.83)	(3.07)	(2.05)	(6.84)	(5.04)	(0.77)	(0.41)
R-squared *)	0.68	0.52	0.12	0.39	0.60	0.72	0.57	0.22	0.91
Oilseeds price									
intercept	-2.544	-1.531	-24.986	35.260	-6140.100	29.551	-44.985	-0.636	-116.56
	(0.17)	(1.28)	(1.10)	(1.43)	(2.49)	(2.43)	(1.08)	(1.22)	(5.41)
lagged price	0.685	0.197	0.239	1.199	0.162	0.211	-0.154	0.218	-0.006
	(3.57)	(1.14)	(1.40)	(3.70)	(1.23)	(0.83)	(1.78)	(2.87)	(0.18)
intervention	0.319	0.959	0.931	-0.309	1.021	0.434	1.179	0.884	1.120
price	(1.17)	(4.38)	(4.10)	(1.19)	(6.17)	(2.01)	(11.59)	(9.47)	(36.41)
R-squared *)	0.82	0.98	0.95	0.73	0.99	0.60	0.99	1.00	1.00

*Absolute t-values in parenthesis. *) Adjusted for degrees of freedom.*
Source: Own estimates

Table 7A-2 Final parameter estimates)*

Country	Germ.	UK	Denm.	France	Italy	Nethrl.	Belgium	Ireland	Greece
Cereals									
intercept	-802.72	-29435.00	-14771.00	-41270.00	-7744.30	-126.70	-1498.20	-1416.70	-1354.40
	-0.1630	-6.3270	-7.7650	-3.4550	-3.0160	-0.6410	-3.0180	-3.9080	-1.2800
p0	32.1940	1106.100	51.6730	191.3800	0.2471	3.3730	0.2105	2.6471	2.7303
	0.6590	4.4020	6.6360	3.3160	5.1670	7.5670	4.4920	1.3550	3.5540
p1	-4.8468	-37.2030	-0.4768	-2.6119	-0.0059	-1.1200	-0.0513	-2.8184	-0.0848
	-1.0220	-2.2460	-2.1590	-1.4420	-2.0930	-2.7640	-2.2240	-3.1050	-1.5810
p2	-3.7624	-12.4370	-0.5239	-4.7346	-0.0031	-0.0749	-0.0013	-0.0792	-0.0145
	-5.0120	-3.8320	-3.4210	-3.5820	-2.2940	-2.6380	-4.8580	-2.4610	-2.2950
y0	-0.5456	1.5181	1.6831	0.1362	-0.0245	0.0240	0.0567	0.4636	-0.6163
	-4.9940	5.2940	4.7580	0.6010	-0.3720	1.3790	0.9290	2.5140	-2.2290
y1	3.3113	3.3254	3.7605	3.0847	1.7815	1.0715	3.1090	1.9130	1.4411
	7.4170	8.3210	8.8960	7.8730	7.8810	5.4410	8.0080	10.5000	7.9960
y2	937.5600	509.7500	140.8200	1478.300	252.0500	14.2330	45.4050	61.1420	123.8100
	19.7970	9.8460	8.4450	11.2740	11.3410	4.7110	8.2610	12.7320	9.1380
Potatoes									
intercept	1517.90	-3065.30	-1077.10	2504.80	-86.11	-785.09	-751.20	-387.63	-290.20
	0.5970	-2.7050	-4.6130	1.6280	-0.2320	-0.8910	-2.0350	-1.5910	-1.5590
p0	-4.8468	-37.2030	-0.4768	-2.6119	-0.0059	-1.1200	-0.0513	-2.8184	-0.0848
	-1.0220	-2.2460	-2.1590	-1.4420	-2.0930	-2.7640	-2.2240	-3.1040	-1.5810
p1	92.3510	50.2780	0.8605	10.1620	0.0050	3.4882	0.0764	12.6500	0.1558
	7.0610	3.1720	3.3770	2.5370	1.7660	2.3360	2.9510	13.3240	1.4060
p2	-2.0790	-6.9830	-0.2512	-2.2137	-0.0020	-0.0366	-0.0012	-0.0251	-0.0068
	-3.3640	-4.0750	-3.9580	-3.3940	-3.0920	-1.6700	-4.4250	-1.9990	-2.2070
y0	-0.3780	0.1854	0.2450	-0.1462	0.0268	-0.0347	0.0714	0.0104	-0.0307
	-3.6430	2.0630	4.3430	-3.3770	3.3780	-0.4060	1.4640	0.0700	-1.0770
y1	1.6788	1.0854	0.3958	0.3874	0.3088	7.7848	2.1525	0.8042	0.4127
	9.5380	8.7410	7.0540	7.9850	8.5100	8.2300	8.1420	9.1820	8.0550
y2	35.5880	71.2430	30.5220	96.5060	-29.7760	61.6190	21.3110	13.8650	11.9130
	2.1170	5.7630	12.0590	6.4900	-7.7380	8.2730	9.1220	6.1130	5.0440

Continued

Table B-2 continued

Country	Germ.	UK	Denm.	France	Italy	Nethrl.	Belgium	Ireland	Greece
Oilseeds									
intercept	-851.76	-1681.60	-1244.50	-5272.40	-1886.10	13.616	-9.3311	3.2698	-63.7890
	-2.9210	-6.1250	-7.1240	-4.1160	-7.6010	0.8430	-1.7030	0.5720	-1.0540
p0	-3.7624	-12.4370	-0.5239	-4.7346	-0.0031	-0.0749	-0.0013	-0.0792	-0.0145
	-5.0120	-3.8320	-3.4210	-3.5820	-2.2940	-2.6380	-4.8580	-2.4610	-2.2950
p1	-2.0790	-6.9830	-0.2512	-2.2137	-0.0020	-0.0366	-0.0012	-0.0251	-0.0068
	-3.3640	-4.0750	-3.9580	-3.3940	-3.0920	-1.6700	-4.4250	-1.9990	-2.2070
p2	-2.1864	20.7260	2.2808	4.5791	0.0312	0.0982	0.0004	0.1286	0.0499
	-1.3420	2.2420	5.2700	1.6800	9.2100	3.7140	0.6620	4.1180	3.7830
y0	0.0523	0.1678	0.1592	0.1488	0.0396	-0.0030	0.0010	-0.0033	-0.0271
	5.1410	9.3450	4.2340	4.5740	2.2410	-1.4580	1.3170	-0.8960	-1.2220
y1	0.0943	0.0797	0.1402	0.1495	0.0487	0.0403	0.0102	0.0109	0.0178
	7.0690	7.5800	7.2790	8.6130	7.8070	7.6450	8.0600	7.0340	8.0390
y2	21.3000	14.4510	11.2660	52.7890	19.3650	0.3042	0.4625	0.0161	1.7122
	15.1180	11.8260	12.8780	10.7770	9.5720	7.7540	11.4220	8.2490	8.3110

**) t-values given below parameter estimates. For Ireland a specific dummy variable is used to correct for a break in the data series, for which the results are not reported.*
Source: Own estimates

Chapter 8

The EU Cattle-Dairy Sector

8.1 Introduction

This chapter is structured as follows. Firstly, in this section a brief overview is given of the main characteristics of the cattle livestock sector, its development over time and the corresponding policy responses. Section 2 presents the economic model used and shows how it captures the sector specific characteristics (rationed milk output). The animal production dynamics (herdsize adjustments) is elaborated on in Section 3. Subsequently, Section 4 indicates prior information used. Section 5 presents the mixed 3SLS estimation results. Section 6 closes with some concluding remarks.

The EU dairy sector represents by far the largest single sector of the EU's agriculture. Dairying is often a farmer's main cash enterprise, which is particularly true, other than providing green forage for dairy and/or beef cattle, land has limited alternative uses. Although during the 1970s, the total number of dairy cows remained constant at about 25 million, significant increases in the yield per cow caused the total raw milk production to increase by some 1.2% annually over the 1960s and 1970s. Between 1973 and 1983, milk output (measured as deliveries to dairies) increased by an annual average of 2.5% (Commission, 1987). This yield increase, which has been as rapid in countries with the highest yields (milk production per cow) as in those with lower yields, is due to steady genetic improvements, improved feed quality, changes in animal housing practices (cubic stalls) and land reparcelling and farm restructuring. The predominant use of concentrate feed in conjunction with pasture and silage has led to the increasing importance of 'factory' farms, in particular in the northern regions of the Union.

Notwithstanding the EU's milk price support policy, real prices for milk have generally been declining over time for all member states, and for both the pre-quota and the quota periods (Parton, 1992,p.198). However, the milk/feed price ratio often increased[1]. Domestic demand in 1990 was about 87 million tonnes (expressed in milk equivalents), while milk supplied to dairies was about 99 mill. tonnes. Besides, in the same year, 10.5 million tonnes went to alternative outlets (direct sales, on-farm use). While in the period 1973-1983, milk production increased on average by 2.1% a year, the average consumption increase was much lower, *i.e.* only about 0.5% a year. The self sufficiency rate for the EU was estimated to be 130% in 1983 (*The Agricultural Situation*, 1985; BAE, 1985, p.224). This explains the growing demand/supply imbalances, stock formation, and tension on world markets for dairy products due to the export of EU surpluses. In 1990 the EU's share in world exports of dairy products was substantial: butteroil (33%), skimmed milk powder (38%), cheese (51%), unskimmed milk powder (60%), and condensed milk (77%).

The production of beef is (at least in the pré-quota period) closely related to dairying, since over 80% of the cows used for beef production are from dairy or dual purpose herds (Harris *et al* 1983, p.106). The development of beef and veal production is different from milk output. From 1973 the total herd size has remained rather stable, fluctuating around 78 million cattle with no significant upward or downward trend (EU-9), up untill 1983. The same pattern holds with respect to slaughterings of adult cattle and calves, which cyclically vary around respectively 21 and 7 million per year. In the early 1990s adult (bovine) cattle slaughterings fluctuate around 23 million per year, while calves slaughterings amount to about 6 million per year (EU-12, 1989-1995). Calves slaughterings show a slight tendency to decline. The cyclical variation both in cattle number and slaughterings (see Figure

[1] Up till the early 1980s institutional milk prices were determined on the basis of the so-called 'objective method', which implicitly guaranteed a sufficient renumeration of the production factors employed in modern well-managed farms (*cf.* De Veer, 1997, and De Bont, 1994, pp.55-57).

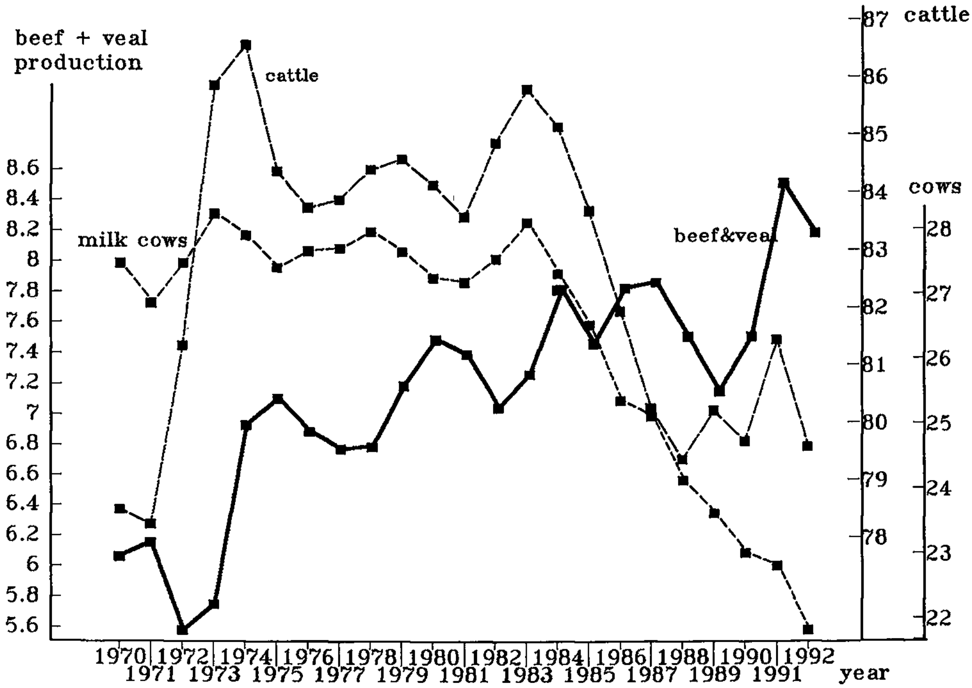

Figure 8.1 Beef and veal production (Mill. t. carcas weight) and milk cow and cattle numbers (Mill. animals)

1) is typical not only for the EU, but also characteristic for other major beef producers, like the US and Australia (BAE, 1985, p.246). Although these main factors underlying beef and veal production have been stable since the early 1970s, there has been a gradual upward trend in total meat output (annual increase over 1973-1984 was about 1.4%). The fluctuations about this trend are mainly due to variations in herd buildup and (following) slaughterings, while the trend itself can be related to increased slaughtering weights. The increase in slaughtering weights is a pattern that still continues, both for adult cattle and calves. Suggested explanations for this latter development are the trend towards larger framed animals and the increased beef/feed price ratio (BAE, 1985, p.247).

Domestic beef and veal consumption is about 7.1 million tonnes (1989-1991 average). Looking more closely, it turns out that beef and veal consumption per capita is gradually decreasing from about 25 kg/head in the 1970s to about 22 kg/head in the late 1980s and early 1990s. In contrast with this, both pig meat and poultry consumption per head increased from respectively 31.5 and 11.8 kg/head in 1973 to 39.5 and 18.6 kg/head in 1990. The decreased relative share of beef and veal can be linked to meat price trends, which show a general tendency in favour of other meats, particularly for pork. While the EU was a large importer of beef and veal, since 1980 it has become a net exporter, with an average self-sufficiency rate of 106.1 percent for beef and veal or 103 per cent for all meats (average 1988-91).

Several policy measures were introduced to reduce dairy surpluses both on the demand and the supply side. With respect to the demand side, policies include disposal schemes for skimmed milk, subsidies on butter consumption, and the school milk programmes. With regard to the supply side, a co-responsibility levy (1977) and a guarantee treshold system (1981) were among the measures applied. These modifications of the support regime did not solve the structural problems of surpluses and strongly increasing budget outlays (necessary to dispose off increasing surpluses at depressed world market prices) (*cf.* for example Oskam, 1983, p.58). The most significant change was the introduction of the quota or super levy-system in April 1984. A production quota, defined at member state level, was introduced and combined with large penalty-levies (super-levy) on excess production[2]. Initially this was 75% of the target price for milk in case of farm-level quotas, or 100% in case of quotas attached to dairies. Currently the penalty on over-production is 100% in both cases. Although implementation of the quota system has proved difficult in some countries (notably Italy and Greece), the previously open-ended price guarantee was thus limited to a maximum quantity for the Union as a whole. The super levy-system effectively brought milk production down from 104 million tonnes in 1983 to 99 million tonnes at the end of the 1980s.

With respect to beef, a target price policy was mainly followed, combined with import levies and a limited intervention policy. In the early 1970s real prices increased for producers, while from 1973 onwards they steadily declined. Up till

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[2] For details and tradability see Burrell (1989) and Oskam and Speyers (1992).

the mid 1970s large intervention stocks were built up as consumers became increasingly reluctant to pay the relatively high beef prices they were confronted with compared with that for other meats. Since 1975 slaughter premiums for cattle and calves were introduced which initially had a special measure-character, but acquired a more general impact when it was extended to suckler cows in 1980/81. Since then the direct income support for specialist beef producers has been further intensified (MacSharry reform) and has been made conditional on certain extensification criteria.

8.2 Economic model

There is an extensive literature on the output supply of the cattle/dairy sector, in particular with respect to the supply of milk in the pre-quota period (for a general overview see Oskam, 1994 and the references cited therein). Roughly speaking two approaches can be distinguished: a) one which directly estimates supply equations using milk and beef and veal quantities as dependent variables, which are regressed on price variables, cow numbers, and technology shifters; and b) one which follows an indirect route by firstly estimating an equation explaining cow numbers and subsequently estimating equations regarding specific outputs (milk yield, beef yield) (Parton, 1992, p.189). The latter approach is also called the investment theory approach to livestock modelling (examples are Rayner, 1975; Burton 1984; Roemen, 1990 and Burrell, 1992). The first approach is most often followed, while the second one has the advantage of giving greater importance to to production-technical considerations. In the older studies, the supply relationships are pragmatically specified, using economic theory mainly as a criterion for selecting the variables, and partial adjustment schemes to account for the dynamics. Often these models have a very partial character in the sense that they only focus on a single product, for example milk, and not do simultaneously consider the supply of beef (*cf.* Parton 1992, and cited review-paper of Oskam 1994). The maximum acknowledgement made to the joint production of milk and beef is done by picking up the beef price as an explanatory variable in the milk supply equation. This approach is relatively inefficient as compared with using a more unified framework (production, profit or cost function). Moreover, sometimes doubts are raised about the exact nature of the supply relationship that is estimated[3].

The more recent studies focusing on the cattle/dairy sector often follow the primal or dual approach in production economics, which has not only the advantage of theoretical consistency and efficiency (systems of equations), but is also suited to cope with supply restrictions (see discussion in previous chapter). Examples are Thijssen, (1992), Guyomard and Mahé (1994), Helming, Oskam and Thijssen (1994), and Guyomard, Delache, Irz, and Mahé (1996). Although not explicitly derived from a dynamic optimization framework, they allow for medium run analysis based on adjustments in quasi-fixed inputs, in particular livestock capital (Guyomard, *et al*, 1996, p.217)[4].

The model structure to represent the behaviour of the EU's cattle/dairy sector chosen here follows the latter approach and opts for a restricted profit function framework. The prerequisite is that the model should reflect the basic characteristics of the sector like the production of multiple outputs by means of multiple inputs. Moreover, the production technology should allow for jointness in outputs and restrictions on both output (supply management in milk) and inputs (quasi-fixed land and capital input). The finally estimated model consists of two outputs (milk and beef&veal output), two aggregated variable inputs (feed and other inputs), two quasi-fixed inputs (grassland, and a proxy for livestock capital), and a technology-shifter.

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[3] For example, the way Oskam and Osinga (1982) assume farmers react to prices implies the imposition of an arbitrary restriction on the production technology, while the low and sometimes negative supply elasticities found by Parton (1992) might not only be due to problems with respect to the specification, but also indicate that GE-curves instead of PE-curves are estimated (see chapter 4).

[4] Studies which use an explicit intertemporal optimization framework, of which there are relatively few, were applied to agriculture with mixed success (*cf.* Vassavada and Chambers (1982), and Tsigas and Hertel (1989) both rejected the model when using aggregate data). Applications of this approach to the dairy sector are Howard and Shumway (1988), Weersink and Howard (1990) and Richards and Jeffry (1997).

Analogously to the arable sector, a normalized quadratic profit function approach is chosen, which yields the following beef and veal supply and concentrate feed demand functions (time subscripts suppressed):

$$y_1 = \alpha_1 + \alpha_{11}\frac{p_1}{w} + \alpha_{12}\frac{p_2}{w} + \gamma_{10}y_0 + \gamma_{11}z_1 + \gamma_{12}z_2 + \gamma_{13}z_3 + e_1 \quad (1)$$

$$y_2 = \alpha_2 + \alpha_{21}\frac{p_1}{w} + \alpha_{22}\frac{p_2}{w} + \gamma_{20}y_0 + \gamma_{21}z_1 + \gamma_{22}z_2 + \gamma_{23}z_3 + e_2 \quad (2)$$

where the normalized profit function and other input demand equation are left out for reasons discussed below. Greek letters denote parameters, while Table 8.1 indicates the variable labels used.

Table 8.1 Variables used as regressors

Symbol	Variable
p1	price of unrestricted output (beef & veal)
p2	price of variable input (concentrates)
w	price of other inputs
y0	quantity of restricted output (milk)
y1	quantity of unrestricted output (beef & veal)
y2	quantity of variable input (concentrates)
z1	quasi-fixed land input (pasture)
z2	quasi-fixed capital input (dairy livestock capital)
z3	technology-shifter (trend)

Three complications arise in estimating the dairy model. The first one is that two different regimes have to be considered. In the pre-1984 (period 1) there is no restriction on milk output, while from 1984 onwards (period 2) milk output is restricted by the super levy-system. The simplest solution would be to estimate two separate models, one for each period. However, due to the relatively limited time series being used here adding further assumptions to both models would allow for more efficient use of information. For example, if it is assumed that the underlying production technology has not changed, there exists a direct relation between the profit maximization-version (period 1) and the cost minimization-version (period 2) of the model used for describing producer behaviour (*cf.* Fulginiti and Perrin (1993)). This linkage can be exploited to estimate the model using information for both periods. The disadvantage of the latter approach is that one ends up with a highly non-linear model. Therefore, the final approach here chosen is a more indirect one. A (double) restricted normalized quadratic profit function specification is chosen. From this a system of meat output supply and feed input demand equations can be derived by applying Hotellings Lemma. Both are a function of the meat price, the feed price, and the amount of available land, livestock capital, restricted milk output, and a trend variable (technology shifter). The price of other inputs (fertilizer, energy, etc.) is used for normalization. An appropriate estimator is chosen to deal with the simultaneity bias.

The second complication concerns the multicollinearity problem associated with estimating flexible functions like the normalized quadratic. In principle it is possible and preferable to jointly estimate the system of behavioral output and input equations with the quadratic profit function[5]. However, earlier efforts to do this were not succesfull because of the multicollinearity of variables in the profit function, in particular of the cross-product variables. Even for this very simplified representation of the dairy sector, the profit function already contains 28 independent

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[5] The restricted profit function is

$$\pi = \alpha_0 + \sum_{i=1} \alpha_i p_i + \frac{1}{2}\sum_{i=1}\sum_{j=1} \alpha_{ij} p_i p_j + \beta_0 y_0 + \sum_{k=1} \beta_k z_k +$$
$$\frac{1}{2}\beta_{00} y_0 y_0 + \sum_{k=1} \beta_{0k} y_0 z_k + \frac{1}{2}\sum_{k=1}\sum_{l=1} \beta_{kl} z_k z_l +$$
$$\sum_{i=1} \gamma_{i0} y_0 p_i + \sum_{i=1}\sum_{k=1} \gamma_{ik} p_i z_k$$

with profits and all prices normalized by the price of other inputs.

variables, while the total number of observations is 18 (estimation period is from 1973-1990). Although estimation of a complete simultaneous system is preferable because of efficiency considerations, this argument weakens if one equation from the system causes problems that spill-over into the estimation results for the other equations[6].

The third complication concerns the estimation of the shadow price function. This function coincides with the milk supply function associated with the pre-quota period. The best solution then seems to be to estimate the supply function based the pre-quota period and extrapolate it. However, since there exist limits on the transferrability of milk production rights in nearly all european countries (*cf.* Oskam and Speijers 1992 for an overview), the relevant shadow price relationship is likely to differ from the unrationed supply equation (see discussion in previous chapter). Because of these complications and since the (milk) shadow price relationship is not strictly necessary to carry out our planned policy simulations, its estimation has been abandoned.

A consequence of not estimating the profit function is that some crucial parameters remain undetermined, which on the one hand limits the information about the behaviour of the normalised input, and on the other hand complicates medium term analyses with the model. The first problem is 'solved' by limiting the profit concept to revenues over variable costs, excluding those variable costs associated with the normalised input. The second problem is discussed in the next section.

8.3 Animal production dynamics

The complications for medium term analysis, touched on in the previous section, can be seen by deriving the medium term supply equation for beef in which livestock capital is allowed to adjust. Formally this medium term supply function is

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[6] This issue is one comparable to the question whether macroeconomic models should be estimated by 2SLS or 3SLS. Although 3SLS is preferable from the point of efficiency, it might lead to biased estimates for some equations, because they are wrongly or incompletely specified.

$$y_1|_{medium\,term} = \frac{\partial\pi}{\partial p_1} + \frac{\partial\pi}{\partial z_1}\frac{\partial z_1}{\partial p_1} \tag{3}$$

where the first right hand side term denotes the short term supply curve corresponding to (1), which is fully determined. The second right hand side term can be decomposed into $\partial\pi/\partial z_1$, which represents the shadow price relationship for livestock capital, and $\partial z_1/\partial p_1$, a term indicating how the quasi-fixed factor reacts to a beef price change. The shadow price function is

$$\frac{\partial\pi}{\partial z_1} = \beta_1 + \gamma_{11}p_1 + \gamma_{12}p_2 + \gamma_{13}p_3 + \beta_{10}y_0 + \beta_{11}z_1 + \beta_{12}z_2 + \beta_{13}z_3 \tag{4}$$

of which the beta parameters remain undetermined. The shadow price relationship should equal some user cost of capital, *i.e.* $\partial\pi/\partial z = u.c.c$, although directly the qualification 'in the long run' should be added. Assuming for a moment that this actually holds, and assuming that the user cost of livestock capital is not influenced by the price of beef/veal output, totally differentiating the shadowprice condition yields

$$\frac{\partial^2\pi}{\partial z_1\partial z_1}dz_1 + \frac{\partial^2\pi}{\partial z_1\partial p_1}dp_1 = 0 \tag{5}$$

which allows for the determination of the second term as

$$\frac{dz_1}{dp_1} = -\frac{\partial^2\pi/\partial z_1\partial p_1}{\partial^2\pi/\partial z_1\partial z_1} = \frac{\gamma_{11}}{\beta_{11}} \tag{6}$$

Again there is a missing parameter, β_{11}. In order to capture some of the medium run dynamics, we estimate a simple direct relationship which approximates livestock as a function of a number of related variables, among which the beef price.

Before specifying this relationship, some specific features of the dynamics of animal economics, as discussed by Chavas and Johnson (1982), Rosen (1987), Schmitz (1997) among others, should be noted. Cattle often has a *dual purpose*-character, *viz.* the production of meat and milk. Moreover, female animals can be kept in the breeding stock to produce valuable offspring and milk, while their own value might also change (positively or negatively)[7]. The milk, beef and veal production process can be seen as being comprised of various stages, for example reproduction, raising, and production. During these stages implicit investment decisions (often with a very specific character) are made, which introduces a number of lock-in effects in the final product supply. As a consequence short-run price elasticities of supply are expected to be rather low. A simple example illustrates that the price reactions might be even more complicated. Assume a profit maximizing cattle/dairy farmer has the choice of selling the animal 'today', or holding the animal until 'tomorrow'. The latter implies obtaining the output of milk production over the first period, and the animal and its progeny in the next period. Selling today yields a certain amount of money, say p_t, which can be invested at the market interest rate. Waiting untill tomorrow, mean that in the next period both the animal and its progeny can be sold for the expected price, say $E_t[p_{t+1}]$, but that holding costs are also incurred, say c_t^h. Hence it is best to sell or hold according to (Rosen 1987, p.549)

$$p^t \;\leq\; \frac{(1+g)}{(1+r)} E_t[p_{t+1}] + r_t^m - c_t^h \qquad (7)$$

where g represents the biological 'interest rate', with net birth equal to g times the female breeding herd, and r_t^m represents the milk revenues. As is shown by Rosen (1987) this herd inventory management phenomenon introduces a particular dynamics in animal supply for slaughtering (see Figure 8.2 for a summary).

Assume, for example, that the demand for meat permanently rises. In contrast with the usual expected reaction, in the short run farmers will reduce supply and increase their stocks. The reduction in current supply will raise prices still further, but will eventually 'turn around', because the longer term effect is an increased supply of animals, which is realized by holding an increased inventory of stocks.

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[7] Often significant fractions of female animals are required for reproduction.

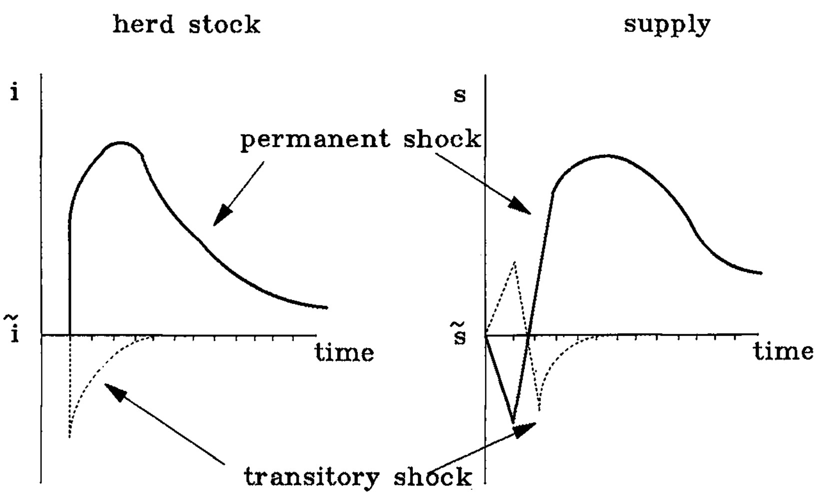

Figure 8.2: Animal cycles and backward bending supply
Source: Rosen (1987, p.555)

Before reaching the final steady state values, in the intermediate term an adjustment trajectory is followed, which may give rise to overshooting[8]. When farmers are confronted with a transitory demand (price) increase, however, their reaction will be completely different. They will try to profit from the temporarily high prices (exploit the boom) by increasing supply at the cost of their inventories. Afterwards, supply is reduced and inventories are increased to their old levels. As a consequence of these dynamics, market equilibrium convergence to steady states show two regimes. Increasing inventory of stocks is associated with high and falling prices, while decreasing inventory is associated with low and rising prices.

Summarizing, livestock capital, measured in terms of cows, can be interpreted as a function of beef and veal and milk output prices, the feed input price (holding costs), biological and real interest rates, and the farmers' expectations[9]. The final

[8] When all individual farmers (price takers) react in the same way to the peaking prices of Figure 8.3, the aggregate effect might be over-supply and (unexpected) price decline, with continuing fluctuations.

[9] Except for the acknowledgement for expectations and the 'interest' rates, the variables mentioned correspond with the derived shadow-price relationship, which can be interpreted as an inverse or price dependent demand for livestock.

specification chosen is to regress the total number of cows on the price of beef&veal two periods lagged, the (current) price of feed, (current) milk production, and a dummy trend variable, which is zero during the pre-quota period and represents a trend from 1984 onwards *(DT)*, or[10]

$$z_2 = v_0 + v_1 p_{1,t-2} + v_2 p_2 + v_3 y_0 + v_4 DT \qquad (8)$$

This specification is rather simple, and does not account for the heterogeneity in the animal capital. In an alternative and in some respects more refined modelling excercise that is still in progress, the EU livestock capital is splitted up into dairy herds and other cows, while also the role of roughage is taken explicitly into account (using the so-called SPEL data set). The results obtained so far indicate that the specification applied above leads to acceptable results.

8.4 Prior information

Besides the sample information, which consists of time series data over the period 1973-1990, prior information derived from previous research is used. Because the supply of milk has been analysed quite extensively, there is considerable information with respect to (pre-quota) milk supply (see Oskam (1994) for an overview). The own price elasticities of milk supply appear to be more or less the same for various EU countries, which suggests that although the national cattle sectors clearly differ from each other, dairying operations rely on a common 'technology' (*cf* Oskam, 1994, Tables 2 and 4). With respect to the supply of beef and veal and the demand for feed, the literature for the EU is more incidental. There are a number of studies like Rayner (1975), Burton (1984), and Burrell (1992), which at least contain some implicit information about price elasticities. One weak point which complicates their use is that they are not explicitly derived from a theoretically consistent optimization

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[10] In order to allow for sufficient dynamics, a Nerlove partial adjustment scheme was also tried, but later on abandoned because, except for Germany, the lagged dependent variable was never significant and the estimated coefficients strongly varied. Since livestock was not measured in 'capital' terms but in cow numbers, the financial variable (interest rate) was ignored. Used time lag regarding the beef price is discussed in next section.

framework. A second point causing complications is the switch to a supply management-regime. If cross price elasticities are available for beef and veal, and feed with respect to milk, and the own price elasticity of milk is available, in principle the elasticities of beef and veal, and feed with respect to milk output can be determined[11]. The problem with following this procedure, however, is that after the regime switch to the quota systems, the pre-quota elasticity structure is likely to have been changed[12]. More generally, microeconomic theory indicates that imposing a quota constraint on one output in a multiple output technology will lower the supply elasticities of the unregulated outputs (Le Chatelier/Samuelson-effect). The structural change to a quota regime thus complicates the use of all information obtained from the older studies.

Focusing on more recent studies, detailed information is available for the Netherlands from Helming *et al.* (1993), who estimated a (micro economic) model taking into account both the pre-quota and quota periods. Another study which takes into account the quota period for France is Guyomard *et al* (1994), but this one follows a cost function approach which treats non-milk output as exogenous and neglects the demand for feed input because of lack of information. As a consequence it is not very useful for our analysis. A third study which considers the quota regime is Nuppenau (1989), who models the German livestock sector, and allows us for obtaining a number of elasticity estimates. Some additional information at the EU aggregate level is provided by Guyomard *et al* (1993)[13]. Whereas the Helming (1993), and Guyomard *et al* (1994) studies are explicitly based on a theoretically consistent underlying optimization framework and annual data, the Nuppenau study uses mainly economic theory for variable selection and relies on monthly data.

Although recent reliable prior information is only available on an incidental basis, it still gives a first impression of the quantitative relationships in the cattle/livestock sector. The prior information ultimately used relies mainly on

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[11] They are obtained by simply dividing the cross price elasticities by the own price elasticity of milk.

[12] For example, for the pre-quota period, often positive cross price elasticities of beef with respect to milk were found. But this implies that the computed beef/milk output elasticities will be positive. In the case of binding quota, however, a negative value is much more likely.

[13] Which relies on the so-called MISS-model (Modèle international simplifié de simulation). An additional source could have been Folmer *et al* (1995), which reports on the ECAM-model, but unfortunately does not provide any elasticity estimates.

Helming *et al* (1993), and to a lesser extent on Nuppenau (1989), Guyomard *et al* (1993), and Burton (1984). The elasticities provided by the Helming study are taken to be the appropriate ones for the Netherlands (see Table 8.2). Since it is known that there are significant differences between the structure of the cattle/dairy sectors in the various EU member states, it is not easy to defend the hypothesis of the Dutch dairy sector being the representative for the EU sample. As was noted before, pre-quota research also suggests that there are a number of similarities prevailing. On the basis of these considerations, prior estimates for the other countries are chosen as a hybrid of various sources, and descriptive information on the cattle/dairy structure, as for example provided by Burrell (1989), and Dillen and Tollens (1990). We distinguish between The Netherlands, and two categories of other countries for which less reliable prior information is available, *i.e.* the 'dairy specialists' and the 'beef specialists'[14].

Using Eurostat monthly price estimates from Nuppenau, the beef supply elasticity with respect to own price is estimated to be 1.8 (short run) to 2.6 (medium run), while Guyomard *et al* (1993) provides a more conservative estimate of 0.488. The relatively high elasticities found by Nuppenau, as compared with Helming *et al* (1993) and Guyomard *et al* (1993), may partly reflect the (very) short run dynamics discussed in Section 8.3. With respect to the own price beef supply elasticity, for dairy specialists, a prior estimate of 0.50 is used and with regard to the beef specialists the elasticity estimate is 1.5. Nuppenau estimates the elasticity of beef supply with respect to milk output to range from -0.22 (short run) to -0.75 (medium run). Accounting for differences in sector structure, the prior estimates of the elasticities of beef supply with respect to milk output are given by -0.60 for dairy specialists, and -0.40 for beef specialists. Guyomard *et al* (1993) provide cross price elasticities of beef supply for a number of feed ingredients, which are all less or equal to -0.4. As compared to the elasticities found at an ingredient level, the compound feed elasticity might be expected to be even more inelastic. For the dairy specialists the

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[14] The 'beef specialists' are those countries where non-milk or other cows are well represented (dairy cows less than 30 % of the total livestock number), like France, the United Kingdom, Ireland. All other countries are grouped among the 'dairy specialists'. This distinction more or less corresponds with that provided by Dillen and Tollens (1990, 49), who report that 'other cows' are well represented in France (60.1 %), Greece (57.3 %), Spain (53.1 %), Portugal (48.4 %) and the UK (47.1 %), whereas they are poorly represented in Denmark (8.8 %, (non-unified) Germany (3.5 %), and the Netherlands (no number) (percentages based on 1988 data).

compound feed elasticity prior estimate is -0.11 (corresponding to the Dutch study), while for the beef specialists, which usually rely on a more extensive type of farming, an elasticity of -0.06 is used. Elasticities of beef and veal supply with respect to land and livestock are taken from the Helming study for The Netherlands because of lack of other information.

Nuppenau estimated the elasticity of feed demand with respect to its own price and milk output as -2.5 and 1.3, respectively[15]. However, in contrast with our model, the livestock 'capital' variable plays no role in Nupenau's feed demand equation. As a consequence, the computed elasticities are conditional on a freely varying livestock herd. Not surprisingly they are relatively high as compared to for example the Helming *et al* (1993) study, which also fixes livestock capital. The prior estimates of the own feed price demand elasticity for dairy specialists is -0.80 and -1.25 for beef specialists. Moreover, the elasticities of feed demand with respect to milk output is 0.65 for both categories. Since no specific information regarding the elasticities of feed demand with respect to land and livestock is available, the estimates provided by Helming *et al* (1993) study are used, except for the elasticity of feed with respect to livestock capital for beef specialists, which is set at 0.24[16]. Relying on Helming *et al* (1993) and Guyomard *et al* (1993) the cross price elasticities of feed demand with respect to the price of beef and veal are fixed at 0.07 for both dairy specialists and beef producers.

The Burton (1984) study suggests that the elasticity for livestock 'capital' (herd size) with respect to the feed price ranges from -0.065 to -0.48, depending on the length of run (1 year, more than 10 year). Non-european studies like those of Howard and Shumway (1988) and Weersink and Howard (1990), which focus on the non-quota restricted US dairy market, are less relevant but support the inelastic response of livestock 'capital' with respect to the feed price found by Burton. On the basis of this information, a prior estimate of -0.10 is chosen for livestock capital with respect to feed price (see Table 8.2, livestock-rows). In order to capture a significant part of the stock adjustment, a beef output price lag of 2 to 3 years seems advisable

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[15] Evaluated for 1983, which is more or less at the middle of the period Nuppenau reviews, while yearly prices were taken as 'converged' equilibrium prices. (Nuppenau uses monthly data and different price lags up to 19 months).

[16] Those countries had a somewhat lower feed intake per animal than the dairy specialists.

(*cf.* Rayner, 1975, pp.135 and 140-141 for a further motivation in terms of breeding lags and opportunity costs of investment). The elasticity of livestock 'capital' with respect to the (2 years lagged) beef and veal output price is estimated to vary from 0.40 for The Netherlands, to 0.80 and 1.25 for dairy and beef specialists respectively. The elasticities of livestock 'capital' with respect to (restricted) milk output are estimated to range from 0.70 for The Netherlands, to 0.60 (dairy specialists) and 0.40 (beef specialists). The variation in the elasticities is mainly based on differences in milk cow and beef cow shares (in the total number of cows) between groups.

Table 8.2 Synthetic prior information for the cattle/dairy sector on own and cross price elasticities

Variable	price beef&veal	price feed	land	livestock 'capital'	milk production
	The Netherlands				
beef & veal	0.15	-0.11	0.34	0.96	-0.78
feed	0.10	-0.03	-0.40	0.48	0.67
livestock	0.40	-0.10	-	-	0.70
	(Other) dairy specialists *)				
beef & veal	0.50	-0.11	0.34	0.96	-0.60
feed	0.07	-0.80	-0.40	0.48	0.65
livestock	0.80	-0.10	-	-	0.60
	Beef specialists **)				
beef & veal	1.50	-0.06	0.34	0.96	-0.40
feed	0.07	-1.25	-0.40	0.24	0.65
livestock	1.25	-0.10			0.40

*) Other dairy specialists: Denmark, Germany, Italy, Belgium/Luxembourg;

**) Beef specialists: United Kingdom, France, Ireland.

In attaching variances to these estimates, two distinctions were made. The first one is that between The Netherlands and the rest of the countries, because for the first rather detailed and reliable prior information was available. The second one is between own price elasticities (about which usually more (certain) information was available) and cross price and production elasticities. Beef and veal own price supply and the feed demand paramaters are set at 50% for the Netherlands, Germany and the United Kingdom, and at 75% for all other countries. For all other parameters a 100% confidence interval is used, which not only preserves the sign, but simultaneously reflects the relatively high degree of uncertainty concerning these estimates. A 100% confidence bound on the feed price in the beef & veal output supply, for example, should be read as a confidence interval of -0.11 ± 0.11, or a 95% probability of a cross price elasticity within the range $[-0.22, 0]$. The information on price and input elasticities is translated into quantitative restrictions on parameters, which in matrix form are equal to $P\mu = p$. The mixed estimation procedure used, which accounts for (semi) endogeneity of rationed milk output, is briefly discussed in Appendix 8A.

8.5 Estimation results and discussion

Before estimating the final model, expected price variables have been generated since producers are assumed to follow expected profit maximization behaviour. Expected prices are explained by an information set which includes lagged (own) price, a trend variable, and a dummy trend variable (zero up till 1984 and a trend thereafter)[17]. Beef and veal prices in particular show strong fluctuations and require careful consideration. Generating prices with a simple AR1 scheme, a not unusual procedure for generating an expected price series, is not satisfactory in this case. As a second step before finally estimating the individual country cattle-dairy models, a Hausman test is computed (on the unrestricted model) in order to test whether there is a significant simultaneity bias (*cf.* Maddala (1992, p.395). Simultaneity is generally rejected, except in the case of Belgium/Luxembourg (meat and feed), the United Kingdom (meat) and the Netherlands (feed). Although not necessary for all countries, for uniform treatment and because imposing restrictions tends to increase

[17] Assuming producers follow a (truncated) rational expectations approach in generating expected prices, a broad information set may be used, which besides the varibles mentioned above, also may include past (other) prices and quantities.

simultaneity problems, the 3SLS estimator is used in all cases.

The results (in elasticity terms) for the final model (consisting of equations 1, 2, and 8) are presented in Tables 8.3 (beef and veal supply and feed demand relationships), and 8.4 (the livestock 'capital' equation). Parameter estimates for the restricted mixed estimates are presented in Appendix 8B (*cf.* Tables 8B-1 and 8B-2).

Table 8.3 Estimation results in elasticity form

		price beef&veal [p1]	price feed [p2]	land [z1]	# cows [z2]	milk output [z3]	trend*) [z4]	α_p
Netherlands	beef&veal	0.14	-0.24	0.37	0.16	-0.28	0.03	0.519
	feed	0.14	-0.03	-0.43	0.55	0.88	0.01	
France	beef&veal	0.07	-0.03	0.43	0.59	-0.07	0.02	0.507
	feed	0.10	-0.03	-0.37	0.14	0.49	0.03	
Germany	beef&veal	0.04	-0.07	0.01	-0.23	0.22	0.01	0.511
	feed	0.14	-0.03	-0.71	0.67	1.68	0.02	
Denmark	beef&veal	0.17	-0.24	0.09	-0.38	0.87	-0.02	0.445
	feed	0.24	0.03	-1.18	1.44	1.98	0.04	
Italy	beef&veal	0.97	-0.45	0.18	2.91	-1.46	0.04	0.450
	feed	0.58	-0.03	-0.14	0.69	1.13	0.07	
United	beef&veal	0.15	-0.22	0.38	1.08	-0.69	0.01	0.481
Kingdom	feed	0.10	-0.03	-0.28	-0.22	1.73	-0.02	
Ireland	beef&veal	0.14	-0.11	0.28	0.57	-0.61	0.03	0.546
	feed	0.14	-0.03	-0.33	0.54	1.12	0.04	
Belgium	beef&veal	0.23	-0.04	0.46	0.45	-0.44	0.03	0.499
	feed	0.05	-0.04	-0.56	0.67	0.58	0.02	
EU (weighted	beef&veal	0.21	-0.15	0.27	0.70	-0.32	0.02	
average) **)	feed	0.18	-0.03	-0.42	0.42	1.17	0.03	

*) *Expressed as yearly growth percentage*; **) *Weighted with 1990 output and input volume shares*

As Appendix 8B (Table 8B-1) shows, the goodness of fit is satisfactory for feed input demand (with the exception of Denmark), but rather low for beef and veal output supply. Given the cyclical character of both supply and prices for beef and veal, this is no great surprise. In particular for the UK and Ireland, large unexplained fluctuations remain. As more stochastic and/or non-stochastic restrictions are imposed, the explained variance declines although adding the theoretical restrictions to the already imposed stochastic prior information in all cases only leads to negligi reductions in the goodness of fit. This indicates that both types of prior information largely point in the same direction and are therefore not really 'independent' restictions, at least in a statistical sense. Although no details are provided, it is a general pattern that the autocorrelation increases when more stochastic and non-stochastic restrictions are imposed. In the case of the unrestricted model, autocorrelation was no problem. However, for the final estimated models autocorrelation sometimes poses a problem, while several times Durbin-Watson (DW) statistics are found in the inconclusive region. However, in this context there is no reason to attach too much importance to the values of the DW statistics. They already have their limitations as misspecification tests (see Spanos, 1986, p.517), and these limitations are particularly relevant in a mixed estimation context[18].

Table 8.3 shows several further details. Both the own price elasticity for feed input and the own price elasticity for beef and veal output show deviations from the prior estimates. A strange result is found for feed demand in Denmark (positive but not significant own price elasticity). The estimates for livestock 'capital' and rationed milk output show still larger variations with sometimes also sign-differences. For Denmark the sign of the elasticity of milk output with respect to beef and veal output is positive (although not significant) in spite of the negative prior estimate. A possibility is that easing the quota restriction will favour both beef and veal and milk production at the cost of other alternatives (like sheep) not taken into account here. The last column of Table 8.3 gives an impression of the general role of prior information. As the α_p -values indicate, the share of the prior information in the posterior precision is about 49.5%, a share more or less comparable to that found for the arable sector (see previous chapter).

Because prior information has been added to all coefficients, except for the

[18] The mixed estimation procedure can be interpreted as a 'solution' to the problem of misspecification in a world where misspecification is on the one hand unavoidable, but where one on the other hand tries to reduce the biasedness in the estimated parameters due to this misspecification. Since the unrestricted estimators revealed hardly problems with autocorrelation, as such non-satisfactory DW statistics point to the tension between sample and prior information, without being very specific however. One conclusion could be that the prior information is incompatible with the sample, and that imposing 'wrong constraints' lead to biased estimates. An alternative conclusion is, however, that the model is misspecified, while at the same time one refuses to to let the included variables pick up the bias introduced by 'omitted variables'. Whereas drawing the first conclusion should lead to action, drawing the alternative conclusion leads to less pronounced advises.

intercept and trend variable, some strange results with respect to these 'free' variables would not have been surprising. However, when looking at the trend-coefficients (expressed in terms of average yearly output/input growth percentage) quite reasonable numbers have been obtained. With respect to the intercept terms this is less clear. The t-values indicate that 7 out of the 16 own price parameters are significant at a 95% confidence level. The trend variable has a high significance level, followed by rationed milk output and livestock 'capital'. In the latter case only half of the estimated parameters appear to be significantly different from zero. Although the reported (non-zero) values are the most likely ones, note that the effects of stock adjustment dynamics should be interpreted with caution.

Table 8.4 Estimation results livestock adjustment equation (in elasticity form)

Country	price beef&veal	price feed	milk output	autonomous growth rate
Netherlands	0.087	-0.031	0.513	-0.024
France	0.090	-0.116	0.281	-0.018
Germany	0.210	-0.085	0.284	0.002
Denmark	0.005	-0.133	0.300	-0.035
Italy	0.216	-0.068	-0.143	-0.012
United Kingdom	0.030	-0.165	-0.162	-0.009
Ireland	-0.050	-0.134	0.042	0.008
Belgium	0.036	-0.022	0.271	0.007

The results (in elasticity terms) of the stock adjustment equations are provided in Table 8.4. There appears to be a lot of variation among the countries. The herd sizes of Germany and Italy appear to be most sensitive to lagged beef price changes. The reaction to a decline in the feed price is a shrinking herd for all countries, with the UK reacting most, closely followed by Ireland and Denmark. Rationed milk output shows a strong effect for typical dairy countries like The Netherlands, Denmark, France, Germany, and Belgium. The final estimation results (see Appendix 8B, Table 8B-2) make it clear that the simplified stock adjustment approximations do reasonably well in terms of goodness of fit (with Ireland as the exception). The dummy trend variable indicates that there is decline in the herd size in the Netherlands, France, Denmark, Italy and the UK since the introduction of the super levy regime. Germany, Ireland, and Belgium in contrast show an increase in the herd size, although this increase is significant only for Belgium.

8.6 Concluding remarks

In this chapter models for the EU cattle-dairy sector have been developed and estimated. Sector specific characteristics, like rationed milk output, and animal production dynamics have been taken into account. Prior information has been used to improve the estimation results. Beef and veal supply and compound feed input demand are in general found to be rather insensitive to price changes. Milk output in general competes with meat production. Beef and veal output shows a slightly positive growth rate, which is probably due to a gradual increase in slaughtering weights. The herdsize adjustment is rather well explained, but the decisive variables differ across the countries. Typical dairy countries show a strong effect of rationed milk output on herdsize, while in other countries (Italy, Germany) lagged beef prices, or compound feed prices (UK, Ireland, Denmark) play an important role. Taking into account the differentiation, decomposing livestock capital into dairy herd-capital and beef herds-capital, and roughage would probably be preferable for a more refined analysis.

APPENDIX 8A Simultaneous mixed estimaton

The estimator used for the short run demand/supply system is discussed in this appendix. The estimator used for the livestock equations is analogous to the mixed estimation procedure for the arable sector model and is therefore not discussed here. Since the explanatory milk output variable is partly endogenous, a simultaneity bias is introduced when the short run supply/demand system is estimated with an OLS or GLS-estimator. Therefore one requirement the estimator has to fulfill is to cope with this endogeneity problem. Before deriving the final estimator, the above model (see equations 1 and 2) is rewritten in matrix notation as

$$y_1 = X\delta_1 + y_0\gamma_1 + e_1 \qquad (A-1)$$

$$y_2 = X\delta_2 + y_0\gamma_2 + e_1 \qquad (A-2)$$

where X represents a TxK matrix of exogenous variables. Or more compactly

$$y_i = Z\mu_i + e_i; \qquad i = 1,2 \qquad (A-3)$$

with $Z_i = Z = [X, y_0]$ and $\mu_i = [\delta_i, \gamma_i]'$. Because y_0 is endogenous for the pre-quota period, it is partly correlated with the disturbance terms e_1 and e_2. Premultiplying (5) with a KxT matrix W (which contains a set of instruments which are uncorrelated with the error terms) gives

$$W'y_i = (W'Z)\mu_i^{IV}; \qquad i = 1,2 \qquad (A-4)$$

with $W'e_i$ equal to zero because of the assumption that $E(W_{jt}e_{it}) = 0$ for $j = 1,\dots,K;\ t = 1,\dots,T$. Given that $W'Z$ is non-singular, the corresponding instrumental variable estimator is

$$\mu_i^{IV} = (W'Z)^{-1}W'y_i; \qquad i = 1,2 \qquad (A-5)$$

The W - matrix of instruments may contain the X - matrix, and even part of the y_0 - vector, *viz.* the part associated with the quota period. The candidate suggested for W is therefore

$$W = \left[X , \frac{\hat{y}_0^0}{y_0^1} \right] \tag{A-6}$$

where y_0^1 represent the exogenous part of y_0 and $\hat{y}_0^0$ represents the instrument used to correct for the endogenous observations. The vector $\hat{y}_0^0$ is obtained by first regressing y_0^0 on the exogenous variables in the system and eventually on some other added variables and then computing the predicted variable, or

$$\hat{y}_0^0 = H(H'H)^{-1}H'y_0^0 \tag{A-7}$$

where H represents a matrix containing X and possibly some other exogenous variables.

The IV estimator has the properties of a 2SLS estimator because the instrument used is 'closer' to y_0^0than any other instrument of this class (see for example Fomby *et al*, 1984, pp.478-482). It satisfies consistency, but is still inefficient because it does not yet take the contemporaneous correlation between the (two) error terms into account. The standard procedure to allow for this is to construct a feasible Aitken or GLS estimator, which ultimately leads to a kind of 3SLS estimator. As a first step the individual equation residuals are generated using the IV or 2SLS procedure discussed before. The estimated residuals are then used to construct a consistent estimate of the contemporous correlation covariance matrix $\hat{\Sigma}$. Rewriting the IV or 2SLS estimator for the whole system as:

$$\mu^{IV} = (I \otimes [W'W]^{-1}W')y \tag{A-8}$$

where the property that $W'Z = W'W$ is used (see Fomby et al, 1984, p.480), $\mu = [\mu_1, \mu_2]'$, and I is the 2-dimensional unit matrix. The 3SLS (or GLS) systems-estimator can then be written as

$$\mu^{3SLS} = \overline{W}'(\hat{\Sigma} \otimes I_T)^{-1}\overline{W})^{-1}\overline{W}'(\hat{\Sigma} \otimes I_T)^{-1}y \qquad (A-9)$$

with $\overline{W}$ the 2Tx2K diagonal matrix $I \otimes W$.

Subsequently, the estimator is transformed to incorporate the available prior information (*cf.* analogy with Section 5.3). Assuming the uncertain quantitative prior information can be expressed by

$$p = P\mu + v \qquad (A-10)$$

with all (known) matrices of the appropriate order (the dimensions partly depending on the number of stochastic restrictions) and having full row rank, $E(v) = 0$ and $E(vv') = V_p$. The corresponding (unrestricted) mixed estimator M-3SLS can then be written as

$$\mu^{M-3SLS} = [\overline{W}'(\hat{\Sigma} \otimes I_T)^{-1}\overline{W} + P'V_p^{-1}P]^{-1} \quad \text{x}$$

$$(\overline{W}'(\hat{\Sigma} \otimes I_T)^{-1}y + P'V_p^{-1}p) \qquad (A-11)$$

where $V_m = [\overline{W}'(\hat{\Sigma} \otimes I_T)^{-1}\overline{W} + P'V_p^{-1}P]^{-1}$ represents the covariance matrix associated with μ^{M-3SLS}. The non-stochastic restrictions are constraints of the form $R\mu = r$ with all matrices again assumed of the appropriate order. The restricted mixed 3SLS estimator is the solution to the following optimization problem

$$\text{Min}.\{(y - \overline{W}\mu^{M-3SLS})'V_m^{-1}(y - \overline{W}\mu^{M-3SLS})\} \qquad (A-12)$$

$$\text{s.t.} \quad R\mu^{M-3SLS} = r$$

and can be written as

$$\mu^{RM-3SLS} = \mu^{M-3SLS} + (\overline{W}'(\hat{\Sigma} \otimes I_T)^{-1}\overline{W})^{-1}R' \quad \text{x}$$

$$[R(\hat{\Sigma} \otimes I_T)^{-1}R']^{-1}(r - R\mu^{M-3SLS}) \qquad (A-13)$$

with

$$V_{r-m} = V_m -$$

$$(\overline{W}'(\hat{\Sigma} \otimes I_T)^{-1}\overline{W})^{-1} R'[R(\hat{\Sigma} \otimes I_T)^{-1} R']^{-1} R(\overline{W}'(\hat{\Sigma} \otimes I_T)^{-1}\overline{W})^{-1} \qquad (A-14)$$

the corresponding 2Kx2K covariance matrix. This result is in fact the natural extension of the restricted SUR-estimator discussed by Judge *et al* (1988, p.457).

Appendix 8B Estimation results

This appendix gives the estimation results of the restricted mixed 3SLS estimation procedure for both the short and intermediate run equations. T-values are given in the lines below the parameter estimates.

Table 8B-1 RM-3SLS estimation results short-run model (t-values below)

Country	variable	intercept a.0	pr.b&v a.1	pr.feed a.2	land b.1	#cows b.2	milkprod b.3	trend b.4	Goodness of fit
Neth	beaf&veal	269.350	0.136	-1.586	0.142	0.032	-0.011	11.479	0.812
		2.75	3.76	-3.90	4.39	4.48	-1.83	8.75	
	feed	-1043.300	1.586	-2.193	-1.828	1.228	0.378	51.729	0.785
		-1.19	3.90	-3.96	-4.36	5.26	7.21	3.96	
Fra	beaf&veal	-445.970	0.103	-0.273	0.067	0.167	-0.005	46.744	0.486
		-0.45	1.10	-1.22	1.27	1.49	-0.13	2.05	
	feed	1093.200	0.273	-0.517	-0.100	0.068	0.064	119.01	0.892
		0.49	1.22	-2.12	-0.92	0.38	0.93	3.18	
Germ.	beaf&veal	1409.000	0.149	-2.317	0.003	-0.066	0.014	19.045	0.816
		1.98	0.62	-1.77	0.04	-0.37	0.49	1.69	
	feed	5819.600	2.317	-4.056	-0.913	0.771	0.426	120.27	0.815
		-1.47	1.77	-2.06	-1.86	1.54	4.15	2.47	
Denm.	beaf&veal	161.820	0.028	-0.282	0.030	-0.094	0.041	-4.597	0.667
		1.31	3.25	-5.03	0.30	-0.97	2.61	-1.84	
	feed	-3314.800	0.282	-0.230	-2.816	2.597	0.687	77.018	0.525
		-3.2	5.03	-1.79	-3.15	4.01	5.68	4.39	
Italy	beaf&veal	-1416.100	0.004	-0.008	0.060	0.853	-0.126	38.957	0.409
		-5.0	16.64	-9.33	0.68	8.32	-3.95	7.40	
	feed	-6981.200	0.008	-0.002	0.168	0.721	0.352	221.23	0.945
		-4.31	9.33	-2.10	0.40	1.72	2.43	9.09	
UK	beaf&veal	254.810	1.848	-5.609	0.034	0.340	-0.046	6.060	0.292
		0.44	2.22	-2.65	1.18	2.36	-2.57	1.28	
	feed	-624.120	5.609	-3.558	-0.115	-0.315	0.530	-78.902	0.717
		-0.30	2.65	-2.03	-0.76	-0.63	7.31	-4.22	

(Table continued on next page)

(Table 8B-1 continued)

Country	variable	intercept a.0	pr.b&v a.1	pr.feed a.2	land b.1	#cows b.2	milkprod b.3	trend b.4	Goodness of fit
Irl	beaf&veal	215.960	0.736	-1.467	0.030	0.192	-0.060	13.940	0.293
		0.62	1.92	-1.74	0.94	0.69	-1.32	2.14	
	feed	-801.050	1.467	-0.830	-0.071	0.370	0.227	35.569	0.865
		-1.40	1.74	-1.98	-0.93	1.17	2.88	2.91	
Bellux	beaf&veal	83.878	0.008	-0.007	0.247	0.135	-0.033	8.127	0.575
		0.37	0.42	-0.88	1.46	0.81	-0.77	2.78	
	feed	178.890	0.007	-0.029	-1.241	0.833	0.181	20.395	0.805
		0.20	0.88	-2.43	-1.58	1.78	1.24	1.84	

Table 8B-2 RM estimation results livestock adjustment equation (t-values below)

Variable / Country	intercept	2 yr lagged pbeef&veal	pfeed	milk production	dtrend	R-square	DW
Neth	1049.400	0.370	8.113	0.065	-44.104	0.961	1.396
	7.771	0.639	2.061	2.451	-7.508		
Fra	24133.000	5.618	-24.585	-0.041	-547.520	0.900	1.426
	3.494	1.533	-1.941	-0.128	-3.400		
Germ	90750.000	10.778	-21.987	0.143	39.015	0.830	1.141
	10.728	2.807	-1.001	1.979	1.251		
Denm	2953.600	0.115	-3.411	0.071	-109.380	0.979	1.809
	4.518	0.634	-2.932	0.523	-6.660		
Italy	11301.000	0.015	-0.001	-0.399	-134.040	0.892	2.055
	7.725	3.349	-0.060	-2.301	-5.387		
Uk	20.186	19.630	-92.151	-0.331	-181.250	0.945	1.809
	11.466	2.362	-2.739	2.283	-2.702		
Irl	7372.600	3.983	-51.364	-0.081	31.790	0.739	1.664
	11.622	0.471	-1.439	-0.329	1.027		
Bellux	2482.700	0.022	0.067	0.058	16.944	0.803	1.511
	4.948	0.928	0.663	0.389	3.720		

Chapter 9

The Intensive Livestock Sector

9.1 Introduction

The subject of this chapter is the intensive livestock sector, which is defined here as the pigs, poultry and eggs producing farm operations. The characteristics of the sector are described, economic models developed and estimated. The chapter is structured as follows. Firstly, a brief introduction to the sector is provided in the rest of this section. The economic modelling framework is presented in Section 2. Particular attention is paid to the specific type of productivity growth (improving feed conversion rates) and the intermediate run (capacity adjustment). Section 3 elaborates on the approximation of the unobservable variables namely animal productivity progress, direct feeding, and production capacity. Section 4 provides the prior information used, which is partly derived from previous research, and partly comes from exploiting the feed balance conditions. Section 5 contains the estimation results. Finally, the paper closes with some final remarks (Section 6).

The intensive livestock sector is an important subsector of EU agriculture[1]. The sector's value share in total production value of EU agriculture is more than 17% (Table 9.1) in 1990, which is more or less comparable with the dairy sector, and

[1] As such it is surprising that relatively few economic studies analysing this sector were found in the European agricultural economics literature. A rough survey of the main periodicals in european agricultural economics showed that when the intensive livestock sector received attention, it usually focussed on the demand for meat, but seldom dealt with supply. The demand for machinery inputs, to mention a relatively derived topic for example, received more attention than pork supply.

about 1.5 times as large as that of the cereals and beef subsectors[2]. In terms of the value of EU agricultural production, pigs accounts for some 10%, while poultry meat and eggs provide about 7%. Pork production is the most important branch of the intensive livestock sector, with a value share in the total produced output of the intensive livestock sector of about 58%. When looking at output volumes of pork, Germany, the Netherlands, France and Spain are the countries most heavily engaged in pork production. When looking at self sufficiency rates (not reported in Table 9.1) The Netherlands, Denmark, and to a lesser extent Belgium are the EU's main net exporters of pork[3]. France, Italy, the United Kingdom, and Spain are dominant in poultry meat production, whereas France, Germany, the United Kingdom, and Spain are dominant in eggs production. Intensive livestock production shows a trend to specialization with increasing concentration of production in terms of enterprises (Agricultural Situation, various years).

Figure 9.1 gives an overview of the developments in the EU's supply of intensive livestock products. Poultry meat production has been most expansive, with egg production hardly growing and pork production showing mitigated growth. Over the period 1980-1991 the average growth percentages for pork, poultry and eggs were 2.2%, 2.6% and 0.5% respectively.

The growth in (total) pork production is in particular caused by continuous growth in Germany, the BLEU, Denmark and Spain. Other countries like France, the Netherlands, the UK, and to a lesser extent Italy show significant output fluctuations. France, Italy and Spain experience a decline in the production of poultry meat, which is not compensated for by continuously growing producers like the UK, Ireland, and Denmark. In the second half of the 1980s all countries are back on their growth paths. With respect to eggs production, the final result shown in Figure 9.1 is due to continuously declining production in Germany and to a lesser extent in the UK and the BLEU, combined with stagnating production in France and the Netherlands, and increasing but fluctuating production in small egg producers like Danmark, Greece, and Portugal. Earlier in the previous 1970s Germany already showed a declining trend, but large producers like France and Italy showed

[2] Of course this is partly due to the fact that the sector is less subject to policy interference.

[3] See Table 11A-1 in Appendix 11A of Chapter 11.

Table 9.1 Share of member state production in total EU production

Country		Pig meat [%]	Poultry [%]	Eggs [%]	Value [Mill. Ecu]	Share in nat. agr. output value [%]
Netherlands		14.1	7.9	13.5	3 805	24.34
Belgium		5.6	2.6	3.7	1 582	25.52
France		13.6	24.6	18.9	6 240	12.91
Germany		23.6	7.1	15.4	6 083	21.98
Italy		9.1	17.4	12.2	5 236	14.42
Denmark		9.1	2.1	1.7	2 090	29.80
Ireland		1.2	1.3	0.7	391	9.34
United Kingdom		7.2	16.5	15.1	3 531	18.81
Portugal		2.1	2.9	1.9	777	21.52
Spain		13.3	13.2	14.2	4 545	16.09
Greece		1.1	2.5	2.7	667	8.22
EC-12	[%]	100	100	100	34 947	17.25
	[1000 t]	13 322	6 314	4 376		

Source: The agricultural situation in the EU; 1992 Report

counter-acting significant growth levels, which in combination with the fluctuating output of the other countries led to a more or less stable output level for the EU as a whole.

Since meat and eggs are nothing less then processed feeds, and expenditures on feed are the most important single cost item, the feed input-side of the sector deserves some specific attention (see Figure 9.1 for the development of compound feed consumption). In at least a number of EU countries, farmers have mixed enterprises which comprise both intensive livestock production and arable production. Intensive livestock production in the Netherlands, Belgium, Northern Ireland, parts of Germany and Spain is mainly based on (imported) feed ingredients, with a significant role for animal feed compounders. In contrast other regions, for example France, rely on local feed ingredients (cereals) and on on-farm processing of feed, with a much less significant role for the compound feed industry. According to some dated estimates by Peeters (1989, p.27), direct on-farm use of cereals in

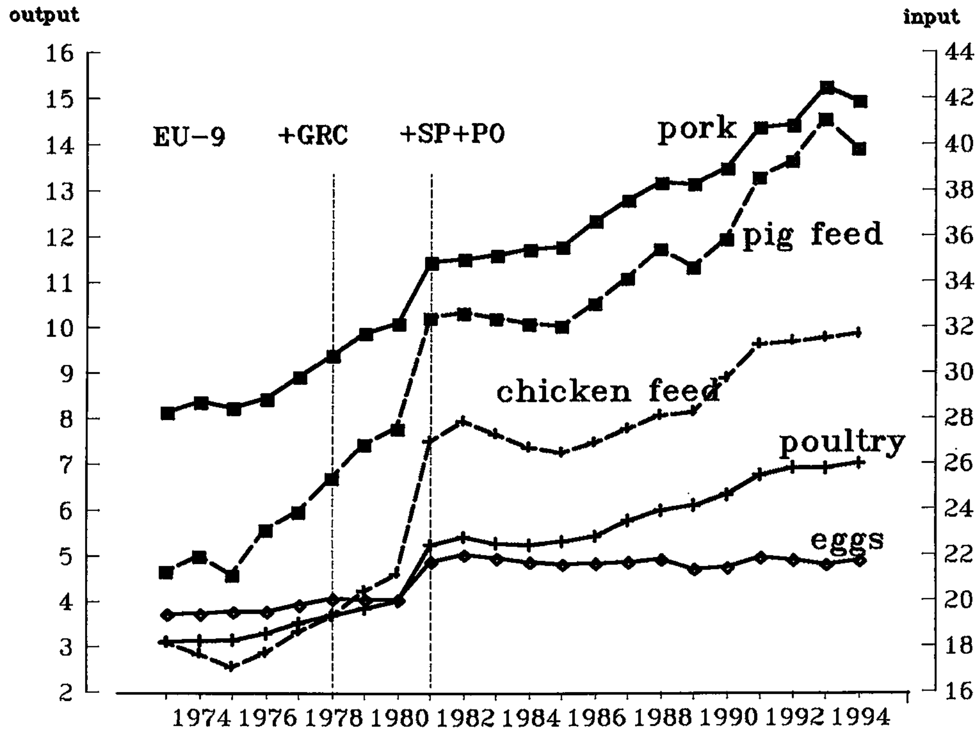

Figure 9.1: The trend in the EU's intensive livestock output and input

the EU9 declined from about 50% in 1975/76 to about 40% in 1984/85, which is still significant. In this study the focus is on the intensive livestock sector as such, while the arable component of the mixed farms is artificially separated and accounted for when modelling the arable sector (see Chapter 7). Nevertheless, mixed farmers often have feed practices that differ from specialized farmers in that they can easily use feedstuffs produced by the arable sector as an input for their livestock enterprise. For example for-slaughtering chickens production, farmers can simply mix in whole grain of wheat and/or maize to the compound feed they obtain from the compound feed industry. Home grown feedstuffs can play an important role, since for slaughtering chickens the share of cereals (mainly wheat and maize) in (complete) compound feed is 40-50%, while for the laying hens (eggs production) this percentage is even higher (50-55%)[4]. This so-called direct feeding requires therefore some specific treatment. The amount of direct feeding is assumed to be the outcome of an optimization process, where farmers compare the opportunity costs of home-grown feeds (off-farm selling) with the alternative of on farm consumption. Under this assumption direct feed demand can be modelled as a normal input, with the shadow price (corresponding to on-farm use) of direct feed equal its market price[5].

The joint budget costs associated with the intensive livestock products amounted to 1.63 billion Ecu (1990), which is about 6% of the total EOGFL guarantee expenditure. The common market organisations (CMOs) for pork, poultry meat and eggs are lightly structured when seen in relation to those for cereals and dairy. Basically they consist of export subsidies aimed at compensating for the competitive disadvantage EU livestock farmers have because of the domestic cereals price support regime. Besides the export subsidies, the pork-regime consists of a scheme of private storage aid, which is however not always in place, but only functions in extreme situations. For poultry meat and eggs, there exists no internal market support, but only export restitutions to compensate for the relatively high feed input costs within the EU.

9.2 The economic model

As was already remarked elsewhere,[6] there is a long tradition of supply research in agricultural economics of which modelling the supply dynamics forms an important part. As the well-known pig cycle-phenomenon suggests, supply dynamics should explicitly be considered when modelling the intensive livestock sector behaviour. The need for explicitly modelling this dynamics, however, depends on both the length of the production cycle, and on the length of the time period chosen for the analysis. The production cycle for pork is estimated to be about 5 months (based

[4] Laying hens are fed with roughly ground feeds in order to avoid so-called luxury consumption and weariness.

[5] Direct feeding is understood to refer to self compounding of concentrate feeds on the basis of local feed ingredients, and is thus not necessary limited to the use of on-own-farm grown feed ingredients.

[6] See previous chapter on the EU dairy sector.

on the fattening period). In the chicken sector broiler production takes a period of about 2 months, while egg production follows a cycle of about 10 months, exhibiting a low laying rate, then a production peak, followed by a slow decline in productivity. Choosing an anual time frame implies that 2.5 times the pig cycle, 6 times the broiler cycle, and 1.2 times the laying hen cycle are included in the period of observation. As a consequence, a considerable part of the production dynamics might be expected to be netted out. Also given that reliable modelling of supply dynamic is far from trivial, in contrast with the dairy sector, here the option chosen is not to take explicitly take the animal dynamics into account.

Another characteristic of intensive livestock production is that technological change has spcifically improved feed conversion rates: the amount of compound feed necessary to produce one unit of meat output tends to decrease over time. This type of technological change is more or less equivalent to the well-known case of factor augmenting technological change. The only difference is that the 'quality improvement' of the input factor is not embodied in the feed input itself, but is due to more efficient feed processing by the animals (genetic improvement). Analogous to Chambers (1988, pp.210-227), the meat producing technology then may be written (in terms of the production function) as

$$y = f(\lambda(t)x, z) \tag{1}$$

with y meat output, x (variable) feed input, and z representing all other (quasi-fixed) inputs. Lambda represents the over time efficiency increase of the feed input, whereas $\lambda(t)x$ represents the effective feed input $\tilde{x}$. Following Chambers this implies that the final profit function may be written as

$$\begin{aligned} \Pi(p,w,z,t) &= \max_{y>0} \{py - C(\tilde{w},z,y,t)\} \\ &= \Pi(p,\tilde{w},z,t) \end{aligned} \tag{2}$$

with $\tilde{w}$ the effective price associated with compound feed input. Because $\Pi(.)$ is non-increasing in w, input augmenting technical change can be said to be profit enhancing, or as increasing the effective per unit return from producing a given output. In the following, genetic improvement will be included in the economic model as a special case of input augmenting technical change. Besides biological technical change, also other forms of technical change (improvements in holding practices) are allowed for, as is expressed by the separate time shift variable *t*.

Besides the production dynamics and feed conversion improvement, a third characteristic of intensive livestock production is, at least for some regions in the EU, the capital intensity. As a consequence of this the production capacity variable plays a significant role, reducing the impact of short run price fluctuations on supply. Including a quasi-fixed capacity variable in the livestock models introduces a distinction between short and medium run famer's behaviour. In the short run the farmer takes his capacity as given, while in the longer run he can adjust his capacity variable to a level consistent with overall-profit maximization.

Choosing a normalized quadratic profit function specification, for sector *h* (*h=1* for pigs; *h-2* for broilers and eggs) the profit and derived netput functions are:

$$\Pi^h = \alpha_0 + \sum_{i=1}^{n} \alpha_i p_i^h + \sum_{i=1}^{n}\sum_{j=1}^{n} \alpha_{ij} p_i^h p_j^h + \sum_{k=1}^{m} \beta_k z_k^h + \sum_{k=1}^{m}\sum_{l=1}^{m} \beta_{kl} z_k^h z_l^h + \sum_{i=1}^{n}\sum_{k=1}^{m} \gamma_{ik} p_i^h z_k^h \qquad (3)$$

and

$$y_i^h = \alpha_i + \sum_{j=1}^{n} \alpha_{ij} p_i^h + \sum_{k=1}^{m} \gamma_{ik} z_k^h \qquad (4)$$

where profits and (expected) prices are all normalized by the price of other inputs. The number of price variables is n, and the number of non-price variables m. For convenience sake prices are expressed as p_i 's, *e.g.* with the price vector

$p=(p_1,p_2,p_3)=(p,\tilde{w}_1,\tilde{w}_2)$.[7] Output of sector h is represented by y_1^h, while y_2^h represents the amount of compound feed used, and (if relevant) y_3^h represents the amount of direct feeding. Because of the difficulties encountered with inter-temporal dynamic profit optimization, here the adjustment of the capacity variable is modelled in a somewhat ad hoc manner. The actual level of the quasi-fixed input approximating capacity is specified to be a function of its lagged own value and a lagged output price-(effective) input price ratio, or

$$z_k^h=\delta_0+\delta_1 z_{k,t-1}+\delta_2\left(\frac{p_{1,t-1}^h}{p_{j,t-1}^h}\right) \tag{5}$$

This specification, although not explicitly derived from economic theory, eccletically captures elements from the accelerator approach, developed by Jorgenson, and the adjustment cost model developed by Lucas and Treadway[8].

9.3 Data: accounting for the unobservables

9.3.1 Feed conversion and production capacity

The sample information available to estimate the intensive livestock models consists of aggregated time series at member state level over the period 1973-1994, except for Greece (series starts in 1980) and Spain and Portugal (series starts in 1986). However, this data set is incomplete with respect to the development over time of feed conversion, direct feeding, and the capacity variable. With regard to feed conversion limited information is available, with respect to the other two variables no direct information was available. In this section some solutions are provided to recover these unobservables.

With regard to feed conversion, note that feed conversion rates cannot be

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[7] An effective expected input price $\tilde{w}_j$ is equivalent to $E_t\left(\frac{w_j/\lambda}{w_n}\mid I_{t-1}\right)$ with w_n a (non-feed) input price used as a normalization factor, E the expectations operator, λ denoting the feed conversion, and I_{t-1} denoting the information set (time subscripts are suppressed).

[8] See for references, further discussion and applications to agriculture for the first approach Oskam *et al* (1988, p.8), and for the second approach Thijssen (1992, pp.67).

derived by simply looking at meat output per unit of compound feed input-ratio's. As noted before, the relative importance of the compound feed industry in total animal feed use differs across countries. Because home-based feed input goes largely unobserved, it is difficult to generate pure feed conversion rates from input/output data. Moreover, feed conversion rates are not only determined by genetic progress, but also influenced by farm management, average slaughter weights and holding practices, as well as the use of so-called performance enhancers (in particular by using antimicrobial agents as feed additives)[9]. Based on Verduyn et al (1988, 74), and Vaessens and Backus (1997) and using simple intrapolation techniques, feed conversion series have been generated.

Unfortunately, no data is available with respect to the quasi-fixed input buildings and equipment, but there is information about number of animals, albeit sometimes incomplete. Rather than neglecting the role of the capacity-variable, and thereby introducing an 'error of omission', these animal numbers have been used to construct a derived proxy variable for production capacity[10]. Of course, the number of animals only reflects production capacity if this capacity is fully utilized. When livestock numbers are reduced, the capacity contraint is unlikely to be binding. If livestock numbers increase beyond (all) previous levels, however, capacity is likely to be a binding variable and both variables will coincide. The capacity proxy z_t is modelled by a specific moving average structure with $z_t = \max\{0.88n_{t-3}, 0.92n_{t-2}, 0.96n_{t-1}, 1.00n_t\}$, with n_{t-i} representing the number of animals at time *t-i*[11]. Normal capacity disinvestment is assumed to be approximated in a proper way by a 4% depreciation rate. The time lag is parametrically chosen between the interval of 1 to 3 years to account for differences in the capital intensities of production.

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9 Summarizing a compilation of studies De Craene and Viaene (1992, p.42) conclude that feed additives (mostly antibiotics) improved the feed conversion rates by 1% to 10% in pig production and 3% to 5% in poultry production. The effects vary with the practical circumstances and across member states. According to FEFAC (1990) statistics (cited in De Craene and Viaene, 1992, p.46), the variation over member states, however, is rather limited. Performance enhancers, at least feed additives, are generally allowed within the EU livestock industry.

10 This issue is discussed in the literature on the use of proxy variables (*cf.* Maddala, 1992, p.464-466 and the references cited therein), which suggests that even if a poor proxy of the capacity variable is available, it would be advisable to use it in the estimation procedure.

11 Note that the option chosen allows for (relatively) higher disinvestments than candidate $z_t = \max\{0.96z_{t-1}, n_t\}$ would have done. So it allows in principle for higher disinvestments (for example by actively making intensive livestock equipment suited for alternative use) than those associated with the normal depreciation rate.

9.3.2 *Food nutrition balance accounting*

The third unobservable refers to direct feeding. Given information about the final output (meat and eggs) of the intensive livestock sector, and additional information about herd population build up, it is possible to develop feed requirement computation schemes, be it in a rather rough way. By means of such calculations a (normative) estimate of direct feeding can be made, for both the pigs and chicken sectors. Following Janssens and Tollens (1990) the compound feeds and single feeds, such as grain and maize, are decomposed into an energy and protein component which represent their basic nutritional value. Energy is denoted in units ME (metabolizable energy, 10^3 Joules/kg. product), and protein in CDP (crude digestible protein, % or gr/kg). For all other variables the coefficients as represented in the computaton scheme of Appendix 9A are used. Comparing our results for computed implicit feed conversion rates with those of Blom (1985, p.249), both appear to be similar.

On the feed demand side, given the production information, the total ME and CDP requirements per animal category (pigs and chickens) are determined using the calculation rules provided by Janssens and Tollens (1990, pp.51-56). An example of the calculation scheme is provided in Appendix 9A. On the basis of herd buildup statistics for 1988, estimates have been made of country specific sector characteristics. For the pigs sector this refers to country specific estimates for the average live weight of fattening pigs, the number of piglets per sow, the number of boars per sow, and the replacement rate. For the chicken sector, country specific estimates for eggs/day/100 hens have been made. Details of these estimates are presented in Table 9.2.

Given the requirements in terms of ME and CDP, the next step is to specify the sector specific compound feeds. Using regression formulas provided by Hof (1985, p.1-15), an estimate is made of the (average) nutritional value of directly fed cereals. The single cereal feeds which are energy-rich, are not complete feeds, but always have to be supplemented by a so-called protein concentrate. So besides determining the average nutritional value of cereals, the average nutritional composition of a protein concentrate and a normal (complete) compound feed is specified. The details are provided in Table 9.3.

Table 9.2 Country specific intensive livestock sector characteristics

Country	Pigs sector				Chicken sector
	Average live-weight fat pigs [kg.]	Number of grown up piglets/sow	Number of boars/sow	Replacement rate	Eggs/day/100 laying hens
Netherlands	121	15.70	0.046	0.51	83.54
Belgium	119	13.19	0.032	0.63	83.47
France	113	16.46	0.057	0.49	69.73
Germany	108	14.09	0.044	0.47	74.78
Italy	146	12.43	0.060	0.35	59.34
Denmark	92	16.73	0.035	0.50	98.27
Ireland	83	13.31	0.047	0.40	55.03
United Kingdom	82	13.71	0.050	0.39	72.51
Portugal	87	12.97	0.073	0.53	65.00
Spain	98	13.88	0.058	0.50	65.00
Greece	87	12.70	0.089	0.54	36.40

Source: Own estimates based on Eurostat's Production Yearbook 1988

Fortunately, at a national level the total amount of compound feeds (including protein concentrates) per sector is known. Given this total amount, and given the total feed requirement and nutritional characteristics of grains, protein concentrate and compound feed, a system of three equations in three unknowns can be written and solved to determine the amount of cereals (equivalents) directly fed, and the amounts of compound feed and protein concentrate used, *i.e.*

Table 9.3 Animal feed specifications

Feed type	Metabolizable energy [KJ]	Crude digestible protein [%]
Single cereals feed	8.61	8.14
Compound feed pigs	12.00	14.50
Protein concentrate pigs	8.97	82.17
Compound feed broilers	12.60	18.87
Compound feed laying hens	11.80	18.87
Protein concentrate poultry	8.97	82.17

Source: Hof (1985) and own estimates based on Blom (1995) and CVB (1997).

$$r = A.b \quad \text{with} \tag{6}$$

with

$$r = \begin{pmatrix} r_{ME} \\ r_{DCP} \\ y_2 \end{pmatrix}; \quad A = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ 1 & 1 & 0 \end{pmatrix}; \quad b = \begin{pmatrix} v \\ w \\ y_3 \end{pmatrix};$$

and with r_{ME} representing the energy requirement, r_{CDP} the protein requirement, and y_2 the total amount of compound feed (including protein concentrate)[12]. A

[12] Note that the energy and protein requirements represent total requirements, *viz* the product of per unit output requirements (as explained in Table 9.3) and the total output volume. Or in matrix terms

$$r = H\begin{pmatrix} y_1 \\ y_2 \end{pmatrix}; \quad \text{with} \quad H = \begin{pmatrix} \tau_{ME} & 0 \\ \tau_{DCP} & 0 \\ 0 & 1 \end{pmatrix},$$

y_1 the total amount of output, and τ_{ME} and τ_{DCP} denoting the per unit livestock output metabolizable energy and digestible crude protein requirements respectively.

represents the coefficient matrix, with elements a_{ij} denoting the nutritional value coefficient for feed type j and requirement i ($i=1$ for energy, $i=2$ for protein). Vector b is a quantity vector, representing the quantities of normal compound feed v, ($j=1$), protein concentrate w, ($j=2$), and single cereals feed y_3 ($j=3$). Solving this system by applying matrix inversion yields

$$b = A^{-1}r \tag{7}$$

implicitly assuming that invertability of A is satisfied.

Applying this computation model to the (individual country) time series on pork output yields estimates for direct feeding. Given the roughness and normative character of the computation method, in particular for countries with known low direct feeding, it is not surprising that some strange results occur (for some years values indicate negative direct feeding). For this reason we neglect direct feeding, and the obtained value is replaced by 'zero' direct feeding. With respect to the pig sector, the Netherlands and Portugal are categorized as non-direct feeders[13]. With respect to the poultry sector a somewhat different approach is followed since Blom (1995, 118), in a detailed study of the EU feed use, reports that in most member states the use of protein concentrates was negligable, while in some it amounted to a few 100.000 tonnes. Following Blom therefore, no protein concentrate for the poultry sector is specified. Instead, two compound feeds are specified, one particularly suited for laying hens, and the other aimed at broiler production, while it is assumed that a mixture of both feeds can also be used as starting feed for young chickens. The computational methodology follows that discussed with respect to the pork sector. Direct-feeders with respect to chickens are the United Kingdom, France, Italy and Greece, while the other countries are categorized as non-direct feeders.

[13] Of course this is a matter of approximation, since it is known that in both countries there is some (incidental) direct feeding.

9.4 Prior information

9.4.1 Model estimation

The intensive livestock sector models are estimated using a mixed estimation procedure. Since the model equations provided in Section 2 form a system of related regressions, and in addition one of the explanatory variables, *viz*. the capacity proxy, appears to be endogenous, a 3SLS systems estimator would be the most appropiate estimation procedure. However, a simpler estimation method is used in which the derived output supply and input demand equations are estimated with a mixed restricted SUR-estimator, while the capacity adjustment equation is independently estimated. This procedure is followed instead of the standard 3SLS procedure for the following reasons: to unavoid reliance on proxy-variables which are certainly measured with error, to compensate for the lack of a real intertemporal optimization framework behind the derivation of capacity adjustment, and to accommodate the recursive structure of the capacity adjustment equation. So the efficiency gain of a 3SLS estimator can easily be offset by the introduced bias-spill-over-effects of an overal systems estimator (*e.g.* Johnston, 1984, p.489). One additional complication with regard to the SUR-block that has to be considered is the dependence between the three explanatory variables arising from the feed balance conditions, according to which

$$y_3 = f(y_1, y_2) \tag{8}$$

where $f(.)$ is a summary device capturing the technical relationships discussed in Section 3[14]. This ultimately translates into singularity of the variance-covariance

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[14] The function $f(.)$ is implicit in $b = A^{-1}H\begin{pmatrix} y_1 \\ y_2 \end{pmatrix}$ from Section 3. Since the matrices A and H are assumed to be filled with constant coefficients, the derivatives $\partial f(.)/\partial y_i$ $i = 1, 2$ come down to simple constants. The sign of $\partial f(.)/\partial y_1$ is clearly positive, while the sign of $\partial f(.)/\partial y_2$ is not a priori clear. The relationship between direct feed input and compound feed input consists of a substitute part (direct feed and complete compound feed) and a possible complementary part (direct feed and protein concentrate). Although not explicitly available in the data, in Section 3 an estimate was made of the magnitudes of complete feed use and protein concentrate use, which clearly suggests that the substitution part is dominating. In that case $\partial f(.)/\partial y_2 < 0$.

Note that $f(.)$ does not present the complete production technology relationship. For if this was the case, knowledge of the complete production function could be combined with the profit maximization hypothesis to completely determine the output supply and input demand functions. However, the complete production function also depends on variables other than the compound feed inputs, such as for example the capacity variable.

matrix when SUR (feasible GLS) is applied to the set of three output/input equations (see equation 4). So one equation had to be deleted during the estimation procedure. The direct feed equation y_3^h is selected for deletion. Fortunately, the parameter estimates from the deleted equation could be fully recovered from the already available information (constraints and parameter estimates).

9.4.2 Prior information

The non-sample information consists of information concerning some main output supply and input demand elasticities derived from previous research, the information about feed technology, and estimates of the feed conversion rates (summarized in Table 9.4). The main source for the supply elasticity estimates are De Craene and Viaene (1992, pp. 71, 86, 90), Voon (1991, p.182), Chavas and Johnson (1982, p.561), and Arzac and Wilkinson (1979, p.307). De Craene and Viaene (who rely on the FAO-model) and Voon come up with relatively high supply elasticities varying from 0.40 to 0.60. Arczac and Wilkinson, and Chavas and Johnson, however, who explicitly try to take into account the dynamics (various production stages), come up with much lower elasticity estimates, with supply hardly responsive to current quarterly prices changes and responsiveness increasing with increasing the time period. The own price output elasticities are largely based on De Craene and Viaene. The cross price elasticities of pork output with respect to the compound feed price are -0.30 for the non-direct feeders and -0.20 for those who have the alternative of direct feeding. For the direct feeders, a cross price elasticity of pork output with respect to the direct feed price is -0.30 for Germany, while those for the other countries are vary according to the share of direct feeding in the total feed (ingredients) value. The cross price elasticity for poultry and eggs output with respect to the compound feed price is a priori estimated to be -0.30 for the non-direct feeders and -0.20 for the direct feeders. The price elasticity of the chicken sector's output with respect to the direct feed price is -0.20 for Italy and the UK, and -0.05 for France because of the relatively less important role of direct feeding in France. Compound feed input elasticity guesstimates were formed based on Surry (1990, p.420) who obtained elasticities of -0.528, -0.663 and -0.934 for pigs, broilers and laying hens respectively, and on Peeters (1990, p.383) who obtained elasticities in the same range. Further, a descriptive analysis of feed practices (relying only on compound feeds, self-compounders, marketing chain integration of farms and compound feed industry) is made to evaluate the various elasticity estimates. (The higher the market penetration of mixed feeds, *viz.* the less competition with homegrown feeds like cereals, the lower the compound feed demand elasticities). For the direct feeders, own price elasticities of compound feed for pigs and poultry are estimated to be -0.50 and -0.75 respectively. For the non-direct feeders, which are faced with no feed input substitution possibilities and are in a number of cases characterized by a more industrialized production structure, the own price elasticities of compound feed are estimated as -0.20 and -0.30 (see Table 9.4).

Unfortunately, not much prior information about the behaviour of self compounders is available. With the exception of Longmire (1980) who explicitly took home mixing into account, other studies either integrate direct feeding and compound feeding in one model explaining the (total) use of feed ingredients (like Blom, 1995, and Peeters and Surry, 1993), or neglect the role of direct feeding practices (*e.g.* Surry, 1984). It seems not unreasonable to compare the use of home grown feeds with the use of individual feed ingredients by feed compounders (see Longmire). Individual ingredients show more sensitive price responses than the complete concentrate feeds, and home grown feeds are being a substitute for concentrate feeds derived from the compound feed industry[15]. The own price elasticities of direct feed demand for pigs and poultry are estimated to be -0.75 and -1.125, *i.e. 1.5* times the own price elasticities of compound feed demand.

From the feed technology relationships used, (while holding total energy and protein requirements constant) the change in compound feed use due to a change in the use of direct feed (on average) is derived to be -0.710 and -0.793 for pigs and poultry[16]. So for example, focusing on pigs, this implies that

$$\left.\frac{\partial y_2}{\partial y_3}\right|_{dy_1=0} = -0.710 = \frac{\partial y_2/\partial p_3}{\partial y_3/\partial p_3} \tag{9}$$

[15] Some temporary policy distortions, like the excemption of on farm used cereals from a co-responsibility levy, might have stimulated self compounding during the past.

[16] This can be interpreted as the slope of an isoquant, or a pure substitution effect. To obtain the total effect the scale effect should be also accounted for. Equation (14) includes both the substitution and scale effects.

Moreover, using a modified version of (8) *i.e.* $y_1 = g(y_2, y_3)$ it is easy to see that the feed technology also determines the derivatives $\partial y_1/\partial y_2$ and $\partial y_1/\partial y_3$. Due to the linear approximation of the feed technology, all these partial derivatives come down to fixed coefficients. Assuming x_i to represents the *i-th* (explanatory) variable of y (output price, input price, fixed factors) a general version of the elasticity relationship between output and inputs is

$$\frac{\partial y_1}{\partial x_i}\frac{x_i}{y_1} = \left(\frac{\partial y_1}{\partial y_2}\right).\frac{\partial y_2}{\partial x_i}\frac{x_i}{y_2}.\frac{y_2}{y_1}+\left(\frac{\partial y_1}{\partial y_3}\right).\frac{\partial y_3}{\partial x_i}\frac{x_i}{y_3}.\frac{y_3}{y_1} \tag{10}$$

where the terms between brackets are completely determined by the feed technology. Given prior knowledge about the own price elasticity of direct feed demand, prior estimates of the cross price elasticity of compound feed demand with respect to the price of direct feed can be obtained, even when the direct feed equation is not explicitly used in the estimation procedure, because

$$\frac{\partial y_2}{\partial p_3}\frac{p_3}{y_2}=\frac{y_1}{y_2}\frac{\partial y_2}{\partial y_1}.\frac{\partial y_1}{\partial p_3}\frac{p_3}{y_1}-\frac{y_3}{y_2}\frac{\partial y_2}{\partial y_3}.\frac{\partial y_3}{\partial p_3}\frac{p_3}{y_3} \tag{11}$$

This relationship is used to determine the cross price elasticities of compound feed with respect to the direct feed price for all countries with direct feeding practices. For the chicken sector, where it is impossible to relate total compound feed consumption by this sector to the laying hen and broiler subsectors, a sectoral average is estimated.

For the simple case where direct feeding is relatively unimportant or incidental (and where it was decided to neglect the direct feeding), the following type of restriction should (approximately) hold

$$\frac{\partial y_1}{\partial y_2} = c \tag{12}$$

with c a constant depending on the feed technology characteristics[17]. But this implies that (in elasticity terms)

$$\frac{\partial y_1}{\partial x_i}\frac{x_i}{y_1} = c.\frac{\partial y_2}{\partial x_i}\frac{x_i}{y_2}.\frac{y_2}{y_1} \qquad (13)$$

where x_i represents the *i-th* (explanatory) variable of y (output price, input price, fixed factors). Note that in this particular case y_2/y_1 represents the (average) feed conversion, which is equal to the marginal feed conversion $\partial y_2/\partial y_1$. In other words, in order to roughly satisfy consistency with feed technology, the elasticities of the compound feed input equation should equal those of output[18]. If there are multiple outputs (poultry meat and eggs) the compound feed input elasticities are in fact weighted by their shares in total compound feed consumption. These latter relationships are used to generate prior estimates for the cross price elasticity of output with respect to the compound feed price, and for the cross price elasticity of compound feed with respect to output prices for all countries with non-direct feeding practices.

The prior-information thus gathered and checked is summarized in Table 9.4. The variances are determined somewhat differently from the procedure previously followed. Given the rather high uncertainty (as compared with previous chapters), lower (or upper) confidence bounds are specified, which are subsequently used to determine the corresponding variances. These bounds are provided in the last column of Table 9.4, and are conservative estimates partly based on specific results found for the most price inelastic production stage of livestock production (*cf.* Arzac and Wilkinson, 1979). With this information the own price supply elasticity for pork for the Netherlands (0.45) can be computed as being approximately $((0.450-0.100)/2)^2$ or 0.031. As a consequence, the variances attached to the

[17] In this case coefficient c can be interpreted as the reciprocal of the marginal feed conversion rate.

[18] If these assumptions hold exactly, there is a one to one correspondence between y_1 and y_2, and so one equation should be deleted during the estimation process. In that case the feed technology information cannot be used to impose cross equation restrictions during the estimation procedure, but only to retrieve the missing coefficients, as was argued before. However, since these restrictions do not (exactly) hold (for example due to changing feed specifications over time and improperly handled direct feeding), it has been decided to always jointly estimate the output equation(s) and (one) compound feed input equation.

Table 9.4 Prior information on output and feed inputs (in elasticity terms; variances between brackets)

Prices	Neth.	Belg.	Frnc.	Germ.	Ital.	Denm.	Irl.	U.K.	Port.	Spain	Grc.	l/u-bound
Pork output												
pork	0.45	0.43	0.45	0.55	0.60	0.40	0.40	0.40	0.40	0.45	0.40	0.100
compound fd	-0.30	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.30	-0.20	-0.20	-0.025
direct fd		-0.05	-0.15	-0.30	-0.15	-0.25	-0.15	-0.25		-0.30	-0.30	-0.025
Compound feed input												
pork	0.45								0.40			0.100
compound fd	-0.30	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.20	-0.50	-0.50	-0.025
direct fd		0.13	0.23	0.47	0.41	0.51	0.23	0.37		0.14	-0.60	0.000
Poultry output												
poultry	0.40	0.48	0.40	0.40	0.40	0.40	0.40	0.40	0.48	0.40	0.40	0.250
compound fd	-0.30	-0.30	-0.20	-0.30	-0.20	-0.30	-0.30	-0.20	-0.30	-0.20	-0.20	-0.025
direct fd			-0.05		-0.20			-0.20		-0.10	-0.30	-0.025
Eggs output												
eggs	0.46	0.45	0.43	0.54	0.80	0.45	0.45	0.46	0.40	0.43	0.45	0.125
compound fd	-0.30	-0.30	-0.20	-0.30	-0.20	-0.30	-0.30	-0.20	-0.30	-0.20	-0.20	-0.025
direct fd			-0.05		-0.20			-0.20		-0.10	-0.30	-0.025
Compound feed input												
poultry	0.19	0.11		0.14		0.25	0.26		0.28			
eggs	0.24	0.35		0.35		0.17	0.16		0.12			
compound fd	-0.30	-0.30	-0.75	-0.30	-0.75	-0.30	-0.30	-0.75	-0.30	-0.75	-0.75	-0.150
direct fd			0.42		0.80			0.63		0.30	-0.50	0.000

Source: Own guesstimates based on reference noted in main text.
Note: With respect to chickens, the cross price elasticity of compound feed for the chicken sector with respect to the price of poultry for the Netherlands of 0.19 means that if the output price for slaughtering chickens goes up by 10%, total(!) chicken compound feed consumption goes up by 1.9%

prior information with respect to a certain price elasticity will vary across countries since all countries face the same lower or upper bound but have different estimated mean values.

9.5 Estimation results and discussion

Before running the final regressions, expected price series have been generated since it is assumed that farmers maximize expected profits. Expected output prices are generated by regressing them on lagged output prices, a price deflator reflecting the general evolution of prices in the economy, and a trend variable. Similarily, expected feed input prices are created by regressing them on lagged output prices, the price deflator, and a trend variable[19]. The expected price regressions are presented in Appendix 9B. A summarized presentation of the estimation results (in elasticity terms) for the pork and chicken sectors is given in Tables 9.5 and 9.6 respectively. For further details see Appendix 9C (various Tables).

Table 9.5 Estimated own and cross price elasticities in the pork sector

variable*)	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
quantity pork											
p.pork	0.252	1.747	0.573	-0.025	0.520	0.303	0.521	0.644	-0.081	-0.699	0.052
p.feed	-0.214	-0.213	-0.349	-0.117	-0.230	-0.259	-0.279	-0.286	-0.002	-0.266	-0.114
p.dir.fd.		-0.050	-0.123	-0.209	-0.001	-0.475	-0.146	-0.170		-0.145	0.082
p.oth.inp.	-0.038	-1.484	-0.100	0.350	-0.289	0.431	-0.096	-0.188	0.084	1.111	-0.020
cap.prox	0.653	1.595	0.332	0.048	0.767	0.713	1.079	0.806	-1.564	0.841	0.276
quantity pig feed											
p.pork	0.346	0.345	0.645	0.393	0.646	0.835	0.552	0.653	0.279	0.505	
p.feed	-0.268	0.073	-0.641	-0.793	-0.438	-0.998	-0.417	-0.246	0.186	-0.767	
p.dir.fd.		0.118	0.048	0.381	0.000	-0.130	0.055	-0.009		0.028	
p.oth.inp.	-0.078	-0.536	-0.053	0.018	-0.207	0.293	-0.189	-0.398	-0.466	0.234	
cap.prox.	0.563	0.989	0.570	0.434	0.528	1.688	0.828	0.415	-1.676	0.155	
α_p	0.140	0.438	0.259	0.289	0.281	0.433	0.292	0.303	0.136	0.270	0.177

*) The following abbreviations are used: prices of pork (p.pork), compound feed (p.feed), direct feed (p.dir.fd), other input (p.oth.inp), and capacity proxies (cap.prox).

[19] Assuming some form of rational expectations in principle, all known past information can be used for generating the expected price series. The rationale for regressing feed input prices on lagged output prices is that in a number of cases animal feed compounders, primary production, and often also the slaughtering industry are highly integrated with some form of 'profit-sharing' between the rings of the production chain. For example, in Spain in the late eighties the integration rates of the pigs and chicken subsectors amounted to 65% and 75% respectively (Hoogendoorn, 1992, 45). Moreover, using lagged feed prices would imply that one observation would be lost since no feed prices for 1972 are available, while output prices are known.

No reliable time series for compound pork feed consumption is available for Greece. So only the pork supply function has been estimated, where it is assumed that the Greece sector relies partly on direct feeding practices. The estimation results for Portugal, Spain and Greece are based on a shorter time series than what is available for the other countries. Besides, the quality of these data is relatively low, and therefore the obtained results should be treated with caution. The (adjusted) R-squares indicate on average a reasonable goodness of fit, with unfavourable exceptions for the UK and Greece, and compound feed demand for Italy (see Table 9C-2 in appendix). Some strange own price coefficients are found for pork supply in Germany, Portugal and Spain, and in the latter case the coefficients are even significant. From the 62 own and cross price coefficients, 8 had an unexpected a sign compared to a-priori expectations, although not always in contrast with economic theory. Complementarity between compound feed and direct feed is not expected on the basis of the feed ingredient comparisons (pure substitution-effect), but cannot be excluded either. Of the 62 price coefficients, 17 are not significant at the 95% confidence level.

The derived elasticities (evaluated at sample means) are presented in Table 9.5, where the elasticities for the deflator are derived exploiting the usual elasticity condition, which states that the sum of all own and cross price elasticities should equal zero. Pork supply price elasticities vary between 0.05 for Greece to 1.75 for Belgium, but are on average clearly inelastic. Compound feed demand is even more own price inelastic, while for Denmark and the UK, compound feed and direct feedstuffs behave as complements. In particular for Germany, Portugal and Spain the final (own price) elasticity estimates differ from the prior estimates (*cf.* Table 9.4, row one). Although the prior information influences the final results obtained, there are only a limited number of sign-switches, since the unrestricted sample estimates (not-reported) in most cases already generated the expected signs (positive own supply price and negative own demand price coefficients). The correct signs under unrestricted estimation are partly due to the use of effective input prices. If normal (non-effective) prices are used output and input prices often have the wrong signs. Given the high correlations that are often found between the various prices, it is non-surprising that adding additional information is likely to reduce the collinearity-problems which arise up under unrestricted estimation. As such the use of various forms of prior information can strongly contribute to the determination of individual price coefficients. As far as the problem of collinearity is concerned, the added prior information is not expected to seriously reduce the goodness of fit. This is exactly what was found, where the theoretical prior information (symmetry) usually appeared to be the most restrictive. A general indicator about the share of the prior information in the precision of the final estimates is given in the lowest row of Table 9.5. As can be seen, this share is significantly below 50%.

Table 9.6 Estimated own and cross price elasticities in the chicken sector

variable*)	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
quantity poultry											
p.pltry	1.363	1.253	0.637	1.542	1.096	0.623	0.795	1.215	-0.073	1.039	0.756
p.feed	-0.895	-0.578	-0.193	-0.662	-0.207	-0.122	-0.282	-0.286	0.011	-0.326	-0.320
p.dir.fd.			-0.044					-0.138		-0.114	0.174
p.oth.inp.	-0.468	-0.675	-0.400	-0.880	-0.890	-0.501	-0.513	-0.791	0.063	-0.600	-0.610
cap.prox.1	0.009	0.118	0.111	0.242	0.055	0.053	0.093	0.074	0.002	0.004	0.211
quantity eggs											
p.eggs	0.645	0.495	-0.249	0.325	0.146	0.294	0.620	0.628	0.402	1.419	0.366
p.feed	-0.364	-0.198	-0.182	-0.211	-0.217	-0.414	-0.240	-0.198	-0.701	-0.185	-0.105
p.dir.fd.			-0.057					-0.204		-0.037	0.062
p.oth.inp.	-0.281	-0.297	0.488	-0.114	0.071	0.121	-0.380	-0.226	0.299	-1.197	-0.322
cap.prox.2	8.044	1.932	5.537	4.260	-1.348	5.913	4.499	10.196	26.519	9.420	0.003
quantity chicken feed											
p.pltry	0.607	0.401	0.155	0.410	0.277	0.214	0.388	0.304	-0.184	0.286	
p.eggs	0.011	0.014	0.006	0.013	0.008	0.015	0.007	0.006	0.419	0.007	
p.feed	-0.268	-0.186	-0.122	-0.365	-0.452	-0.036	-0.187	-0.199	-0.270	-0.331	
p.dir.fd.			-0.009					0.170		-0.019	
p.oth.inp.	-0.349	-0.229	-0.030	-0.059	0.167	-0.193	-0.208	-0.280	0.035	0.058	
cap.prox.1	0.010	-0.008	0.091	0.030	0.101	0.020	0.057	0.022	0.006	-0.016	
cap.prox.2	4.723	3.105	0.806	2.751	-2.605	16.841	2.898	-1.370	-29.386	-3.676	
α_p^{pltry}	0.161	0.136	0.193	0.153	0.024	0.135	0.116	0.174	0.221	0.228	0.160
α_p^{eggs}	0.227	0.235	0.323	0.213	0.199	0.197	0.611	0.245	0.250	0.232	0.190

*) The used abbreviations are the same as those in Table 9.5.

With respect to the chicken sector, there are some more sign problems when relying only to the sample data, although in nearly all cases the feed input price shows the appropriate sign[20] (see Table 9C-3 in appendix). Nevertheless, even when taking the prior-information into account, some troublesome results are found for France (negative own price coefficient for eggs supply), and Portugal (wrong own price sign for poultry supply). For Italy there are probably measurement errors in the data since there are several years for which exactly the same production numbers were reported, which is highly implausible given the natural variation in this type of production processes[21]. (However, they do not cause wrong coefficients). (Absolute) feed input price elasticities are relatively low for all countries, both for those which rely heavily on bought compound feeds, like the Netherlands, Belgium, and (parts of) the UK, and those relying on combined feeding practices (see Table 9.6). In all cases the poultry meat output price shows a much larger influence on the feed input demand than eggs-prices. Correspondingly, the feed input prices changes affect eggs output less than poultry meat output (ceteris paribus). The reported shares of prior information in final precision are in general lower than 30%, in the member countries, with the exception of France and Ireland. Because of lack of reliable data on compound chicken feed input, no feed input equation could be estimated for Greece.

As was discussed in the previous section, the estimated parameter coefficients and prior restrictions are sufficient for obtaining the coefficients and elasticities for direct feed use[22]. The computed results are provided in Table 9.7[23]. Some strange results are found for the role of the capacity proxies in chicken feed demand. Except for Italy, for all other countries the calculated elasticity estimates are unrealistically

[20] As remarked when discussing the results for the EU pig sector, appropriate feed price signs might be seen as an indication of a rather good model approximation of the intensive livestock sector. Because generally feed input prices increased more strongly than output price, while simultaneously output and input use show a clear growth tendency, one typically finds positive correlations between feed prices and both output and input.

[21] As Table 9.4 shows, a relatively high prior supply price elasticity of 0.80 was attached to Italy, but with a rather high degree of uncertainty since the same lower bound of 0.125 was used as for all other countries.

[22] With the exception of Greece, where the sample information with regard to compound feed use, both for pigs and chickens, was very incomplete.

[23] Note that using feed balance conditions (implicit in equation 8) may introduce some error, because it is assumed all countries follow an average feed technology, while in reality there is some variation across countries. However, sufficient information was not available to recapture the country specific feed technologies.

Table 9.7 Derived elasticities for direct feed use

variable*)	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
direct pig feed use											
p.pork		0.320	0.418	0.419	0.003	0.950	0.589	0.364		0.391	
p.feed		-0.465	-0.088	-0.227	0.000	0.081	-0.112	0.009		-0.039	
p.dir.fd.		-0.696	-0.389	-0.555	-0.002	-0.646	-0.434	-0.276		-0.311	
p.oth.inp.		0.842	0.060	0.363	-0.001	-0.385	-0.044	-0.097		-0.041	
cap.prox.		3.623	-0.089	-0.199	1.072	-0.082	1.059	0.978		1.394	
direct chicken feed use											
p.poultry			0.325		0.001			0.450		0.984	
p.eggs			0.016		0.000			0.021		0.013	
p.feed			0.084		0.001			-0.522		0.192	
p.dir.fd.			-0.405		0.000			-1.149		-0.672	
p.oth.inp.			-0.020		-0.002			1.199		-0.517	
cap.prox.1			0.066		-0.102			0.116		0.128	
cap.prox.2			17.082		3.770			26.165		71.369	

*) The used abbreviations are the same as those in Tables 9.5 and 9.6.

high. Again complementarity between compound feed and direct feeding is found for France, Germany, Ireland and Spain with respect to pigs, and for the United Kingdom with respect to chickens.

Finally, Table 9C-4 (see appendix) shows the regression results for the capacity adjustment equations. Although in a strict sense the partial adjustment model specification does not change the properties of the error term, the Durbin Watson (DW) statistics associated with OLS-estimation shows that for several countries and sectors there are problems with autocorrelation. Although the DW-statistics are likely to be biased toward 2, the calculated Durbin's h-test and Breusch-Godfrey-tests confirm the presence of serial correlation of the residuals (Maddala, 1992, pp.248-250). Therefore the capacity adjustment equations have been reestimated using an iterative Cochrane-Orcutt procedure (reported in Table 9C.4). The lagged dependent variable parameter estimates show a general pattern in accordance with expectations and are, with a few exceptions, significant.

The lagged dependent variable coefficients have an adjustment rate interpretation, because $1 - \delta_1$ (see equation 5) gives the actual capacity change as a fraction of the desired capacity change. For example the lagged dependent variable coefficient of 0.91 for the pigs capacity adjustment equation for the Netherlands implies that the actual capacity adjustment is about 10% of the desired adjustment. Not all estimated adjustment-parameters satisfy $0 < \delta_1 < 1$ which is a requirement for the partial adjustment-model. The coefficients for the output price/input price-ratio's are rather unreliable. Only in 3 of the 33 cases are the coefficients significantly different from zero, while in two of them they are significant but with a wrong sign. Moreover, 14 of the 33 coefficients have the wrong sign. Although in a number of cases the goodness of fit is reasonable, the explanatory power of the results is therefore rather poor. This outcome may be because capacity is poorly approximated, and/or currently expected prices are inadequate as indicators for profitability of investments in livestock operations.

Based on the most plausible estimates (appropiate signs) 'informed guesses' are made about the average stock equation elasticities. The elasticities of the pig stock with respect to laged stock, output price, and input price are 0.65, 0.50, and -0.50 respectively. For poultry stock and laying hens stock the estimated average elasticites are 0.79, 2.00, -2.00; and 0.69, 5.00, and -5.00 respectively. These latter results will be used in dynamic simulations.

9.6 Concluding remarks

Modelling intensive livestock production requires consideration of some of the typical characteristics of the sector. This chapter has incorporated into the model the typical form of genetic improvement (expressed in terms of factor augmenting technical change or improved feed conversion rates) and mixed feeding practices. Moreover, a proxy variable is used to reflect the missing capital (or capacity) variable. The modelling approach to technical change has appeared to be fruitful in that it succeeds in avoiding the typical phenomena of positively correlated supplied quantities and feed input prices and negatively correlated correlations between outputs and output prices.

Including a proxy variable for production capacity appears to be rather succesfull, since in most of the final estimation results it has generated plausible and significant coefficients. What it simultaneously does is strengthen the short-run nature of the estimated models. This probably explains why the resulting supply elasticities are rather low as compared to the supply elasticities based on the FAO-model. However, because the price coefficients obtained in the capacity adjustment equations are often not significant and of the wrong sign, the estimation results do not provide very much insight into the long run (capacity-price) elasticities.

Information about feeding technology has been used to refine the input structure of the sectors, in particular the use of manufactured compound feeds, and direct on-farm feed use. Within the context of the final model, the structure of which has been already discussed in Chapter 5 (see Figure 5.2), this distinction is necessary.

The mixed estimation procedure, which tries to make the best use of all available sample and non-sample information, has contributed to an improved estimation of the price-parameters by reducing the typical collinearity problems in the (price) data. But it has not been able to prevent some unexpected results from being obtained. As can be concluded from the reported α_p coefficients (see Tables 9.5 and 9.6) the role of the prior information is less than in earlier chapters. The main explanation for this is the relative large uncertainty attached to the prior information of the intensive livestock sector as compared with other sectors.

Appendix 9A Feed requirement computation

This appendix provides a feed nutrition requirement computation scheme, which determines the amount of feed required per unit of final output in terms of metabolizable energy, crude digestible protein and compound feed. For the underlying requirement, formula one is referred to Janssens and Tollens (1990).

Pig meat production and feed requirement

Meat output	kg	1.00
Activity need		0.00069
Fattening pigs		
Killing out ratio		0.78
Average liveweight	kg	105.00
Required number of fattening pigs		0.01182
Fattening process		
Average starting weight piglets	kg	20.00
Fattening period	days	130
Feed conversion efficiency		1.00
Average daily gain pigs	kg	0.65384
Metabolizable energy/pig	Mj	3471.57
Digestible crude protein	kg	41.66
Feed requirement converted to desired output		
Total ME requirement	Mj	41.04
Total DCP requirement	kg	0.49
Compound feed		
Energy content	Mj/kg	12.00
DCP	%	14.50
Required feed	kg	3.42
Feed conversion ratio		3.42
Sows		
Average live weight	kg	125.00
Number of piglets/sow		17.00

Lactation period/litter	days	42
Number of recovery days	days	35
Rotation/year		1.90
Replacement rate		0.47
Maintanance requirement		
Metabolizable energy	Mj	9109.79
Crude digestible protein	kg	109.32
Replacement requirement		
Metabolizable energy	Mj	2507.45
Crude digestible protein	kg	30.08
Production of piglets		
Metabolizable energy	Mj	8603.70
Crude digestible protein	kg	147.08
Total requirement per sow		
Metabolizable energy	Mj	20220.90
Crude digestible protein	kg	286.48
Feed requirement converted to desired output		
Total ME requirement		14.06
Total DCP requirement		0.20
Compound feed		
Energy content		12.00
DCP		14.50
Required feed		1.37
Boars		
Boars per sow		0.05
Average live weight		180
Average daily gain		286
Replacement rate		0.50

Feed conversion efficiency	1.00
Metabolizable energy/pig	19095.70
Digestible crude protein	229.15
Feed requirement converted to desired output	
Total ME requirement	0.66
Total DCP requirement	0.008
Compound feed	
Energy content	12.00
DCP	14.50
Required feed	0.06
Compound feed (over all)	4.85
Feed conversion (implicit)	4.85

Poultry meat and eggs production and feed requirement

Poultry meat output	
Carcas w/live w.	0.73
Metabolizable energy content	12.55
Digestible crude prot. content	0.19
Feed conversion	2.05
Feed requirement per kg meat	
Metabolizable energy	35.24
Digestible crude protein	0.53
Feed requirement converted to desired output	
Total ME requirement	35.24
Total DCP requirement	0.53
Compound feed	
Energy content	12.51
DCP	18.87
Required feed	2.83
Feed conversion ratio (computed)	2.83

Laying hens		
Eggs output	kg	1.00
Laying hens		1.00
average egg weight	gr	57.50
average live weight	kg	2.20
eggs/day/100hens		73.97
hatching eggs	%	6.00
Feed requirement cons. eggs prod		
Metabolizable energy	Mj	509.74
Digestible crude protein	kg	6.27
Feed requirement for replacing hens		
Metabolizable energy	Mj	81.90
Digestible crude protein	kg	1.01
Feed requirement including replacement and hatching		
Metabolizable energy	Mj	603.88
Digestible crude protein	kg	7.43
Feed requirement converted to desired output		
Total ME requirement	Mj	38.90
Total DCP requirement	kg	0.48
Compound feed		
Energy content	Mj/kg	12.50
DCP	%	18.87
Required feed	kg	3.11
Feed conversion		3.11

Appendix 9B Expected price regressions

Table 9B-1 provides the expected price regressions for the pork sector. Besides the t-values (below the parameter estimates), goodness of fit (R-square) and autocorrelation statistics are given. With a few exceptions (France pork and Portugal feed) the goodness of fit is reasonable[24]. The lowest part of the Table provides the expectations for the direct feed price. The direct feed price is based on an index of soft wheat (coarse grains) prices. A standard measure for detecting autocorrelation is the Durbin-Watson or DW-statistic, which indicates that there are some problems with autocorrelation with respect to generating expected feed input prices for Germany, Italy, Ireland and Greece[25]. Some other values are in the inconclusive region. When autocorrelation is detected, OLS estimates are still unbiased, but not efficient. Moreover, there is a tendency for the t-values (based on a wrong covariance matrix) and goodness of fit indicators to be exaggerated. Unsatisfactory DW-statistics indicate that the dynamics of the expectations formation might be misspecified. In case lagged dependent variables are used as regressors, the DW-statistic is no longer appropriate, and Durbin's h or some other alternative should be used. Since Durbin's *h* cannot always be computed, and there are indications that it sometimes has low power in small samples, here the so-called Breusch-Godfrey or BG-statistic for first order autocorrelation is used. The BG-statistic, which follows a χ^2-distribution, indicates that the hypothesis of autocorrelated residuals is rejected for all cases[26]. Because in small samples it is not necessarily true that estimating the (unknown) correlation coefficient ρ and applying GLS leads to better results (see Maddala, 1992, p.244), and our interest is not primarily in exactly modelling the expectations formation process, no corrected estimates have been made.

[24] The R-squares are likely to be somewhat overstated by time dependency (common factor) of the variables.

[25] For the Netherlands, Belgium, France, Italy, Denmark, Ireland and the U.K. the number of observations is 21, for Portugal and Spain 13 and for Greece 16.

[26] For all member states (with the exception of Greece, Spain and Portugal for which shorter time series are avialbale), the critical value (5% significance) is 11.6 (or 10.3 when assuming 2.5% significance).

Table 9B-1 Expected price estimation results for the pig sector

variable*)	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
price pork											
constant	242.90	2395.00	635.58	134.91	122.12	193.36	122.12	24.79	20282.0	-2514.8	734.72
t value	3.093	3.036	2.401	2.280	13.845	2.339	13.845	2.972	1.301	-0.303	0.580
p. pork [-1]	0.199	0.068	0.311	-0.148	0.119	0.363	0.119	0.580	0.811	0.643	-0.403
t value	0.860	0.321	1.393	-0.801	1.741	2.591	1.741	2.643	3.871	4.237	-1.325
deflator	3.173	80.859	-6.784	4.839	-0.277	10.355	-0.277	0.283	2161.00	-1277.8	2556.10
t-value	1.998	3.804	-1.221	4.433	-1.460	4.774	-1.460	0.899	0.837	-1.721	4.713
trend	-17.447	-264.88	31.719	-16.019	-0.649	-31.156	-0.649	-0.948	-221.39	150.49	20.839
t value	-2.977	-3.920	1.374	-5.880	-0.681	-4.810	-0.681	-0.844	-0.977	1.412	1.026
R-square	0.780	0.680	0.280	0.860	0.750	0.880	0.750	0.790	0.790	0.700	0.950
BG	0.926	0.239	2.688	1.490	0.690	2.491	0.690	2.582	0.583	2.753	3.004
price pig feed											
constant	26.03	270.29	23.90	17.40	3.83	5.07	3.83	2.65	52.64	1239.60	-396.62
t value	8.405	3.976	2.314	2.056	3.094	0.458	3.094	2.871	1.450	1.818	-2.460
p. pork [-1]	0.010	0.023	0.016	0.034	0.021	0.055	0.021	0.064	0.005	0.094	0.039
t value	1.118	1.288	1.787	1.289	2.217	2.945	2.217	2.632	0.987	7.568	1.073
deflator	0.454	12.210	2.237	0.488	0.190	1.740	0.190	0.098	-9.983	85.803	207.100
t-value		6.667	10.323	2.868	7.138	5.995	7.138	2.806	1.659	1.407	3.233
trend	-1.294	-29.939	-4.474	-1.288	-0.294	-3.472	-0.294	-0.010	0.974	-0.567	9.752
t value	7.261	-5.143	-4.969	-3.306	-2.201	-4.006	-2.201	-0.082	1.844	-0.065	4.065
R-square	0.900	0.920	0.930	0.810	0.940	0.940	0.940	0.960	0.420	0.930	0.990
DW	2.084	1.604	1.580	0.321	0.931	1.802	0.931	1.412	1.262	1.645	0.762
price direct feed											
constant	9.69	88.89	14.96	7.57	2180.40	14.03	3.18	2.42	2271.80	950.64	-1585.8
t value	2.208	1.519	2.346	1.611	1.204	1.939	2.239	2.871	1.013	1.364	-2.388
p. dir. fd. [-1]	0.672	0.773	0.696	0.755	0.818	0.601	0.591	0.585	0.921	0.580	0.411
t value	4.305	5.547	3.806	7.001	6.266	4.482	2.427	2.626	5.083	2.823	1.796
deflator	-0.714	-14.496	-1.423	-0.500	-560.10	-2.908	-0.096	-0.156	-102.77	-130.44	231.080
t-value	-2.278	-2.784	-3.082	-2.773	-1.470	-4.304	-0.687	-1.461	-0.217	-0.607	2.838
trend	0.151	3.106	0.435	0.092	125.220	0.890	0.030	0.048	-0.965	19.683	-1.865
t value	1.792	1.876	1.901	1.007	1.628	3.240	0.843	1.384	-0.024	0.634	-0.770
R-square	0.917	0.887	0.939	0.947	0.955	0.936	0.693	0.905	0.844	0.636	0.964
BG	1.645	1.030	2.713	1.241	1.078	2.725	0.307	2.064	0.324	2.742	4.181

*) Abbreviations used refer to variables indicated in main text.

The estimation results for the chicken sector are provided in Table 9B-2. Both the BG-statistics and the DW-statistics indicate that there are no serious autocorrelation problems. In both tables, the trend variable has a negative sign in 40 of the 55 cases. This indicates that when accounting for the general development of prices (deflator), agricultural output and (feed) input prices have a tendency to lag behind, which is in keeping with expectations.

Table 9B-2 Expected price estimation results for the poultry sector

variable*)	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
price poultry											
constant	141.75	2809.80	97.14	172.25	25.08	-143.58	25.08	11.78	2237.40	-1180.5	-3812.5
t value	2.764	3.793	1.450	3.098	2.237	-1.638	2.237	2.213	0.510	-0.166	-2.518
p. plt. [-1]	0.442	0.176	0.547	0.222	0.938	0.722	0.938	0.789	0.980	0.706	0.524
t value	2.461	0.789	3.556	0.898	7.511	5.514	7.511	3.436	4.244	1.993	2.273
p. pork [-1]	-0.134	0.024	-0.009	-0.032	-0.015	0.321	-0.015	0.122	-0.064	-0.026	0.001
t value	-1.646	0.186	-0.176	-0.176	-0.163	1.654	-0.163	0.517	-0.727	-0.096	0.006
deflator	2.019	50.314	6.201	1.549	0.269	-3.330	0.269	-0.017	6.571	101.720	-15.756
t-value	3.638	3.494	2.860	1.808	0.646	1.370	0.646	-0.083	0.108	1.105	-1.905
trend	-6.451	-128.36	-21.357	-3.899	-2.763	-4.472	-2.763	-0.220	-121.95	-731.15	934.270
t value	-3.201	-3.286	-3.047	-1.778	-1.855	-0.401	-1.855	-0.294	-0.176	-1.145	3.403
R-square	0.650	0.860	0.880	0.460	0.960	0.970	0.960	0.930	0.890	0.740	0.990
BG	2.363	0.732	0.081	2.560	7.607	0.311	7.607	3.603	2.837	2.989	5.800
price eggs											
constant	8.37	96.36	10.67	16.76	1.46	8.74	1.46	1.34	-126.84	607.33	-342.15
t value	3.292	2.025	2.517	4.241	3.033	2.417	3.033	5.962	-0.455	1.764	-2.465
p. eggs [-1]	-0.488	-0.297	-0.002	-0.310	0.526	0.453	0.526	-0.390	0.172	-0.509	0.367
t value	-2.060	-1.316	-0.007	-1.025	2.457	1.872	2.457	-1.897	0.880	-1.543	1.138
p. plt. [-1]	0.016	0.010	0.019	0.095	0.013	-0.002	0.013	0.015	0.073	0.028	-0.020
t value	1.696	0.719	1.654	0.878	2.892	-0.377	2.892	2.079	5.030	2.696	-0.098
deflator	0.094	1.898	0.254	0.051	-0.031	0.265	-0.031	0.047	-0.486	1.222	-1.737
t-value	4.137	2.149	1.813	1.333	-1.951	2.194	-1.951	4.735	-0.121	0.308	-2.762
trend	-0.378	-7.741	-0.353	-0.278	0.112	-0.868	0.112	-0.232	13.315	29.391	89.886
t value	-5.451	-3.282	-0.799	-3.314	1.992	-1.312	1.992	-5.279	0.269	0.962	3.285
R-square	0.710	0.530	0.810	0.650	0.830	0.870	0.830	0.790	0.980	0.860	0.980
BG	0.122	1.361	0.555	4.163	1.187	0.073	1.187	1.444	0.861	1.125	2.527

(Table 9B-2 continued)

variable	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
price chicken feed											
constant	19.93	327.25	32.14	26.38	3.84	8.42	3.84	2.51	62.82	1952.2	-239.93
t value	2.165	1.998	2.156	2.030	3.465	0.714	3.465	2.326	1.813	1.568	-0.655
p. plt. [-1]	0.057	0.013	0.090	0.120	0.037	0.013	0.037	0.179	0.005	0.136	0.155
t value	1.701	0.262	2.196	3.380	3.631	0.873	3.631	5.077	2.566	3.617	2.985
p. eggs [-1]	-0.751	0.556	-0.160	-2.643	1.044	1.387	1.044	-0.680	-0.045	-0.139	0.201
t value	-0.954	0.715	-0.168	-2.657	2.121	1.761	2.121	-0.692	-1.834	0.569	0.236
deflator	0.812	15.659	1.716	0.735	0.043	1.698	0.043	0.099	0.562	-3.808	10.973
t-value	9.827	5.164	3.487	5.790	1.202	4.314	1.202	2.078	1.125	-0.265	6.407
trend	-2.171	-35.29	-2.232	-2.243	0.081	-4.710	0.081	-0.305	-4.118	63.018	31.041
t value	-8.630	-4.348	-1.438	-8.160	0.632	-4.056	0.632	-1.452	-0.669	0.569	0.430
R-square	0.910	0.920	0.920	0.890	0.970	0.930	0.970	0.960	0.640	0.860	0.990
DW	1.928	1.368	1.142	1.030	1.035	1.031	1.031	1.487	1.854	1.434	2.239

*) Abbreviations used refer to variables indicated in main text.

Appendix 9C Estimation results

This appendix provides the results of the restricted mixed estimation procedure. Firstly, Table 9C-1 presents the main sample means and average direct feeding estimates.

Table 9C-1 Sample means and feed characteristics

variable*)	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
pork sector											
q.pork	1434.6	745.6	1721.3	3178.8	1064.1	1051.0	150.5	1004.2	215.6	1546.8	148.1
p.pork	369.1	5926.4	748.0	320.6	201.2	1008.9	107.0	83.2	24266.3	20015.0	19068.8
q.feed	6425.1	2735.8	4881.1	5779.3	2318.1	2103.6	499.7	2365.6	1211.1	4650.7	107.7
p.feed	51.1	998.0	142.9	52.4	33.0	156.6	16.3	15.5	126.8	3509.5	3245.6
q.dir.fd.		987.5	4239.8	13018.9	3126.1	4206.0	402.5	3728.6		5071.3	246.4
p.dir.fd.	43.87	701.3	89.6	39.0	26.5	125.9	9.9	10.4	3060.6	2267.9	3935.3
dir.f./tot.f.		0.20	0.38	0.62	0.49	0.59	0.36	0.53		0.44	0.62
p.oth.inp.	79.5	75.8	71.0	86.4	79.3	78.1	71.8	78.0	103.4	103.6	122.6
pigs capacity	11252.6	5651.1	11706.4	22774.6	8938.5	9204.1	1094.3	7956.8	3046.5	15187.3	1107.8
chicken sector											
q.poultry	434.1	138.1	1301.3	401.2	1005.1	117.2	59.5	898.2	180.5	828.4	145.1
p.poultry	320.6	6441.8	622.9	322.5	195.3	1298.6	118.8	76.1	13651.7	17867.3	12533.1
q.eggs	544.1	544.1	867.5	807.6	640.1	78.9	37.0	820.4	83.7	661.4	124.2
p.eggs	11.4	167.3	36.5	16.1	8.5	39.3	4.1	2.6	1000.4	931.8	916.1
q.feed	2966.4	991.1	5645.1	3477.1	3898.7	554.8	315.2	3519.4	1106.0	4125.7	112.1
p.feed	69.3	1294.6	178.1	60.0	37.6	156.6	16.3	18.3	126.8	4090.2	3302.1
q.dir.fd.			1226.9		2124.0			2009.0		753.1	760.4
p.dir.fd.	43.8	701.3	89.6	39.0	26.5	125.9	9.9	10.4	3060.6	2267.9	3935.3
dir.f./tot.f.			0.15		0.30			0.31		0.13	0.84
p.oth.inp.	79.5	75.8	71.0	86.4	79.3	78.1	71.9	78.1	103.4	103.6	122.6
poultry cap.	321474	93574	599322	245188	371340	86372	32876	497887	126409	520945	70871
laying hen cap.	33560	13082	68534	55116	49962	4460	3420	55285	8249	49966	16794

*) Quantities are measured in 1000 tonnes and prices in national currency per 100 kg product. Capacity is in terms of 1000 animals.

Tables 9C-2 and 9C-3 provide the parameter estimates of the mixed estimation procedure for respectively the pigs and poultry sectors. T-values and goodness of fit statistics are added. Autocorrelation statistics are not provided, because they have no clear interpretation in this modelling context (*cf.* discussion in Chapter 8).

Table 9C-2 Estimation results pork sector

variable	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
quantity pork											
p.pork	21.311	4.549	25.578	-5.754	59.507	6.726	14.391	165.760	-0.075	-1.460	0.013
t value	0.830	5.350	-6.101	-0.074	0.874	0.795	3.569	2.118	-0.856	-2.395	0.375
p.feed	-130.68	-3.296	-81.689	-167.32	-161.09	-37.143	-50.619	-395.91	-0.377	-3.172	-0.167
t value	-2.723	-2.730	-6.101	-1.621	-2.782	-3.311	-3.830	-3.602	-1.208	3.287	-1.412
p.dir.fd.		-1.103	-45.944	-401.46	-0.886	-84.525	-43.509	-348.47		-2.680	0.099
t value		-3.923	-2.640	-3.333	-5.879	-5.403	-3.003	-2.306		-2.767	1.608
cap.prox.	0.083	0.210	0.049	0.007	0.091	0.081	0.148	0.102	-0.111	0.086	0.037
t value	4.485	10.913	1.348	0.334	1.844	3.483	13.122	3.209	-8.621	9.09	2.582
R-square	0.891	0.899	0.619	0.822	0.863	0.835	0.858	0.526	0.671	0.900	0.531
quantity compound pig feed											
p.pork	130.680	3.296	81.689	167.320	161.090	37.143	50.619	395.910	0.377	3.172	
t value	2.723	2.730	6.101	1.621	2.782	3.311	3.830	3.602	1.208	3.287	
p.feed	-731.75	4.112	-424.56	-2065.0	-668.85	-286.13	-251.18	-801.29	48.019	-27.476	
t value	-4.389	1.046	-6.814	-4.959	-2.208	-5.597	-3.523	-1.667	5.288	-684	
p.dir.fd.		9.526	50.935	1333.90	-0.480	-46.298	54.113	-44.056		1.535	
t value		2.496	0.630	2.872	-1.523	-0.864	0.913	-0.086		0.557	
cap.prox.	0.321	0.479	0.238	0.110	0.137	0.386	0.378	0.123	-0.666	0.048	
t value	7.460	13.234	2.606	1.270	1.051	6.521	10.338	1.189	-11.911	1.582	
R-square	0.977	0.819	0.715	0.435	0.289	0.851	0.820	0.210	0.747	0.650	

Table 9C-4 contains the estimation results of the capacity adjustment equations. As was already indicated in the main text, the price coefficients are rather unreliable and often have signs in contrast with expectations.

Table 9C-3 Estimation results chicken sector

variable	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
quantity poultry											
p.poultry	40.071	0.556	25.834	45.271	122.200	1.199	7.809	306.060	-0.026	1.303	0.280
t value	6.131	4.596	2.905	5.977	5.512	3.397	4.531	4.468	-2.608	4.638	4.007
p.feed	-121.87	-1.275	-27.343	-104.40	-119.65	-1.947	-20.184	-299.70	0.404	-1.785	-0.450
t value	-15.489	-7.304	-2.684	-10.734	-2.799	-2.348	5.466	-3.742	2.838	-5.023	-3.686
p.dir.fd.			-12.405		-0.226			-253.65		-1.121	0.205
t value			-3.561		-5.313			-2.539		-4.161	3.265
cap.prox.1	0.000	0.001	0.002	0.002	0.001	0.001	0.002	0.001	0.000	0.000	0.002
t value	0.455	20.441	11.400	10.953	4.200	14.896	20.803	12.657	8.351	1.965	5.367
R-square	0.716	0.875	0.948	0.838	0.826	0.970	1.022	0.979	0.821	0.090	0.618
quantity eggs											
p.eggs	667.170	33.291	-114.72	385.490	237.270	12.555	109.480	4286.60	0.909	27.231	1.587
t value	1.620	2.675	-0.935	1.276	0.342	0.798	2.139	3.061	0.912	5.638	2.294
p.feed	-62.130	-1.718	-17.229	-66.855	-79.922	-4.453	-10.685	-189.74	-12.498	-0.810	-0.127
t value	-3.557	-3.001	-2.578	-4.224	-2.558	-4.958	-2.308	-2.516	-8.627	-3.276	-1.88
p.dir.fd.			-10.658		0.030			-343.20		-0.288	0.062
t value			-4.614		0.672			-3.024		-1.240	3.297
cap.prox.2	0.014	0.011	0.008	0.014	-0.002	0.005	0.005	0.017	0.018	0.012	0.000
t value	7.407	6.149	8.243	17.816	-1.716	1.829	4.120	7.666	2.344	5.043	0.002
R-square	0.908	0.668	1.071	0.885	0.004	0.693	0.513	0.887	0.379	1.099	0.327
quantity compound chicken feed											
p.poultry	121.870	1.275	27.343	104.400	119.650	1.947	20.184	299.700	-0.403	1.785	
t value	15.489	7.304	2.684	10.734	2.799	2.348	7.004	3.742	-2.838	5.023	
p.eggs	62.130	1.718	17.229	66.855	79.922	4.453	10.685	189.740	12.498	0.810	
t value	3.557	3.001	2.583	4.224	2.558	4.958	2.308	2.514	8.627	3.267	
p.feed	-249.76	-2.939	-74.822	-498.75	-1015.4	-2.706	-70.833	-818.37	-63.476	-9.035	
t value	-6.803	-2.986	-0.934	-9.058	-1.668	-0.686	-5.561	-1.260	-4.089	-4.112	
p.dir.fd.			-11.264		-0.788			1221.70		-0.957	
t value			-0.133		-1.192			1.941		-0.376	
cap.prox.1	0.001	-0.001	0.008	0.002	0.008	0.003	0.005	0.001	0.001	-0.001	
t value	0.896	-0.859	9.847	2.384	1.934	7.338	18.586	3.127	1.111	-6.401	
cap.prox.2	0.044	0.033	0.008	0.039	-0.027	0.108	0.028	-0.010	-0.257	-0.029	
t value	11.010	3.895	1.246	8.315	-1.516	7.975	2.874	-0.724	-5.570	-1.120	
R-square	0.907	0.270	0.922	0.595	0.375	0.458	0.971	0.462	1.701	1.823	

Table 9C-4 Estimation results capacity adjustment equation

variable	Neth.	Belg.	Frnc.	Germ.	Italy	Denm.	Irl.	U.K.	Port.	Spain	Grc.
pork capacity											
lag.dep.	0.91	0.98	0.76	0.70	0.56	0.62	0.62	0.60	0.75	0.44	0.22
t value	12.84	7.25	3.30	3.60	2.67	2.72	3.13	3.47	11.55	1.65	0.82
price ratio	-657.67	-1548.2	-87.28	6731.10	55.18	-4762.5	-76.98	40.63	-8.48	-6615.9	-46.01
t value	-1.60	-0.46	-0.28	1.54	0.07	-1.32	-1.34	0.07	-4.22	-1.50	-1.20
R-square	0.97	0.96	0.40	0.56	0.60	0.74	0.78	0.65	0.83	0.69	0.26
poultry capacity											
lag.dep.	0.79	1.04	0.92	0.69	0.67	0.92	1.12	0.97	0.96	-0.55	1.13
t value	5.17	13.18	10.54	5.34	4.99	8.15	25.11	21.81	5.37	-1.52	12.09
price ratio	16371.0	40431.0	-176780	45888.0	77285.0	4527.20	2355.80	-155540	1233.80	-146490	3340.30
t value	0.58	1.26	-0.94	1.66	0.91	1.38	1.41	-1.00	0.99	-3.28	0.83
R-square	0.57	0.95	0.92	0.83	0.67	0.95	0.97	0.96	0.78	0.54	0.79
laying hens capacity											
lag.dep.	0.83	0.86	0.54	0.85	0.21	0.86	0.72	0.81	0.85	0.48	0.55
t value	10.92	8.40	2.11	6.18	0.89	7.38	2.91	7.29	2.59	1.80	2.11
price ratio	-230470	38944.0	-117340	115650	13219.0	13219.0	-8389.9	181340	156.88	35179.0	22345.0
t value	-0.80	0.87	-0.19	1.08	-1.10	1.25	-0.94	1.67	0.74	0.24	2.08
R-square	0.87	0.94	0.59	0.39	0.52	0.74	0.41	0.93	0.63	0.18	0.66

Chapter 10

The EU's Compound Feed Industry

10.1 Introduction

This chapter focuses on the EU's compound feed industry. Of all the costs involved in the various livestock production systems, feed costs are the most important single item. So an efficient compound feed manufacturing sector is a key factor in both the profitability and competitiveness of the livestock sector (see Table 10.1). Although more than half of the annual requirement for livestock feeding still comes from grassland and fodder crops, the use of manufactored feeds has expanded rapidly in the late 1960s and through the 1970s till the early 1980s, after which the increase has moderated (Peeters and Surry,1997, p.380). The marked increase is largely a result of the accelerated rationalisation, specialisation and intensification tendencies characterizing EU agriculture in the past decades. The increased output has been produced with a host of ingredients, including cereals and in particular imported non-grain feed ingredients, like oilmeals, manioc, corn gluten feed, bran, midlings, brewers' grains, etc. Even less conventional products, such as animal meal, which is generally considered to be waste, are being applied in animal feeding.

In the following, empirical models of the EU compound feed sector are provided, albeit at a rather aggregate level. The chapter is organized as follows. Section 1 gives an overview of the main charateristics of the compound feed sector, and of the relevant economic literature. Section 2 presents an economic model for the compound feed sector derived of the minimization from a restricted separable cost function. As in previous chapters, a mixed estimation procedure using sample and

*Table 10.1 Feed costs as a percentage of total costs of livestock farming *)*

Country	Milk	Fattening pigs	Laying hens	Broilers
Netherlands	60	64	64	68
Belgium	55	82	82	85
France		70	63	66
Germany	28	70		
Italy	64	82	86	
Denmark	44			
Ireland	46	74	63	58
United Kingdom	44		74	
Greece		75		83

**) Incomplete data; costs of on-farm family labour excluded.*
Source: De Boer and Bickel, 1988, p.6, who gathered data from several studies done in the mid 1980s.

non-sample information (economic-theoretical constraints, elasticity information obtained from previous research, and physical balance conditions) is used. Section 3 outlines the prior information used and also the sample information. Particular attention has to be paid to the latter here because the sample consists partly of so-called pseudo-data, *viz*. artificial data obtained from a linear programming model used by the compound feed industry. Section 4 presents the estimation and calibration results. Section 5 ends with some concluding remarks.

The total amount of feedstuffs used in the EU depends greatly on the total output of livestock products, *i.e.* production of milk, beef, pork, broilers and eggs production. As can be seen from Figure 10.1, the production of cattle feed has fallen since 1983. In contrast, there have been more moderate but steady increases in the output of pig and poultry feed since the 1970s.

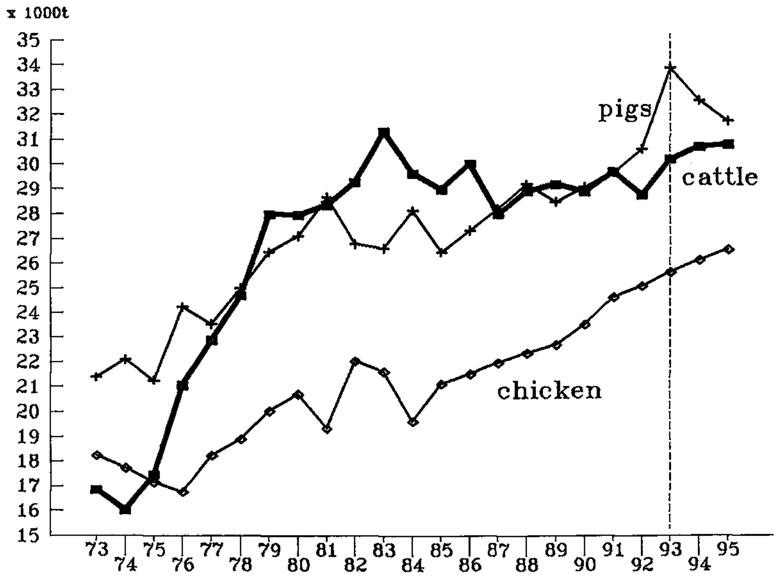

Figure 10.1 Compound feed use in EU-9 by livestock category

Source: Agricultural Situation in the European Union (various years), own computations (direct feeding). Countries not included are Greece, Portugal and Spain. From 1992 onwards the German Lander is included.

Only part of the feedstuffs used is processed by the EU's compound feed industry. A still considerable part is fed directly, without being processed by the compound feed manufacturers (*cf.* for example Peeters, 1989, p.29 for some estimates)[1]. Countries with high direct feeding rates (over 65%) are Germany, Denmark and France, while in the Netherlands there is hardly any direct feeding. Of the total amount of cereals used in the EU's feed sector in 1990, 62% was directly fed. Figure 10.2 gives a historical overview of the development of compound feed production and total cereal use in compound feeds (excluding direct feeding). As the figure

[1]Following Parris and Tisserand (1988, p.381), direct feeding or on-farm feed use is defined as including feed grown and fed on-farm, straight feeds sold between farms, feeds used by non-sale feed compounders (self-compounders), and imported straight feeds sold directly to farmers.

shows, production stagnated in the early 1980s. Initially, cattle feed use increased steadily, while pig feed use stagnated, but overall use of compound feeds increased. Since the mid-1980s cattle feed has stagnated. However, pork and poultry feed use have started to increase again since 1985/86. After a period of stagnation in the early and mid 1980s, in the second half of the 1980s total compound feed production is growing again. The use of wheat and coarse grains significant declined in the 1980s, with a partial recovery at the end of the decade.

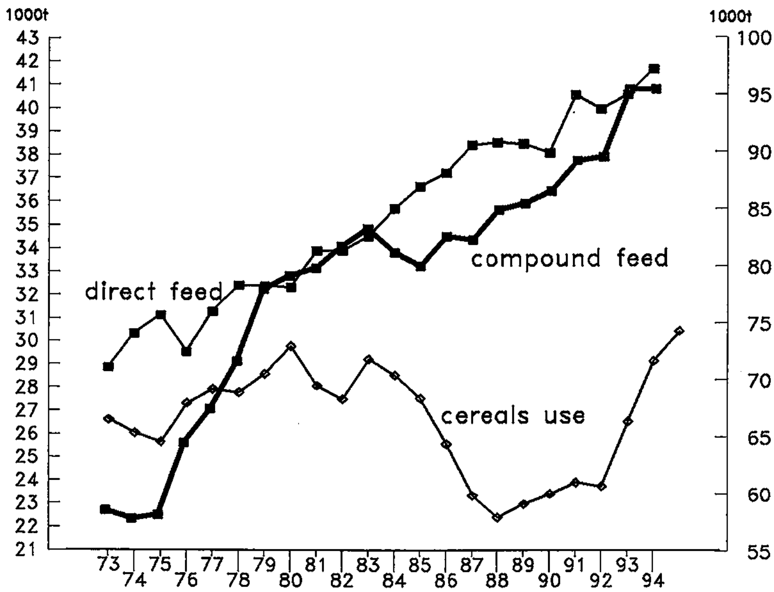

Figure 10.2 Compound feed production, direct feed and cereals feed

Source: Agricultural Situation in the European Union (various years), and own computations (direct feeding). Total compound feed production includes other compound feeds and is measured along the right scale.

As Figures 10.1 and 10.2 show, the rationalisation and modernization of the EU's livestock sector since the operation of the CAP has led to a rapid increase in the demand for compound feeds. In the early 1950s the feed manufacturing industry was almost non-existent in some EU countries and in others limited to a host of small scale local milling and feed mix enterprices hardly comparable with the current industries (Surry, 1990, p.405). The rapid development of the compound feed sector has not only increased its magnitude and scale, but has also led to a growing interweaving between the compound feed industry and specific parts of the livestock sector. In particular with respect to the pig and poultry sector, often high degrees of vertical integration can be found (Srivastava *et al*, 1998). The largest compound feed sectors are found in the Netherlands, Germany and France. The structure of the industry differs across EU member states. In the Netherlands, for example, the industries are characterized by a high degree of concentration, while in France the average size is rather small (Surry, 1990, p.405). In 1988 the total number of mills in the EU was 4330, of which 215, *viz*. 5% of the total, accounted for 52% of the output (Tracy, 1993, p.64).

Concentration generates economy of scale returns since average production costs tend to decline as plant size increases. However, since livestock feed is bulky in relation to its volume, these returns might be offset by transport and service costs, which increase with the size of the distribution area. The industries have therefore been established and developed particularly in areas with dense livestock populations. There is a preference to locate near ports where the required raw materials can be delivered more cheaply. The large-scale structure of the Dutch compound feed industry is therefore not surprising given plenty of waterways, good transport infrastructure and relatively short distances. Besides a relatively small number of large scale firms like BP Nutrition, Ferruzzi, Dreyfus, and US-based firms Cargill and Bunge & Born, there is a large number of relatively small scale co-operatives. The latter account for half or more of total feed output in the Netherlands, Denmark, the UK and Ireland (Tracy, 1993, p.63). Total employment in the EU sector is 92.000 persons (1990), a number which is steadily falling as a consequence of mechanisation and automation forces (Tracy, 1992, p.63).

A major characteristic with regard to the feed ingredient use is the declining share of cereals in the livestock rations, especially in France and Portugal (*cf.* Figure 10.2 with cereal use measured along the left vertical axis). At the given relatively high internal support prices, they are often not competitive with other raw materials, especially manioc and by-products like the oilmeals, or cereal-substitutes, as termed by the Commission[2]. In particular in the period 1983-1988 the use of cereals in compound feeds has rapidly declined (probably partly due to the depreciation of the US$ which made dollar priced substitutes relatively cheap). Since the late 1980s cereal use shows some tendency to increase, arriving at a level of 24 mill. tonnes, or about 26%. In spite of the possibilities for replacement, cereals remain the main concentrate in the EU because of its characteristic as a high-energy, highly palatable feed suited for all classes of animals. In Europe the proprotion of cereals is usually between 60-85% in poultry rations, 40-85% for pigs, and 10-40% for diary cattle (Todorov, 1988, p.47). Although for highly productive livestock systems it is generally necessary to feed a liberal amount of cereals, there are upper limits, in particular for ruminants, where extreme quantities of cereals will cause digestive problems (accidosis or bloat). In contrast, poultry and pigs allow and often require high cereals proportions in their rations (Todorov, 1988, p.48).

Previous research (*cf.* Surry and Moschini, 1984) on the compound feed sectors of Belgium and the Netherlands has suggested taht the own price elasticities of input demand for cereals, high-protein feeds (including oilmeals and also corn-gluten feed) and cereal substitutes (brans, milling residues, manioc, molasses and citrus pulp) is of the order of magnitude of -0.7, -0.2 and -0.2 respectively. High-protein feeds and cereal substitutes are complements, while both of them jointly form a substitute with respect to cereals (Hillberg, 1986, p.54). These findings are consistent with cereals being a feed with a high energy level and a moderate protein level, whereas cereal substitutes have a low protein content and the protein feeds have a low energy content (see Table 10.2 for an overview of nutritional characteristics of selected feedstuffs). Elasticities for feed ingredients found for other EC member states in general sustain this pattern of input characteristics (Surry and Moschini, 1984, p.462)[3]. Within the high-protein feeds, soybean meal (protein content approximately

[2] The use of the label cereal-substitutes is questionable, since a product like citrus pulp belonging to this group hardly competes with cereals. Moreover, products like soybean meal and molasses are classified as non-cereal substitutes, but they can to a considerable degree substitute for cereals (Blom, 1989, p.1). Finally, energy rich products like manioc and corn gluten feed cannot on their own replace the complete feed cereals, but only in combination with other products (Peeters, 1989, p.33).

[3] Le Mouël (1995, p.456) argues that the substitutability of protein rich products (like soymeal and to a lesser extent corn gluten feed) with cereal has an 'artificial' nature as with relatively high cereal prices they may be considered as cheap energy sources as well as traditional protein sources. According to her, lower cereals prices may lead to the re-emergence of a 'natural' complementarity relationship, *viz* the completion of energy (cereals) with protein.

38%) has a special position because of its relatively favourable amino-acid profile for non-ruminants. This causes soybean meal to be an imperfect substitute for other protein rich ingredients (*i.e.* the EU-meals) and partly explains the relatively strong inelastic demand found for this feedstuff (Knipscheer, et al, 1982, p.252).

Table 10.2 Nutritional characteristics of distinguished feed ingredients

Feedstuff	ME ruminants	DE pigs	ME chickens	Crude Protein	General description
cereals					
soft wheat	14.0	16.0	14.8	130	rich in carbohydrates, energy source;
barley	13.7	14.9	13.6	120	low protein level;
maize	14.2	16.4	15.9	106	deficient in some minerals (Ca), amino acids (M+C) and vitamins (A+D);
oilmeals					
soybean meal	12.7	13.8	9.9	467	rich in protein; favorable amino acid pattern (sbm) with good availability;
rape meal	10.4	10.8	9.6	365	mixed in minerals (low Ca, fair P);
sunflower meal (dehulled)	10.7	11.4	7.4	386	contain anti-nutritional factors (trypsin inhibitors, glucosinolate); contain important amino acids (rape:Lys.+Meth. and sun.: Arg.)
manioc	11.8	16.4	17.1	25	energy source; mixed minerals (low Ca, high P); contains anti-nutritional factor.

Used abbreviations: Metabolizable energy (ME), digestible energy (DE), Methionine (M), Cystine (C), Lysine (Lys), and Arginine (Arg).
Sources: CVB (1997, pp.82-101), Todorov (1988, pp.49-50; 92-93), Boucqué and Fiems (1988, pp. 109-111), and Van der Poel, 1987, pp.44-46, 53-57, 102-104). (For broilers and laying hens average numbers are used).

As a result of the CAP, prices for cereals, milk and meat products within the EU and in the world market differ from each other, which in turn influences the consumption of meat, the composition of the livestock sector, and the use of feed ingredients. Tariffs on oilmeals (in particular soybean products imported from the US and Brazil) and corn gluten feed (mainly imported from the US) are zero, allowing them free access to the EU. The imports of manioc (mainly from Thailand and Indonesia) have been constrained as a result of bilateral agreements between the EU and the exporting countries. Moreover there exists a 6% ad valorem tariff on manioc. At the same time feed grains (except maize, which is now grown mostly in the EU) have a competitive disadvantage because of the relatvely high internal support prices generated by the intervention and variable import levy/export subsidy system. The CAP's co-responsibility levy on cereals, which was in place from 1986 till 1992, can be interpreted as a measure improving the competitive position of cereals. Since cereals used directly on-farm are exempted, compound feed manufacturers may, however, interpret it as a tax which is partly effectively paid by the compound feed industry. The latest adjustment (MacSharry reform) of the CAP, has implied abolition of the forementioned co-responsibility system, introduction of compulsory set-aside, reduction of institutional prices, and direct (per hectare) payments, among a host of other measures. This has improved the competitive position of home-grown cereals relative to non-cereals feed ingredients. Blom (1995) computed, that for the period 1993-1996, the EU's net cereals export roughly halved as compared to a without-reform scenario. This result arises due to two tendencies: decline in domestic cereals supply as a reaction to lowered cereal prices and set-aside, and increase in cereals feed ingredient use (a 10% increase in the share of domestic cereals; Blom, 1995, p.166).

Reviewing the literature, there are a few fairly complete studies covering the entire EU feedstuff market (PhD-thesises from Peeters, 1989, and Blom, 1995). Besides there are a number of partial studies focusing on specific subregions of the EU, and restricted to a disaggregation of major feed ingredients. Examples are Longmire (1980, United Kingdom), McKinzie *et al* (1986, the Netherlands), Hillberg (1986, West Germany), Surry and Moschini (1984, the Netherlands and Belgium), Mergos and Yotopoulos (1988, Greece), Surry (1990, France), and Peeters and Surry (1993, Belgium). Besides, there are some studies focusing on the EU and the international market for feedstuffs, more specifically on the 'rebalancing' of the common agricultural policy (CAP), like Von Witzke and Houck (1987), Hartmann and Schmitz (1991), Guyomard *et al* (1993), Le Mouël (1995), and Giraud-Héraud, Le Mouël and Requillart (1997). The studies not only focus on different regions and topics, but also differ with respect to the methodologies followed. There are some pure econometric studies, for example Surry and Moschini, and Mergos and Yotopoulos, but these are relatively few. The reason is that econometric estimation of the complex relationships between feed ingredients is often obscured by the lack of data and the high collinearity between prices. Other studies, like Longmire, and Blom, rely on linear programming techniques, which are better suited to incoporate the technical and nutritional constraints that feed compounders face in their manufactoring process. Several other studies use a combined approach: using a linear programming (LP) model pseudo-data are generated, which form the inputs of a subsequent econometric (cost function) estimation procedure. Examples of the latter approach are McKinzie *et al* (1986), Hillberg (1986), and Peeters (1989). Reviewing the results obtained, these latter studies often result in relatively high elasticity estimates as compared with the pure econometric models. This can be partly explained by the level of disaggregation, which is usually higher, and by the long-run or normative character of economic behaviour within a LP-programming context[4].

In a recent study Peeters and Surry (1993) show that even when data availability is limited, the (econometric) cost function approach is suitable for obtaining so-called feed-utilisation matrices (FUM)s[5]. More rigorously than in Surry and Moschini (1984), they impose additional structure on the cost function in terms of economic-theoretical constraints, separability assumptions and functional form. When the analysis is focused on a not too disaggregated level of feed ingredients, the econometric approach seems a suitable approach, especially when the inference procedure can be enriched with reliable non-sample information and sufficient structure is imposed on the model, as done by Peeters and Surry (1993). Moreover, econometric models have the advantage of being able to better reflect constraints wider than nutritional and technical requirements, like market constraints and transaction costs. So econometric models have a better potential for following the general evolution of feed ingredient use patterns over time than (normative) LP-

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[4] Feed compounders may follow some kind of 'satisfying' behaviour instead of the (extreme) 'maximizing' behaviour implicitly assumed within the LP-context.

[5] A FUM indicates the utilisation of all types of feed by different livestock categories on a crop-year basis, and is usually expressed both in terms of product weight and in energy and protein equivalents (*e.g.* Parris and Tisserand, 1988, p.375)

models. For those reasons in this study the approach chosen is to derive a structured economic model, which is subsequently econometrically estimated using an inference procedure which allows for extensive use of prior information.

Before providing the algebraic formulation in the next section, the general modelling framework for the compound feed sector is given in Figure 10.3. It illustrates the main characteristics of the imposed model structure. As can be seen from the figure, it is assumed that feed ingredients and compound feed outputs are functionally separable, which allows aggregation of all compound feeds into one composite output (*cf.* also Surry, 1990, 408). Moreover, a separability assumption is made with regard to the feed ingredient part. In fact a two-stage structure is created by distinguishing a group labelled high protein feeds, which consists of soybean meal and meals derived from rapeseed and sunflower seed. Finally, a specific treatment for manioc is necessary since this input faces a quantity constraint.

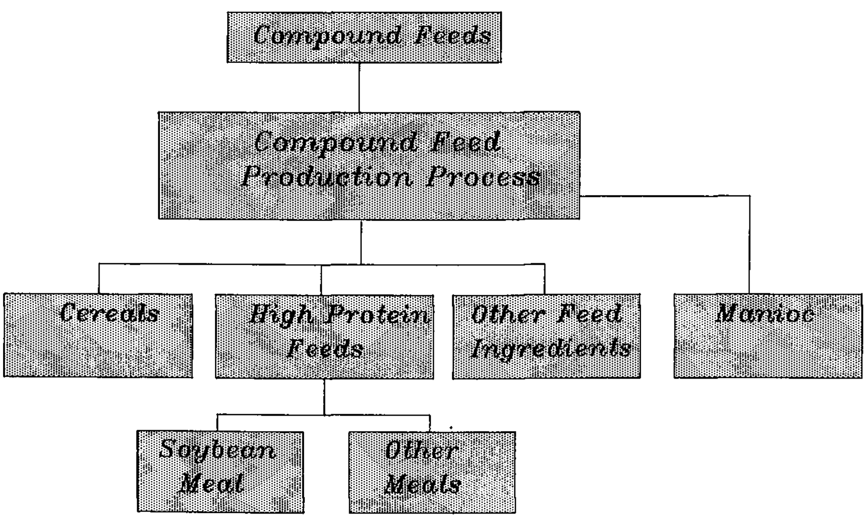

Figure 10.3 The structure of the compound feed technology

The group 'other feed ingredients' is a rather mixed group, which is not further characterized. It includes among others feedstuffs that are comparable to the oilmeals (linseed meal, safflower meal, peas), animal proteins (meat meal, fish meal, dairy products), and a host of by-products from agro-industrial origin (corn gluten feed and meal, bran, middlings, beet pulp, brewer's grain, citrus pulp). The 'other feed ingredients' group potentially competes with both the distinguished oilmeals as well as the cereals group (*e.g.* corn gluten feed and manioc can jointly substitute cereals), and as such is not an ideal composite commodity, but within the limitations of this study no further refinement was possible.

10.2 Economic model

10.2.1 Model structure

This section develops an algebraic model for the compound feed sector, to explain the demand for feed ingredients conditional on the amount of compound feeds demanded. The adopted formal framework is based on duality theory, *i.e.* the minimization of a restricted separable cost function. It follows the general structure provided in Figure 10.3, to which some further restrictions are imposed.

The compound feed sector is assumed to minimize a cost function of the following form

$$C(w,r;q,y) = C^F(w;q,y) + C^{NF}(r;y) \quad (1)$$

where $C(.)$ represents the total cost function which is additive separable into a feed $C^F(.)$ and a non-feed sub cost function $C^{NF}(.)$. This separability assumption seems not restrictive since feed and non-feed inputs are in general not substitutable (Peeters, 1989, p.136). All cost and sub cost functions are assumed to satisfy the usual regularity conditions (*cf.* Chambers, 1988, p.52 for details). The arguments $w,r;q,y$ represent respectively a vector of feed ingredient prices, a vector of factor prices, the quantity of rationed input and an output vector representing the amount of animal specific feeds produced (concentrates). The main feed ingredients in $C^F(.)$, which represents the upper level of the feed ingredient part, are 1) cereals, 2) high protein feeds, 3) other feed ingredients (excluding manioc), and 4) manioc (which is rationed due to import restrictions).

The upper level feed cost function $C^F(.)$ is assumed to be implicitly separable with respect to the individual high protein feed ingredients: soybean meal and meals derived from other oilseeds. Formally, this implies that

$$C^F(w;q,y) \quad = \quad C^F(w_1, C^{HPF}[w_{21}, w_{22}; q, y, x_2], w_3; q, y) \tag{2}$$

with w_{21} and w_{22} representing the prices for soybean meal and for other meals (price index) respectively, and x_2 denoting the amount of high protein feed (input) (see equation 8). This assumption allows for a weak partition of feed ingredients on the basis of their nutritive values (energy, protein).

As formulated in (2), $C^{HPF}[w_{12}, w_{22}; q, y, x_2]$ represents a sub cost function which still has a rather general structure. Some further structure is imposed by assuming $C^{HPF}[.]$ to be a (homogeneous) function in prices and total high protein feed use x_2 (which is assumed to indirectly depend on compound feed output y and available manioc q). The lower level cost function may then be written as

$$C^{HPF}[.] \quad = \quad C^{HPF}(w_{21}, w_{22}; x_2(y,q)) \tag{3}$$

In the following, the cost functions are specified and the corresponding conditional demand functions are derived for both stages. Starting with the lower level or second stage, first C^{HPF} is specified as a restricted quadratic function

$$C^{HPF} \quad = \quad \mu_0 + \sum_{i=1}^{2} \mu_i w_{2i} + \frac{1}{2} \sum_{i=1}^{2} \sum_{j=1}^{2} \mu_{ij} w_{2i} w_{2j} + \sum_{i=1}^{2} \rho_i w_{2i} x_2 \tag{4}$$

which can be seen as a truncated Taylor series approximation of the real underlying cost function. The demands for individual oilmeals can then be derived as (applying Shephard's lemma to the total cost function $C^{HPF}[.]$)

$$\frac{\partial C^{HPF}}{\partial w_{2j}} \quad = \quad x_{2i} \quad = \quad \mu_i + \sum_{j=1}^{2} \mu_{ij} w_{2j} + \rho_i x_2; \qquad i = 1,2 \tag{5}$$

Assuming the sub cost function satisfies the usual regularity properties, the following parameter restriction should hold (symmetry):

$$\mu_{12} = \mu_{21} \tag{6}$$

Besides these theoretical restrictions, additional restriction on the ρ_i -*s* could be imposed by exploiting the non-economic information on compound feed processing. From this non-economic information it is known that certain material balance constraints should hold. For the submodel, this implies $x_2 = \sum_{i=1}^{2} x_{2i}$, or (see Appendix 10A for the derivation)

$$\rho_1 + \rho_2 \quad = \quad 1. \tag{7}$$

The conditional demands for the aggregated inputs, *i.e.* the upper level (first stage), can be derived by applying Shephard's lemma to (1) which yields

$$\frac{\partial C(.)}{\partial w_i} \quad = \quad x_i \quad = \quad \frac{\partial C^F(.)}{\partial w_i} \quad = \quad x_i(w;q,y) \quad ; \qquad i = 1,\ldots,3 \tag{8}$$

and again assuming taht the compensated demands satisfy the well-known properties of homogeneity, symmetry and negativity of the substitution matrix.

The feed sub cost function is specified by a (restricted) quadratic flexible form, *i.e.*

$$C^F(.) \quad = \quad \alpha_0 + \sum_{i=1}^{3} \beta_i w_i + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} \beta_{ij} w_i w_j + \sum_{i=1}^{3} \gamma_{i0} w_i q + \sum_{i=1}^{3}\sum_{h=1}^{3} \gamma_{ih} w_i y_h \tag{9}$$

with w_i representing the input prices for cereals ($i=1$), high protein feeds or oilmeals

($i=2$), and other feed ingredients ($i=3$). The price for high protein feeds is approximated by the per unit cost function $C^{HPF}(.)/x_2$. The restricted input manioc is represented by q. The output of concentrates vector $y=(y_1, y_2, y_3)$ contains the amount produced of dairy, pigs, and poultry feed respectively.

The conditional input demand functions for feed ingredients (at the first stage) are then

$$x_i = \beta_i + \sum_{j=1}^{3} \beta_{ij} w_j + \gamma_{i0} q + \sum_{h=1}^{3} \gamma_{ih} y_h \qquad (10)$$

for $i = 1, ..., 3$.

From the theoretical properties, the following dependencies between the parameters of the system must hold:

$$\beta_{ij} = \beta_{ji}; \quad \forall i, j \qquad (11)$$

which reflects the symmetry condition (Young's theorem). Linear homogeneity of the cost function in prices can be imposed by using price normalisation.

Besides the theoretical restrictions, again the material balance conditons can be exploited. This yields two linear restrictions on the γ-parameters (see Appendix 10A for derivation):

$$\sum_{i=1}^{3} \gamma_{i0} = -1; \qquad \sum_{i=1}^{3} \gamma_{ih} = 1; \quad h = 1, ..., 3 \qquad (12)$$

The supply function for concentrates can be obtained by equating the marginal cost function (obtained by differentiating (1) with respect to output) to the price of concentrates, *i.e.* it is obtained by solving

$$\frac{\partial C(.)}{\partial y_h} = MC_h(w,r;q,y) =$$

$$\frac{\partial C^F(.)}{\partial y_h} + \frac{\partial C^{NF}(.)}{\partial y_h} = p_h; \quad h=1,\ldots,3 \tag{13}$$

where C^{NF} is still unknown. Note that this optimum condition derived from the profit maximization behaviour of the feed compounders only holds if the feed technology satisfies decreasing or constant returns to scale. It can be easily deduced from the foregoing that the marginal feed costs are constant (depending on input prices, but not on the amount of specific feed output). Marginal non-feed costs should therefore be at least non-decreasing in output. A possible simple candidate for the non feed cost function could be

$$C^{NF} = \delta_0 + \sum_{i=1}^{3} \delta_i r y_i + \sum_{i=1}^{3}\sum_{h=1}^{3} \delta_{ih} r^2 y_i y_h \tag{14}$$

Note that δ_i may be interpreted as a coefficient indicating the amount of factor input per unit of output of feed y_i, and that the term $r(\delta_i y_i)$ represents the feed-specific factor costs. The (second order) output product term is added because it is logical to approximate an unknown function with a flexible form but has a less pronounced interpretation. In order for C^{NF} to satisfy the required regularity conditions (non decreasing in output, non-negativity for positive output levels), the following contraints should hold

$$\delta_0 \geq 0, \quad \delta_i \geq 0, \quad \delta_{ii} \geq 0$$

Marginal non-feed costs are

$$\frac{\partial C^{NF}}{\partial y_i} = \delta_i r + \sum_{h=1}^{3} \delta_{ih} r^2 y_h \tag{15}$$

which is (given non-negative factor prices) clearly non-decreasing in output for $\delta_{ii} \geq 0$. If δ_{ih} equals zero for all *i, h* (implying non-jointness in feed production; *e.g.* Peeters and Surry, 1993, p.112), the constant returns or mark-up solution is obtained. In this case marginal non-feed costs are constant with the feed specific mark-up equal to $\delta_i r$.[6] The mark-ups, which are feed type (δ_i) and country specific (country specific factor prices r), can be determined via calibration by exploiting the optimum conditions given in (13). Denoting the marginal feed costs for output *i* by $z_i(w)$, and substituting (15) in (13) gives the optimal pricing relationship

$$z_i(w) \quad + \quad \delta_i r \quad \equiv \quad p_i; \quad i = 1,\dots,3 \tag{16}$$

from which the δ_i's can be solved up to a factor r.

10.2.2 Compensated and uncompensated elasticities

Finally, the price elasticities are derived. The conditional upper level price elasticities are equal to

$$\epsilon_{ij}^{c} \quad = \quad \frac{\partial x_i(.)}{\partial w_j}\frac{w_j}{x_i} \quad = \quad \beta_{ij}\frac{w_j}{x_i}; \qquad i,j, = 1,\dots,3 \tag{17}$$

The conditional price elasticities of aggregated feed inputs with respect to oilmeal prices and those of the individual oilmeals with respect to the prices of aggregated feed inputs are given by

[6] From private information obtained from insiders in the Dutch compound feed industry, it appeares that under normal processing and marketing conditions the actual pricing policy does indeed look like mark-up pricing.

$$\epsilon^c_{i,2k} = \frac{\partial x_i(.)}{\partial w_{2k}}\frac{w_{2k}}{x_i} = \frac{\partial x_i(.)}{\partial w_2}\frac{\partial w_2(.)}{\partial w_{2k}}\cdot\frac{w_{2k}}{x_i}$$

$$= \beta_{i,2}\frac{\partial w_2(.)}{\partial w_{2k}}\cdot\frac{w_{2k}}{x_i} \qquad (18)$$

$$\epsilon^c_{2k,i} = \frac{\partial x_{2k}(.)}{\partial w_i}\frac{w_i}{x_{2k}} = \frac{\partial x_{2k}(.)}{\partial x_2}\frac{\partial x_2}{\partial w_i}\cdot\frac{w_i}{x_{2k}} = \rho_k\beta_{2i}\frac{w_i}{x_2} \qquad (19)$$

with $k = 1, 2$ denoting respectively soybean meal and other oilmeals. The term $\partial w_2/\partial w_{2k}$ represents the change in the group price of high protein feeds as a result of a change in a single commodity belonging to that group. It will depend on the aggregator function used, with C^{HPF}/x_2 being an obvious candidate. In that case (18) comes down to

$$\epsilon^c_{i,2k} = \beta_{i,2}\frac{x_{2k}}{x_2}\cdot\frac{w_{2k}}{x_i} \qquad (18')$$

The conditional own-price and cross-price elasticities of high-protein feeds are given by

$$\epsilon^c_{2k,2l} = \frac{\partial x_{2k}(.)}{\partial w_{2l}}\frac{w_{2l}}{x_{2k}} = \left(\frac{\partial x_{2k}(.)}{\partial w_{2l}} + \frac{\partial x_{2k}(.)}{\partial x_2}\frac{\partial x_2}{\partial w_2(.)}\frac{\partial w_2(.)}{\partial w_{2l}}\right)\cdot\frac{w_{2l}}{x_{2k}}$$

$$= \left(\mu_{kl} + \rho_k\beta_{22}\frac{x_{2l}}{x_2}\right)\frac{w_{2l}}{x_{2k}} \qquad (20)$$

with k, $l = 1, 2$ and $w_2(w_{21}, w_{22})$ replaced by $C^{HPF}(.)/x_2$ as before. Finally the elasticities of inputs with respect to feed outputs can be written as

$$\frac{\partial x_i}{\partial y_h}\frac{y_h}{x_i} = \gamma_{ih}\frac{y_h}{x_i}; \qquad \frac{\partial x_{2k}}{\partial y_h} = \frac{\partial x_{2k}}{\partial x_2}\frac{\partial x_2}{\partial y_h}\frac{y_h}{x_{2k}} = \rho_k\gamma_{2h}\frac{y_h}{x_{2k}} \qquad (21)$$

and with respect to manioc availability as

$$\frac{\partial x_i}{\partial q}\frac{q}{x_i} = \gamma_{i0}\frac{q}{x_i}; \qquad \frac{\partial x_{2k}}{\partial q} = \frac{\partial x_{2k}}{\partial x_2}\frac{\partial x_2}{\partial q}\frac{q}{x_{2k}} = p_k \gamma_{20}\frac{q}{x_{2k}} \tag{22}$$

This latter expression only holds when the manioc import quota is binding[7].

10.3 Sample and prior information

10.3.1 Sample and pseudo data

There are severe data problems which prevent the estimation of a detailed model of the compound feed sector at the individual country-level. Fortunately, for some EU member states, there are applied studies (Peeters, Surry, a.o.) which provide information about some elasticities for specific countries. From these studies, some general idea about the elasticity and substitutability-structure can be formed. Moreover, the study of Blom (1995) provides an extensive base year data table for the EU compound feed industry[8]. In addition, quite detailed information about some simulation runs on the rebalancing-issue that Blom did in 1990 are available. This latter information, for convenience sake labelled as pseudo-data, incorporates a lot of technical information about compound feed manufactoring (*cf.* Blom, 1995, p.109 a.o.)[9]. At the aggregated EU-level, somewhat more reliable data are available (computed from indigenous production and import and export statistics). The data used finally are provided in Appendix 10B. This Table shows that in general only two observations per unit (country) are available, with the exception of the EU as a whole for which 8 observations are available.

A secondary source of pseudo data has been generated by using a least cost formulation-model of the kind actually used by many compound feed industries (Taylor and Newland, 1976, p.9). Details about the formulation of various feed

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[7] In 1995 for example, the utilitsation rates of the (country specific) manioc quota for Thailand, Indonesia, and China were respectively 56%, 14% and 0%, and thus clearly non-binding.

[8] The table was constructed for 1989 and as such is not completely consistent with base-year 1990 conditions. For details see Blom (1995) p.118-119 (compound feed consumption), p.121-127 (prices), and p.145 (feed ingredients).

[9] The use of pseudo data for a sector characterized by a lack of usual price and quantity data but where a lot of technical information is available is not unusual, and more intensively followed by McKinzie *et al* (1986), Hillberg (1986), and Peeters (1989).

rations and applied requirements and constraints following from the animal nutrition perspective, as well as the pseudo-data, are reported in Appendix C.

The limited availability of reliable data and general knowledge about the compound feed production process provide reasons to impose further structure on the theoretical model derived in the previous section. By imposing this structure, the number of free parameters to be estimated could be significantly reduced. Two systems of equations have to be estimated (*cf.* equations (5) and (10), where the first has 4 free parameters and the second has 15 free parameters)[10]. Given these limitations, the following feasible estimation procedure is suggested. Firstly, the lower level system will be estimated. The estimated unit cost, say C^{HPF}/x_2^*, will serve as a proxy for w_2 in the upper level system. Secondly, the upper level system will be estimated. Both systems, which have the character of a set of seemingly unrelated regressions, will be estimated with an appropriate estimator. The lower level system will be estimated with a restricted SUR-estimator. The upper level system will be estimated with a restricted mixed GLS-estimator (as discussed in Chapter V, Section 4). The prior-information that has been collected is taken into account (see following). Both systems are estimated using the already mentioned cross-section dataset consisting of 30 observations derived from Blom and EU statistics ('sample'), and 64 pseudo-data observations derived from a compound feed industry least cost formulation-model.

10.3.2 Prior information

For the upper-level model some prior-information, derived from the individual country studies, has been used. The non-sample information used, expressed in conditional elasticity-form, is shown in Table 10.3. Prior information on the elasticities of the three variable inputs with respect to the quantity of manioc is not available. Given the uncertainty regarding this information, rather high variances have been included. These variances have been constructed from assumed confidence areas, since not much empirical guidance is available. It is assumed that, with a probability of 95% the actual elasticity will not deviate from more than 90% of the

[10] Because of data limitations, at the upper level it was impossible to jointly estimate the cost function with the derived conditional input demands.

prior elasticity. For example, if the own price elasticity of cereals is -0.80, this implies that with a probability of 95%, the actual elasticity will lie within the range -1.52 and -0.08, *viz.* a 95% confidence bound of -0.80 plus or minus 0.72.

Table 10.3 Prior information on the compound feed sector's own and cross price elasticities

Price Product	cereals	high protein feeds	other feedstuffs
Cereals	-0.80	0.40	0.40
High protein feed	0.45	-0.20	-0.20
Other ingredients	0.35	-0.15	-0.30

Source: Own estimates based on the available literature, including which Surry and Moschini (1984, p.462), Peeters (1989), Surry (1990), Peeters and Surry (1993, p.123), and Blom (1995)[11].

10.4 Estimation results and discussion

The estimated model in fact assumes that there exists one production technology for the whole EU. Given the differences in industry structure between countries (mentioned already in the introduction), this is a really satisfactory assumption to make. Since it appears that the technical characteristisc of feed manufactoring production technologies partly depend on scale, the models have been estimated on a per firm basis. For each country, a representative firm has been constructed by

[11] The results from LP or LP-econometric type studies (which usually provide rather high elasticities on an individual product basis) were informative for developing a general idea about the substitution patterns, but were not so easy to transform into feed input-group elasticities.

'deflating' the quantities by the number of firms[12]. Moreover, dummy variables have been generated by categorizing the representative firms into small, medium and large firms[13].

Table 10.4 Estimation results for the main (upper stage) model of the compound feed industry

Dependent variable	Cereals		High protein feed		Other feed	
Explanatory variable	coefficient	t-value	coefficient	t-value	coefficient	t-value
Dummy large	1.149	1.54	0.377	0.846	-1.677	-1.13
Dummy medium	1.228	1.20	0.939	2.99	-1.972	-2.01
Dummy small	0.033	0.47	0.694	2.90	-0.651	-0.98
P-cereals	-0.157	-6.81	0.103	5.85	0.035	4.00
P-high prot.fd.	0.103	5.86	-0.093	-5.46	-0.004	-0.79
P-oth.feed	0.035	3.80	-0.004	-0.79	-0.032	-3.40
Q-manioc	-1.120	-7.65	0.058	1.45	0.062	0.44
Dairy feed	0.228	2.33	0.009	0.36	0.772	8.57
Pig feed	0.416	4.80	0.170	7.22	0.413	4.96
Chicken feed	0.371	4.86	0.349	16.80	0.279	3.81
R-square	0.578		0.879		0.760	

The estimation results for the upper stage are shown in Table 10.4, which gives the results of the Restricted Mixed Estimator (including prior information and theoretical constraints (t-values in adjoining columns). For each equation, (normally calculated) R-square's are added to get an impression of the goodness of fit. The compatability statistic α_p equals 0.14, indicating that the contribution of the stochastic prior-restrictions to the ultimate precision is only 14%. However, it should be noted that this statistic is not very informative in this case, because a lot of the prior infromation now enters the estimation procedure as pseudo-data.

[12] For each country thus a homogeneous firm structure was assumed, which was the best possible under the circumstances. The limited information about firm composition that could be obtained suggested that this assumption is not really satisfactory.

[13] In fact this comes down to replacing the term $\sum_{i=1}^{3} \beta_{ij} w_j$ in equation 9 by $\sum_{m=1}^{3} \sum_{i=1}^{3} \beta_i w_i d_m$ where d_m represents the m-th dummy variable, with $m=1$ for small, $m=2$ for medium, and $m=3$ for large representative firms respectively.

The estimation results for the lower level model are provided in Table 10.5. Because of the linear dependence and singularity of the variance covariance matrix, one equation in each system has to be removed from the estimation procedure. For the upper stage model the cost function has been left out, while for the sub model the other oil meals input demand equation has been deleted. The coefficients not estimated can be determined using the theoretical restrictions. Since besides the theoretical restrictions no specific prior information (about particular coefficients) is available, for the sub model only the unrestricted and restricted SUR estimates are provided.

Table 10.5 Estimation results for the lower level compound feed sector submodel

Dependent variable	Cost function		Soymeal demand	
Explanatory variable	coefficient	t-value	coefficient	t-value
intercept	-5.382	-1.25	0.387	2.27
P-soymeal	0.387	2.27	-0.004	-1.13
P-oth.meal	-1.165	-1.80	-0.015	-1. 18
Q-high prot.fd.			0.848	105.14
P-soymeal*P-soymeal	-0.004	-1.13		
P-soymeal*P-oth.meal	-0.015	-1.18		
P-oth.meal*Poth.meal	0.048	1.87		
P-soymeal*Q-high prot.fd.	0.151	17.73		
P-oth.meal*Q-high prot.fd.	0.846	105.14		
R-square	0.992		0.897	

Even though rather high variances have been added the pattern of the prior information is still clearly recognizable (see also Table 10.7 in the next section as compared with prior-info presented in Table 10.3). In fact this resembles the relatively weak significance of the pure sample estimates[14]. However, the relatively high significance levels associated with the final (or posterior) estimates indicates that the (rather vague) prior information, the sample information, as well as the

[14] From an econometric point of view, there seems to be a rather flat (non-sharply peaked) likelihood function. Including additional information improved the results (diminishing the dispersion about the optimum value) without much costs in terms of the minimum log likelihood value.

pseudo-data all tend to agree. The output coefficients all have the expected signs and can be interpreted as reflecting 'average ingredient use' (not corrected for influences of relative prices). Not-surprisingly pigs feed and chicken feed have relatively high feed grain 'shares' (both about 0.4). Chicken feed also plays a dominant role in manioc demand. This corresponds with what is known about diet composition, in particular regarding the high cereals (especially maize) share in the energy rich chicken feed (Peeters, 1989, p.162 and Appendix C, Table 10C-1). Cattle feeds contain a relatively large amount of other feed ingredients, including products like citrus pulp and cereals by-products. The negative sign of manioc in the cereals input equation confirms that both are competitors as energy sources in animal feeds. The manioc parameter estimates for both other ingredients (see Table 10.4 'high protein feed' and 'other feed') are non-negative, but seem at first sight rather low given the property of manioc and high protein feeds to jointly form a rather complete feed to replace cereals (Peeters, 1989, p.37). The R-squares found are rather high for regressions on cross section data, implying a satisfactory goodness of fit for the model.

Table 10.6 Compensated input price and quantity elasticities

	Prices					Feed output			Restr.inp.
	P-Crls	P-Ofi	P-HPF	P-Sml	P-Oml	Q-Dairy	Q-Pigs	Q-Chick.	Q-Manioc
Q-Crls	-0.338	0.065	0.229	*0.203*	*0.046*	0.24	0.44	0.33	-0.28
Q-Ofi	0.474	-0.369	-0.059	*-0.052*	*-0.012*	5.22	2.73	1.57	0.10
Q-HPF	0.336	-0.012	-0.315	*-0.279*	*-0.063*	0.01	0.27	0.47	0.24
Q-Sml	*0.284*	*-0.010*	*-0.266*	*-0.331*	*-0.127*	0.02	0.30	0.53	0.02
Q-Oml	*0.052*	*-0.002*	*-0.049*	*-0.427*	*-0.085*	0.01	0.17	0.30	0.01

Values for lower-stage model in italics. Abbreviations: P = price, Q = quantity, Crls = cereals, Ofi = other feed inputs, HPF = high protein feed, Sml = soybean meal, Oml = rape and sunflower meals.

Table 10.6 gives the economic characteristics, *i.e.* the compensated input price elasticities and the elasticities of inputs with respect to feed outputs and manioc availability. The elasticities are calculated at average prices and quantities. The input price elasticities are all inelastic, with the high protein feeds group the least sensitive for own price changes. High protein feeds and other feed ingredients are both substitutes for cereals and complementary with respect to each other. In particular the other feed ingredients group (which contains among others cereal by-products and corn gluten feed) shows high elasticities with respect to feed output (especially with respect to cattle or dairy feed). Within the high protein group, soymeal which is known for its favourable amino-acid profile, shows its superior position as a protein source: it has a negative cross price elasticity with other oilmeals (rape and sun) indicating that both behave as complements rather than as serious competitive substitutes. The output elasticities underscore the remarks made before when discussing Table 10.5. The demand for soybean meal shows the strongest positive relationship with the available quantity of manioc. Apart from manioc, however, also soybean meal and other feed inputs make often interesting combinations.

Given the estimated parameters and known output prices, the explanatory variables for the Marshallian supply functions (*cf.* equation 16) can be generated, and the supply equations subsequenty estimated. Unfortunately, a consistent picture could only be obtained for the base year (11 observations; see Appendix B). The output prices are based on reported compound feed prices for 1989 and 1990 (European Commission, 1991; 1992). Given the limited availability of reliable data the econometric estimation of the general non-feed costs function as presented in equation 14 had to be abandoned. It is assumed that under normal competitive circumstances, actual output prices are equal to computed ingredient costs plus an approximately fixed factor. In that case the estimated mark-ups can be established by means of equation 16. The calibrated mark-up factors are presented in Table 10.7.

On average, the mark-up factors found are lowest for dairy feed, intermediate for pig feed, and highest for poultry feed. Average mark ups are about 19.5%, 22.4% and 31.9% of the output prices of dairy feed, pigs feed and poultry feed respectively. These differences cannot be explained by looking solely at processing costs. The main reason for these differences is the incomplete measurement of food

Table 10.7 Calibrated non-feed cost mark-up factors

Country	Feed	specific	mark-up
	dairy	pigs	poultry
Netherlands	1.01	3.18	6.67
Belgium	5.47	7.25	11.72
France	8.04	9.23	10.25
Germany	1.15	3.88	5.98
Italy	10.94	8.29	12.32
United Kingdom	7.60	12.18	11.97
Ireland	4.65	7.90	10.01
Denmark	1.76	4.49	6.60
Greece	4.95	8.05	7.35
Spain	9.85	12.21	13.25
Portugal	10.91	11.45	13.46
Average*)	5.55	6.86	10.30

*) Weighted average with 1990 feed output shares.
Source: calibrated

ingredients, in particular of the so-called feed additives, most of which are used in the pig and poultry sectors[15]. Apart from this there remains some unexplainable variation, which is probably due to the poor quality of the data (output prices).

10.5 Concluding remarks

In this chapter the EU compound feed sector has been modelled and estimated. Besides prices and quantities which is the standard data economists rely on, a lot of other information has been used. Firstly an explorative analysis has been made of the EU compound feed industry, and of the main nutritional chracteristics of the relevant feed ingredients. This has provided a stepping stone for developing a

[15] Note that by treating the use of manioc as a quasi-fixed factor, the ingredient costs associated with manioc use become a fixed cost factor which are no longer reflected in the marginal costs (a change in the manioc price means a change in fixed not in marginal costs, at least as long as the quota restriction is binding). However, since compound feed prices are mainly based on ingredient pricing, manioc costs will be an implicit part of the calculated mark-ups.

structured cost minimization model and has generated prior information about important parameters. The limited data available has not allowed for estimating compound feed models at the member state level. The data has been supplemented by so-called pseudo-data, which have been derived from least cost programming model of the kind often actually used by feed compounders. This has provided a lot of additional insight into the technicalities of feed compounding and has allowed for an enriched final econometric inference procedure.

Summarizing the main results from this excercise, it can be stated that there exists a substitute-relationship between cereals on the one hand, and soybean meal and manioc on the other hand. Moreover, soybean meal appeares to have a strong position within the high protein feeds group, mainly due to its favourable characteristics, and can only to a limited extent be substituted for by the traditional EU meals (rape meal and sunflower meal). Manioc competes with cereals as an energy source. All feed ingredients have inelastic own price relationships, and their demand to a significant extent depends on the specific feed output for which they are used. From an animal nutrition point of view, there is a strong possibility that cereals will be intensively used as a feed ingredient (wide variations in cereals share are allowed), but this will require significant price reductions, since it has to compete with a host of by-products. Moreover, the prices of those by products are likely to follow cereal price developments.

Appendix 10A Technical restrictions on output parameters

Assuming no weight losses, the total weight of inputs must be the same as the amount of output produced, also measured in weight-units. Of course there are some losses but they do not invalidate the following derivation if it is assumed that they can be corrected for by a general loss-coefficient. For some Dutch compounders, it appeares that this loss percentage varied between 0.8 and 1.5%, where the latter percentage is seen by the industry as too high and so as a reason to investigate what factors are causing this loss. Because no general information is available, and the losses seem of negligable magnitude, it has been decided to specify no correction coefficient.

With respect to the use of high protein ingredients (lower stage), the balance constraint $x_{21}+x_{22}=x_2$ holds. Totally differentiating this constraint implies that

$$dx_2 = \frac{\partial x_{21}}{\partial x_2}dx_2 + \frac{\partial x_{22}}{\partial x_2}dx_2 \qquad (A-1)$$

which directly leads to (7) since the change in individual protein meals is given by

$$dx_{2k} = \frac{\partial x_{2k}}{\partial x_2}dx_2; \quad k=1,2 \qquad (A-2)$$

and $\partial x_{2i}/\partial x_2 = \rho_i$.

Looking at the upper stage, if the physical balance must hold, it follows that

$$dy = dy_1+dy_2+dy_3 = dx_1+dx_2+dx_3+dq \qquad (A-3)$$

where it is implicitly assumed that the changes in additives can be neglected. The cost-function approach is conditional on output y which is assumed to be exogenous. For a given output, the following relationship between the freely variable and resticted inputs should hold.

$$dq = -dx_1 - dx_2 - dx_3 \qquad (A-4)$$

Replacing the changes in feed ingredients x_i by partial derivatives, as in *(A-2)*, yields

$$dq = -\left(\frac{\partial x_1}{\partial q} + \frac{\partial x_2}{\partial q} + \frac{\partial x_3}{\partial q}\right)dq \qquad (A-5)$$

From this it directly follows that the term between brackets should be equal to -1, which implies the parameter restriction on the γ_{i0}'s (*cf.* equation 12; left part).

An analogous way of reasoning can be used to capture the constraints on the output-coefficients. Given a fixed amount of constrained input and other outputs, a change in output y_h can only be made possible by apropriate changes in variable inputs. But then it follows that

$$dy_h = \left(\frac{\partial x_1}{\partial y_h} + \frac{\partial x_2}{\partial y_h} + \frac{\partial x_3}{\partial y_h}\right)dy_h \qquad (A-6)$$

which directly leads to the required constraint on the γ_{ih}'s (*cf.* equation 12; right part).

Appendix 10B Price and quantity data

The quantity data are derived from Blom (1995) and the Blom rebalancing simulations (private information). Price data were generated based on Blom (1995), Eurostat, Peeters (1989) (transport cost differences), Product Board for Margarine, Fats and Oils, and own computations and guesstimates for some specific data (in particular for Greece and Portugal). The variable 'number of firms' was recaptured from Hogendoorn (1990), an unpublished study on the EU compound feed industry which has gathered a lot of information from local sources throughout the Community[16].

*Table 10B-1 Data set EU compound feed industry *)*

	quantities (t)							prices (Ecu/100kg)				output (t)		
Cntry	qcrls	qsml	qoml	qofd	qman	pcrls	psml	poml	pofd	pman	ydairy	ypigs	ypoultry	#Firms
EU1	30842	17569	5139	35684	7634	15.00	16.57	12.84	15.27	12.81	33332	35133	28403	5016
EU1a	34544	15539	5011	36304	5489	15.00	18.96	14.32	15.48	13.16	33332	35133	28403	5016
EU1b	42620	14768	4492	34142	865	15.00	20.20	15.51	16.15	15.52	33332	35133	28403	5016
EU1c	33012	16192	5133	36289	6261	13.50	16.64	12.65	14.37	11.77	33332	35133	28403	5016
EU1d	37452	15232	4703	34707	4793	13.50	18.67	14.11	14.76	12.30	33332	35133	28403	5016
EU1e	44695	14770	4048	34350	24	13.50	20.20	15.51	15.54	15.52	33332	35133	28403	5016
EU2	33202	17104	4948	36303	7520	16.48	22.41	14.91	17.31	16.03	37102	34822	27155	5016
EU3	31403	18728	6432	33778	6534	17.53	18.64	13.37	17.10	16.67	33123	32303	31449	5016
NE1	1992	2071	527	8901	3164	16.61	20.64	15.39	16.89	15.42	5602	7779	3273	326
NE2	2060	1844	934	8328	2846	16.51	16.82	11.21	14.93	16.03	4828	7439	3744	326
BLEU1	1382	766	114	1555	1245	16.37	21.35	14.59	17.00	16.12	1440	2688	934	205
BLEU2	921	953	326	2012	848	16.66	18.56	12.92	17.12	16.11	1366	2680	1014	205
FR1	6655	3136	1080	5151	685	16.80	21.54	13.76	17.28	16.33	5421	5128	6158	488
FR2	5008	3661	1165	5823	337	15.09	19.47	13.92	18.13	16.41	4051	4688	7255	488
GRM1	4239	3269	1601	6757	1005	16.41	21.94	15.00	17.27	16.72	7472	6098	3301	712
GRM2	3241	2782	1495	7459	1066	16.88	17.91	11.84	15.79	17.11	6528	5321	4194	712
IT1	3596	2544	373	4316	48	16.95	26.14	18.38	18.29	20.92	4405	2588	3884	1400
IT2	5123	2820	263	197	96	21.36	18.98	14.62	18.61	22.32	4013	2230	4638	1400
UK1	5140	1145	247	3716	272	16.41	21.25	15.36	15.68	16.03	4850	2181	3489	369
UK2	4200	1554	1001	3741	0	16.16	19.92	14.25	17.70	22.32	4177	2113	4206	369

(continued on next page)

16 This study was done at the LEI and kindly provided to me by Jan Blom. The use of various local sources raised problems of consistency (different sources reporting different numbers). For example, some sources counted mills while others focused on enterprises. The total number of 'firms' according to our construct is 5016 (1989) which clearly differs from the 4330 (1988) reported by Tracy (*cf.* introduction).

(Table 10B-1 continued)

	quantities					prices					output			
Cntry	Crls	Soyml	Omeal	Ofeed	Manioc	Crls	Soyml	Omeal	Ofeed	Manioc	Dairy	Pigs	Poultry	#Firms
IRL1	1288	187	34	647	0	14.71	22.55	15.80	18.84	17.33	1340	445	371	78
IRL2	718	168	190	1044	35	15.60	19.98	15.14	17.70	24.12	1269	412	475	78
DM1	1236	843	455	2011	305	15.39	21.84	14.56	17.75	16.62	1921	2426	503	471
DM2	1585	1343	488	1399	37	16.93	19.48	15.34	18.38	25.00	1680	2490	682	471
GRC1	348	221	36	235	10	16.83	23.55	14.51	18.35	18.32	269	172	409	48
GRC2	400	236	20	199	0	17.03	19.47	14.62	18.50	28.57	271	173	411	48
SP1	6403	2396	395	1955	160	16.33	22.94	13.81	19.31	17.72	3319	4215	3778	830
SP2	7136	2892	406	197	677	19.87	18.56	14.00	17.50	31.57	2089	4266	4953	830
PO1	923	526	86	1059	626	17.88	21.64	15.63	17.50	16.42	1063	1102	1055	89
PO2	1011	475	144	999	592	28.66	18.56	14.25	17.50	32.33	879	1166	1175	89

*) Column variables are quantities of cereals (qcrls), soybean meal (qsml), other meals (sunflower meal and rape meal; qoml), other feed ingredients (qofd) and manioc (qman), prices of cereals (pcrls), soybean meal (psml), other meals (poml), other feed (pofd) and manioc (pman), and output of compound feeds for dairy (ydairy), pigs (ypigs), and chickens (laying hens plus poultry; ypoultry). The final column denotes the selected number of compound feed firms. Row variables or countries are the EU-12 (EU), the Netherlands (NE), Belgium Luxembourg Economic Union (BLEU), France (FR) West Germany (GRM), Italy (IT), the United Kingdom (UK), Ireland (IRL), Denmark (DM), Greece (GRC), Spain (SP) and Portugal (PO).

In the Table, the first country specific observation (*eg*. PO1) concerns 1988, and the second one (PO2) 1990. A subset of these data that is used for calibration of the mark-ups in feed pricing.

Appendix 10C Pseudo-data generation

The (secondary) pseudo data has been generated using least cost linear programs for four types of Dutch feed rations. The feed rations are a standard dairy cow ration, a ration for fattening swine from 45 till 110 kg. liveweight, a broiler ration and a laying hen ration (untill 32 weeks age). The nutritional characteristics are based on CVB (1997, pp.19, 54, and 61), which held surveys among the Dutch compound feed sector, and reports a number of standard feeds. The rations are assumed to be representative for each livestock category. Dutch data has been chosen because information on nutritional composition, ingredient prices, and technical constraints often used are available only for the Dutch compounders. Moreover, the Dutch compound feed industry (with Germany) belongs to the class of largest compound feed producer within the EU. From other studies (Hillberg, 1986, Paarlberg *et al* 1986, p.26) it is suggested that the Dutch compound feed producing process is comparable with that of the UK, Germany, and Belgium.

The LP-models are used to calculate optimal (single) blends for fixed output quantities of various types of feed[17]. Subsequently the feed compositions are analysed under varying prices (parametric programming). Finally, for different prices and output compositions, 'national'-level (pseudo-) data are constructed. The set of main restrictions for the feed rations are shown in Table 10A-1. The nutritional restrictions include minimum energy requirements and minimum and maximum protein requirements (*cf.* the ME and DCP criteria used in Chapter 9) which are estimates mainly based on CVB (1997; energy) and Blom (1995; protein) data. Although for non-ruminants, constraints on amino acids are more relevant, DCP bounds have been formulated for all feeds (Bickel, 1988, pp.211-213; NRC, 1984, p.5). Besides energy and proteins, a number of other factors have been taken into account. Among

[17] So no 'blends of blends' procedure, which solves for several feed formulations simultaneously within ingredient inventory constraints, is followed since it is impossible to include the inventory management side due to lack of information.

them are restrictions on fat, fiber, amino acids (digestible Lysine, Methionine and Cystine, Threonine and Tryptofaan), and minerals (Calcium, Phosphorus, Magnesium).

Table 10C-1 Restrictions on feed programming model

Restrictions	Type	Units	Dairy	Pigs	Laying hens	Poultry
Nutritional						
(Energy and protein)						
VEM	Min		940			
EW	Min	MJ		1.03		
ME	Min	MJ			11.8	12.5
DVE	Min	g/kg	100			
DXP	Min	g/kg	180	160	155	185
(Other restrictions)						
DXF	Max	g/kg				
DXL	Max	g/kg		50	35	35
dLysine	Min	g/kg		6.6	6.2	10.2
dMethionine	Min	g/kg		2.3	3.7	5.4
dMethionine + Cystine	Min	g/kg		4.4	5.7	7.7
dThreonine	Min	g/kg		4.0	4.5	6.3
dTryptofaan	Min	g/kg		1.3	1.3	1.8
Calcium	Min	g/kg	6.0	5.4	38.0	7.8
Phosphorus	Min	g/kg	4.5	1.8	4.0	3.8
Magnesium	Min	g/kg	4.0			
Technical						
(Cereals and derived products)						
Wheat	Max	%	40.0	30.0	40.0	25.0
Wheat products	Max	%	40.0	15.0	15.0	5.0
Wheat + wheat products	Max	%	40.0	40.0	55.0	30.0
Corn	Max	%		50.0		(15.0)
Corn	Min	%			25.0	
Corn gluten feed	Max	%	30.0	10.0	10.0	5.0
Corn gluten meal	Max	%	30.0	15.0	15.0	5.0
All corn by-products	Max	%	50.0	25.0	25.0	10.0
Oats	Max	%	20.0	20.0	10.0	
Rye and rye products	Max	%	25.0	15.0		0.0
Barley	Max	%			10.0	5.0
Barley products	Max	%	25.0	10.0	5.0	0.0
Barley + barley products	Max	%			15.0	5.0
Triticale	Max	%		20.0	20.0	15.0

Restrictions	Type	Units	Dairy	Pigs	Laying hens	Poultry
(High protein feeds)						
Rape meal	Max	%	15.0	5.0	2.5?	0.0
Sunflower meal	Max	%	15.0	10.0	7.5	5.0
All non-soja high prot. feeds	Max	%	25.0	15.0	10.0?	5.0
Soybean meal	Max	%		20.0		
Manioc	Max	%	25.0	40.0	15.0	20.0
(Other ingredients)						
Dairy products	Max	%		10.0		
Fish meal	Max	%	0.0		3.0	3.0
All animal proteins	Max	%		50.0	10.0	10.0
Krijt	Max	%			11.0	11.0
Molasses	Max	%	8.0	5.0	2.5	2.5
Molasses	Min	%	2.5	2.5		
Oils and fats	Max	%	2.5	5.0	5.0	8.0
Other meals	Max	%	10.0	5.0	5.0	5.0
All other meals	Max	%	25.0	10.0	7.5	5.0
Peas and beans	Max	%	25.0	15.0	15.0	10.0
Pulp	Max	%	30.0	10.0		
Vinasse	Max	%	2.0	2.0	0.0	0.0
Salt	Max	%	0.45	0.35	0.30	0.30
Salt	Min	%	0.25	0.10	0.05	0.05
Animal-specific pre-mix	Eq	%	1.0	1.0	1.0	1.0
Weight	Eq	%	100	100	100	100

Explanation: VEM, literaly fodder unit milk, is the Dutch net energy unit for dairy cows (1 kg. VEM corresponds to 1 kg. barley of 12.5 MJ mtabolizable energy (ME) per kg (cf. Honing and Alderman, 1988, p.233). EW is the Dutch energy value measure for pigs. DXP is digestible crude protein. DVE (dillial digestible protein) is a Dutch protein measure for ruminant animals, which has the advantage over the DXP system in that it takes into account the central role of microbial fermentation in the two-stage digestive system of ruminants. DXF and DXL stand for digestible crude fat and fibre respectively. Instead of absolute levels only (more binding) digestible amino acids constraints are taken into account. Coarse grains include barley, maize, oats, rye, sorgum and others. Pulp includes beet pulp, potato pulp and citrus pulp. Premixes contain additives to meet the requirements of specific minor nutrients (minerals, vitamins) of which here only the most relevant ones (e.g. Ca and Mg) have been taken into account. If no number is provided in a cell there is no restriction, or if there is a restriction it is assumed to be non-binding. The restrictions 'All cereals and derived products', 'Animal proteins', 'Pulp', 'Dairy products', 'Other (inividual) meals' and 'All other meals' are restrictions on joint use of ingredients belonging to a certain group.
Sources: Own guestimates based on references and expert knowledge mentioned in main text.

In addition, a number of technical (palatability) restrictions is added which limit the use of various specific feed ingredients. Information on these constraints was available only to a very limited extent (most information was extracted from

Van der Poel, 1988a and 1988b). McKinzie *et al.* (1986, p.26) give a number of constraints based on observed useage patterns. Some further information regarding oilmeals has been extracted from Boucqué and Fiems (1988, p.126), and FNM (1997). Based on expert knowledge from the Animal Nutrition Group at Wageningen Agricultural University (in particular Thomas van der Poel, Peter van der Togt, and René Kwakkel), this information has been modified for this application. Moreover some more (disaggregated) information has been added with respect to cereals (taking into account anti-nutritional factors). For poultry rations, density constraints have been taken into account to guarantee a correct balance between calorie/nutrient ratio's (NRC, 1984, p.3). Following discussions with the expert group, limited and incidentally available feed ingredients have been excluded from the analysis.

Using the above information, rations have been simulated for all four animal groups (dairy cows, pigs, laying hens, poultry) under several price patterns. The price patterns have been formed as deviations from some actually prevailing price constellations. This involved letting the prices of other feeds (which allows for about 100 products, among them derived cereal products) stay more or less in line with actual plausible realizations. Subsequently, the individual ration compositions have been multiplied by plausible national compound feed output amounts to obtain input/output and price combinations that more or less correspond to the actual data found. The pseudo-data thus generated are presented in Table 10C-2 below. Finally the sample data as given in Table 10B-1 have been combined with those in Table 10C-2 for final model estimation.

Table 10C-2 Generated pseudo-data *)

			quantities				prices					output		
Obs	qcrls	qsml	qoml	qofd	qman	pcrls	psml	poml	pofd	pman	ydairy	ypigs	ypoultry	nfirm
1	608.50	549.88	50.00	1430.45	511.18	14.06	19.57	11.81	12.00	10.64	1050.00	1100.00	1000.00	89.00
2	597.65	545.95	55.35	1419.34	531.71	16.17	19.61	11.81	12.00	10.64	1050.00	1100.00	1000.00	89.00
3	672.74	546.79	55.35	1369.73	505.40	11.95	19.61	11.81	12.00	10.64	1050.00	1100.00	1000.00	89.00
4	607.92	520.53	104.33	1404.19	513.03	14.06	22.56	11.81	12.00	10.64	1050.00	1100.00	1000.00	89.00
5	463.12	208.11	17.50	1248.17	213.10	14.06	19.57	11.81	12.00	10.64	1335.00	465.00	350.00	78.00
6	458.74	205.65	19.76	1246.24	219.61	16.17	19.61	11.81	12.00	10.64	1335.00	465.00	350.00	78.00
7	484.96	207.29	19.76	1226.20	211.79	11.95	19.61	11.81	12.00	10.64	1335.00	465.00	350.00	78.00
8	462.89	195.10	40.47	1239.84	211.72	14.06	22.56	11.81	12.00	10.64	1335.00	465.00	350.00	78.00
9	3846.20	3128.44	250.00	9072.99	3202.38	14.06	19.57	11.81	12.00	10.64	7000.00	7500.00	5000.00	488.00
10	3802.38	3126.01	286.45	8957.96	3327.21	16.17	19.61	11.81	12.00	10.64	7000.00	7500.00	5000.00	488.00
11	4178.90	3106.27	286.45	8757.51	3170.88	11.95	19.61	11.81	12.00	10.64	7000.00	7500.00	5000.00	488.00
12	3843.86	2981.15	620.43	8854.72	3199.86	14.06	22.56	11.81	12.00	10.64	7000.00	7500.00	5000.00	488.00

Table 10C-2 continued

	quantities					prices					output			
Obs	qcrls	qsml	qoml	qofd	qman	pcrls	psml	poml	pofd	pman	ydairy	ypigs	ypoultry	nfirm
13	2166.88	1990.06	230.00	5137.35	1325.70	14.06	19.57	11.81	12.00	10.64	4000.00	2250.00	4600.00	1400.00
14	2116.49	1972.68	240.94	5108.78	1411.12	16.17	19.61	11.81	12.00	10.64	4000.00	2250.00	4600.00	1400.00
15	2461.83	1977.67	240.94	4878.30	1291.26	11.95	19.61	11.81	12.00	10.64	4000.00	2250.00	4600.00	1400.00
16	2164.19	1894.00	341.13	5077.78	1372.91	14.06	22.56	11.81	12.00	10.64	4000.00	2250.00	4600.00	1400.00
17	2583.47	2235.70	245.00	6202.57	1633.26	14.06	19.57	11.81	12.00	10.64	5000.00	3000.00	4900.00	830.00
18	2529.79	2216.85	259.58	6167.76	1726.02	16.17	19.61	11.81	12.00	10.64	5000.00	3000.00	4900.00	830.00
19	2897.66	2222.16	259.58	5922.25	1598.35	11.95	19.61	11.81	12.00	10.64	5000.00	3000.00	4900.00	830.00
20	2580.60	2124.71	393.17	6126.43	1675.08	14.06	22.56	11.81	12.00	10.64	5000.00	3000.00	4900.00	830.00
21	1874.08	1670.04	190.00	4437.16	1128.72	14.06	19.57	11.81	12.00	10.64	3500.00	2000.00	3800.00	1400.00
22	1834.64	1659.46	199.72	4403.06	1203.12	16.17	19.61	11.81	12.00	10.64	3500.00	2000.00	3800.00	1400.00
23	2120.16	1658.55	199.72	4222.67	1098.90	11.95	19.61	11.81	12.00	10.64	3500.00	2000.00	3800.00	1400.00
24	1871.97	1594.58	288.78	4375.50	1169.16	14.06	22.56	11.81	12.00	10.64	3500.00	2000.00	3800.00	1400.00
25	1855.14	2146.13	195.00	4012.04	1991.69	14.06	19.57	11.81	12.00	10.64	2000.00	4300.00	3900.00	369.00
26	1813.51	2131.98	215.90	3965.75	2072.86	16.17	19.61	11.81	12.00	10.64	2000.00	4300.00	3900.00	369.00
27	2106.42	2133.70	215.90	3775.35	1968.64	11.95	19.61	11.81	12.00	10.64	2000.00	4300.00	3900.00	369.00
28	1852.92	2033.32	407.38	3906.55	1999.84	14.06	22.56	11.81	12.00	10.64	2000.00	4300.00	3900.00	369.00
29	1594.84	1773.03	160.00	3440.57	1631.57	14.06	19.57	11.81	12.00	10.64	1800.00	3600.00	3200.00	205.00
30	1564.17	1767.51	177.50	3387.01	1703.82	16.17	19.61	11.81	12.00	10.64	1800.00	3600.00	3200.00	205.00
31	1804.86	1760.92	177.50	3246.70	1610.02	11.95	19.61	11.81	12.00	10.64	1800.00	3600.00	3200.00	205.00
32	1593.20	1688.86	337.80	3337.44	1642.69	14.06	22.56	11.81	12.00	10.64	1800.00	3600.00	3200.00	205.00
33	6377.91	1625.37	194.50	2677.23	0.00	9.00	15.00	12.00	12.00	12.00	4400.00	2585.00	3890.00	369.00
34	3861.60	1676.25	194.50	5142.65	0.00	12.00	15.00	13.00	12.00	13.00	4400.00	2585.00	3890.00	369.00
35	2335.03	1497.57	194.50	6458.90	389.00	14.00	20.00	16.00	12.00	13.00	4400.00	2585.00	3890.00	369.00
36	1707.22	1237.98	194.50	7346.30	389.00	17.00	25.00	16.00	12.00	15.00	4400.00	2585.00	3890.00	369.00
37	1834.21	564.28	76.25	850.26	0.00	9.00	15.00	12.00	12.00	12.00	1350.00	450.00	1525.00	78.00
38	1141.79	568.33	76.25	1538.63	0.00	12.00	15.00	13.00	12.00	13.00	1350.00	450.00	1525.00	78.00
39	653.14	516.35	76.25	1849.26	230.00	14.00	20.00	16.00	12.00	13.00	1350.00	450.00	1525.00	78.00
40	463.36	447.65	76.25	2107.74	230.00	17.00	25.00	16.00	12.00	15.00	1350.00	450.00	1525.00	78.00
41	12142.57	2761.22	260.00	4536.22	0.00	9.00	15.00	12.00	12.00	12.00	7300.00	7200.00	5200.00	830.00
42	7516.82	2820.91	260.00	9102.28	0.00	12.00	15.00	13.00	12.00	13.00	7300.00	7200.00	5200.00	830.00
43	4080.98	2413.61	260.00	12465.41	480.00	14.00	20.00	16.00	12.00	13.00	7300.00	7200.00	5200.00	830.00
44	3092.93	2017.18	260.00	13849.89	480.00	17.00	25.00	16.00	12.00	15.00	7300.00	7200.00	5200.00	830.00
45	6095.13	1788.97	230.00	2535.91	0.00	9.00	15.00	12.00	12.00	12.00	3800.00	2250.00	4600.00	369.00
46	3775.60	1857.81	230.00	4786.59	0.00	12.00	15.00	13.00	12.00	13.00	3800.00	2250.00	4600.00	369.00
47	2311.11	1685.71	230.00	5983.18	440.00	14.00	20.00	16.00	12.00	13.00	3800.00	2250.00	4600.00	369.00
48	1700.79	1379.14	230.00	6900.07	440.00	17.00	25.00	16.00	12.00	15.00	3800.00	2250.00	4600.00	369.00
49	7243.72	1954.99	232.50	2918.80	0.00	9.00	15.00	12.00	12.00	12.00	4500.00	3200.00	4650.00	369.00
50	4477.34	2021.29	232.50	5618.87	0.00	12.00	15.00	13.00	12.00	13.00	4500.00	3200.00	4650.00	369.00
51	2644.92	1805.17	232.50	7227.41	440.00	14.00	20.00	16.00	12.00	13.00	4500.00	3200.00	4650.00	369.00
52	1962.36	1484.88	232.50	8230.26	440.00	17.00	25.00	16.00	12.00	15.00	4500.00	3200.00	4650.00	369.00
53	5340.30	1522.85	185.00	2151.85	0.00	9.00	15.00	12.00	12.00	12.00	3200.00	2300.00	3700.00	1400.00
54	3344.54	1569.61	185.00	4100.85	0.00	12.00	15.00	13.00	12.00	13.00	3200.00	2300.00	3700.00	1400.00
55	1940.06	1405.95	185.00	5289.00	380.00	14.00	20.00	16.00	12.00	13.00	3200.00	2300.00	3700.00	1400.00
56	1441.75	1164.11	185.00	6029.14	380.00	17.00	25.00	16.00	12.00	15.00	3200.00	2300.00	3700.00	1400.00
57	10573.75	2229.64	160.00	3586.61	0.00	9.00	15.00	12.00	12.00	12.00	5600.00	7750.00	3200.00	488.00
58	6688.40	2249.36	160.00	7452.23	0.00	12.00	15.00	13.00	12.00	13.00	5600.00	7750.00	3200.00	488.00
59	3281.17	1845.33	160.00	10963.49	300.00	14.00	20.00	16.00	12.00	13.00	5600.00	7750.00	3200.00	488.00
60	2566.03	1571.93	160.00	11952.04	300.00	17.00	25.00	16.00	12.00	15.00	5600.00	7750.00	3200.00	488.00
61	6878.86	1858.49	190.00	2422.65	0.00	9.00	15.00	12.00	12.00	12.00	3300.00	4250.00	3800.00	830.00
62	4443.56	1904.74	190.00	4811.70	0.00	12.00	15.00	13.00	12.00	13.00	3300.00	4250.00	3800.00	830.00
63	2311.86	1652.76	190.00	6835.38	360.00	14.00	20.00	16.00	12.00	13.00	3300.00	4250.00	3800.00	830.00
64	1791.07	1375.85	190.00	7633.07	360.00	17.00	25.00	16.00	12.00	15.00	3300.00	4250.00	3800.00	830.00

*) See Table 10B-1 (previous Appendix) for an explanation of the abbreviations used.

PART III

POLICY SIMULATION

Chapter 11

GOLF Simulation Model

11.1 Introduction

This chapter describes the GOLF simulation model. The simulation model mainly follows the empirically estimated sector models discussed in the foregoing chapters. The elasticity and growth trend estimates obtained earlier and the base year developed are used as basic ingredients to calibrate the GOLF-model. Besides this information, some additional steps have to be taken in this chapter. Firstly, in some cases the results previously obtained have to be polished up in order to avoid the non-convexities that are detrimental for simulation excercises (causing model non-convergencies). Secondly, several issues of model-closure are raised, in particular the determination of net excess supply and demand functions of the EU GOLF complex with respect to the rest of the world. Thirdly, the EU's common agricultural policy (CAP) and the associated financial streams have to be explicitly modelled.

The chapter is organized as follows. Section 11.2 starts with the model calibration procedure, including the calibration of net excess demands and supplies for the rest of the world. Section 11.3 describes the way the CAP is incorporated into the model. Finally, Section 11.4 discusses the operational compensation and deadweight loss measures used. The latter are extensions and modifications of the theoretical measures discussed in Chapter 3. The Chapter ends with a summary and concluding remarks (Section 11.5).

11.2 Model calibration and closure

11.2.1. Model calibration

In order to parameterize the GOLF simulation model, two inputs are required, *viz.* elasticity estimates and base year data. For the current simulation exercise, 1990 is chosen as a base year, which largely reflects the 1990s actual situation with some normalisation for extreme circumstances. The base year data are presented in Appendix 11A (various Tables). The elasticity estimates are derived from previous chapters, with some minor adjustments, as is discussed below.

The consumer demand model's parameters are calculated following the AIDS-model specification as discussed in Chapter 6. Final consumer expenditure and domestic (human) consumption of farm products are linked by measuring human consumption in farm-equivalents. The non-farm value in consumer expenditure is decomposed into a quantity (non-farm input) and a price component (price index). The simulation model allows for consumption taxes on all final consumption categories. In order to being able to compare the 'true' EV and CV measures with the so-called traditional single-equation approach, simple Marshallian demands were calibrated, in which demand is modelled as only a function of its own price. The Marshallian demands are calibrated using the elasticities associated with the so-called SWOPSIM-model[1].

The calibrated arable sector's model follows Chapter 7. The own-price elasticity of oilseed supply for Germany is taken to be 0.30 (*cf.* Table 7.3). A number of policy instruments are added. Set-aside is implemented by including base areas for cereals and oilseeds in the model. Set-aside imposes a correction on the arable land allocated to cereals and oilseeds, where the correction factor accounts for slippage. Moreover, in the profit relationship, direct compensation payments for both idled land, and cultivated cereals and oilseed areas (corrected for differences in regionalized normative yields per hectare) are included. Actual cultivated areas are estimated and compared with known base areas for cereals and oilseeds in order to

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[1] SWOPSIM stands for Static World Policy Simulation modelling framework. The multi-product multi-country model was developed at the Economic Research Service, US Dept. of Agriculture and is used used for a number of purposes including analysing the effects of the Urugay Round (cf.Sullivan et al, 1992 for details about data sets and elasticities).

allow for possible down-scaling of arable payments.

The structure of the compound feed sector model is analoguous to that described in Chapter 10. However, instead of the (average) elasticity estimates presented there, elasticities corresponding to each individual country's typical situation were used. As can be easily seen recalling the linear demand specifications, this implies that countries that have a below-average input level show higher (absolute) own price demand elasticities, and also the other way around. For example, the own price input demand elasticity for cereals for the Netherlands is now estimated as -0.37 and for France -0.16, while the reported average value is -0.30. Mark-up relationships are calibrated using base year input and (compound feed) output prices.

The cattle-dairy model corresponds to the specification and estimates discussed in Chapter 8. For Greece, Spain and Portugal, the average elasticity estimates (see Table 8.3, lowest line) are used. An additional equation is introduced which accounts for the (normative) milk yield per cow and its development over time (autonomous biological technical progress). The number of dairy cows (necessary for milk production) is determined by dividing actual (fixed) milk supply by normative production. This latter number can be used to analyse milk cow premiums (premiums attached to quota rights can easily be modelled anyway). The profit function is modified to include direct premiums on dairy and suckler cows.

The intensive livestock sector's elasticity estimates are modified whenever strange values are obtained, as in the case for Germany, Spain and Portugal for pork, and France and Portugal for eggs. 'Wrong' elasticities are transformed in elasticities with the appropriate sign, but with values close to zero. With regard to the (animal) stock equations, output price elasticities of 0.15 and input price elasticities of -0.15 are assumed for all countries, while the coefficients for the lagged stock equations are taken to be the same as that in the earlier regression estimates (when lying within the 0-1 range) or equal to the average lagged variable coefficient (for values outside the 0-1 range) (Table 9C-4).

Finally, to complete the revenue and costs structure of the various subsectors, the non-feed variable input costs have to be included. The (non-feed) variable input costs for the base year are indicated in Table 11A-3. The arable sector's variable inputs expenditure is estimated based on FADN-data on intermediate inputs (in particular plant protection products and fertilizer and soil improvers), with the fertilizer decomposed into fertilizer use by the arable sector and the cattle/dairy sector (based on cultivated land use-shares). Unfortunately, FADN-data only provide information on some intermediate inputs which are difficult to decompose into subsectors, and which include fixed input cost-elements. As a consequence the variable input costs have to be estimated from other sources. The variable input cost for the cattle-dairy consists of the already mentioned expenditure on fertilizers and includes a mark-up for veterinary costs (80 Ecu/animal), energy costs (25 Ecu/animal), and other variable input costs (25 Ecu/animal) (mainly based on Holwerda, 1994, pp. 15, 19). The variable input costs associated with the livestock sectors consist mainly of breeding material costs, veterinary costs, and energy costs. The main part of the breeding material costs is, however, already implicitly taken into account because the feed input is activity-based, *viz* the feed input of a fattening pig includes the feed costs of a piglet and part of those of the sow. Estimates were based on De Craene and Viaene (1992, pp. 69, 85, 88, 101; partly French and partly on Dutch holding practices), Vaessens and Backus (1997), Holwerda *et al* (1994, pp.55, 57, 68, 79, 105) and private information from Dutch experimental stations on animal husbandry. Veterinary, energy, and other variable costs (water, etc.) for pigs, are estimated as respectively 4.5, 2.5 and 3.85 Ecu per pig/year. The corresponding costs for the poultry sector are 2.5, 3.1, and 1.3 Ecu/100 slaugther hens/year, and for the laying hens sector are 2.85, 0.1, and 3.2 Ecu/100 hens/year. Some regionalization of these costs is accounted for (based on, among others, Veassens and Backus), with costs in Denmark and the Netherlands equaling 100%, Belgium 102%, UK 93%, France 90%, Italy 104%, and the other countries 101%.

11.2.2 Model closure

To these (subsector) models derived from previous empirical research, an additional block is added in order to close the model with regard to the rest of the world. Linking the GOLF-complex with the rest of the economy, which is also an element of model closure, is discussed in section 11.4 because it fits in directly with the account for the financing of the CAP in the used compensation measures.

Linking the EU to the rest of the world (ROW) is no trivial excercise. It is beyond the scope of this research project to estimate ROW net excess demands for EU products and to explain world market price formation. International trade in agricultural products is a highly manipulated trade (due to exporting countries' surplus disposal), and sensitive to incidental shocks (weather, disease, policy). As a result world markets are often characterized as "thin", which makes it questionable to assume infinitely elastic world market demands or supplies (Zhu, Cox, and Chavas, 1998, p.12). As will be discussed further in Chapter 12, before the agreement on tarrification, EU price levels could be assumed to be more or less exogenous. As will be argued in Chapter 12, even after tarrification the old system retained a lot of its power. In order to endogenize export subsidies, world market prices are endogenized by specifying net excess demand functions derived from ROW demand and supply conditions (*eg.* Ritson and Harvey, 1997, pp.401-402). The (own-)price ROW demand and supply elasticities used to calibrate these functions are synthetic estimates based on those used in the SWOPSIM model developed at the USDA (Sullivan *et al*, 1992), and the model of Tyers and Anderson (1992).

Table 11.1 gives an overview of the assumed elasticities and market data (with calculated implicit net excess demand elasticities). For the dairy products, besides the product elasticities, elasticities based on calculated fat and milk components are also derived. Since the model cannot handle individual dairy products, the world dairy market will is simplified into a fat and skimmed component market, where it is assumed that the fat/skimmed component composition of the domestic dairy consumption basket does not change over time[2]. Changes in domestic production and/or consumption will lead to changes in net exports of components, and cause their world market prices to adjust. Consequently the calculated world market price of raw milk, and via tarrification the EU milk price, will also adjust.

The net excess demand (own) price elasticities are high when compared to the elasticities prevailing in the subsector models. For some products (like potatoes and eggs) they may even suggest that the EU-12 can be almost considered to be a price taker. However, as already remarked above, one should be cautious here. The followed calculation implicitly assumes the ROW markets to be non-distorted, with the full market cushioning changes in EU's net exports. In reality this is not the case, since many countries are known to intervene in their agriculture. The other

[2]See Oskam (1988) for a clear discussion of milk arithmatic on skimmed and fat components.

Table 11.1 Assumptions regarding Rest of the World

Product	world supply [Mill.t.]	% gpa ****)	world demand [Mill.t.]	% gpa ****)	net excess demand [Mill.t.]	supply elasticity ***)	demand elasticity ***)	excess demand elasticity
Cereals*)	1286.400	1.3	1316.310	1.5	29.910	0.45	-0.25	-30.37
EU oilseeds*) **)	46.972	3.0	46.168	3.5	-0.814	0.25	-0.35	-34.97
Soybeans**)	108.134	1.0	91.751	2.0	-16.383	0.25	-0.30	3.33
Sugar*)	93.182	0.7	98.620	0.5	5.438	0.33	-0.45	-13.82
Potatoes**)	268.107	0.0	268.675	0.0	0.568	0.35	-0.25	-283.46
Beef&Veal*)	45.955	0.7	46.522	1.0	0.567	0.35	-0.80	-94.01
Pork*)	54.454	1.5	54.998	1.5	0.456	0.50	-0.45	-114.08
Poultry**)	29.547	1.3	29.838	1.4	0.291	0.55	-0.70	-127.62
Eggs**)	26.782	1.2	26.931	1.2	0.149	0.40	-0.55	-171.31
Butter**)	7.553	0.5	7.940	0.3	0.387	0.30	-0.70	-20.22
SMP**)	4.167	0.2	4.483	0.3	0.316	0.15	-0.30	-6.24
WMP**)	2.106	0.2	2.608	0.3	0.502	0.15	-0.30	-2.19
Cheese**)	14.574	1.1	14.798	1.5	0.404	0.40	-0.50	-32.74
Other**)	4.674	0.2	5.023	0.2	0.349	0.20	-0.30	-7.00
Fat component	285.691		300.950		15.259	0.32	-0.60	-17.89
Skimmed component	199.266		211.160		11.893	0.31	-0.43	-12.71

Comment: Autonomous percentage growth of world supply and demand (% gpa). Butter, SMP, WMP, Cheese, and Other (concentrated milk) converted into milk equivalent by using fat component factors 22.14, 0.00, 6.72, 6.54, 1.94, and skimmed component factors 0.17, 11.38, 7.91, 8.38, 2.46 respectively. Fat and skimmed component elasticities based on a component-weighted (production) average of the product elasticities. Oilseed consumption converted into seed-equivalents.

Source: *) USDA (1992) *Agricultural Statistics*, Washington DC, various pages; **) FAO (1991) *Yearbook Production*, Vol.45, Rome, various pages; ***) Sullivan *et al* (1992), pp.184-185 (SWOPSIM elasticity data), and Tyers and Anderson (1992), Appendix A. ****) Autonomous percentage annual growth of world supply and demand (% gpa) based on 20-year averages (supply) and on combined income elasticities (Tyers and Anderson, 1992, Table A-3) and income growth assumptions (world demand).

extreme may be to focus on EU shares in world trade. The 1990 share of the EU in total world exports for beef and veal, butter and skimmed milk powder (SMP) is 22, 38 and 37% respectively. For cheese the EU's share is 57% and for condensed milk it is over 70%. Such high world export shares suggest that at least for some products, the influence of EU net export changes might be greater than what is suggested by the elasticities indicated in Table 11.1. For example, applying the same rule to trade shares for cheese, the calculated price elasticity of ROW excess demand is -1.56 (based on total world cheese export of 882 thousand tonnes and unaltered demand and supply elasticities). This gives a number of about a factor 20 less elastic that the current number provided in Table 11.1. However, this latter number implicitly assumes that domestic markets are completely insulated from export markets. That is unrealistic, for even when domestic sectors are protected (by fixed tariffs), in principle price changes work fully through markets inducing adjustments. In the model, the ROW net excess demands are derived from calibrated ROW supply and demand functions, which are chosen to satisfy the constant elasticity characteristic. In order to obtain net excess demands and supplies at the appropriate level, corrections are introduced to account for 'industrial use' of cereals, potatoes and eggs, and the (assumed autonomous) supply of some non-modelled minor oilseeds.

Although balance of trade functions are used, they are not interpreted as strict budget constraints here, but rather as compensation-measure devices. The initial balance of trade is therefore not required to be in equilibrium, but may have a deficit or surplus, which, however, will be held constant at its initial level in the simulation exercises.

11.3 The Common Agricultural Policy

It is beyond the scope of this study to give a detailed discussion of the CAP (recent references are Tracy, 1997 and Ritson and Harvey, 1997), but in this section some detail is provided on the way the policy instruments and financial streams associated with the CAP are included in the modelling framework. The section starts with a brief sketch of the various product specific policy arangements. Details about including the various associated policy instruments in the model framework are provided in Apendix 11B. The impact of the fixation of tariffs (tarification) imposed by the Uruguay Round is saved for Chapter 12, which has a detailed discussion about trade liberalisation. This section functions as a stepping stone for formulating operational national welfare or compensation measures. These measures, which are derived by applying the trade balance function to the EU's institutional CAP framework, are the subject of Section 11.4.

Starting with the cereals regime, the "old" policy (which prevailed in 1990) and the "new" policy (after MacSharry reform) are schematicaly described in Figure 11.1. Since the cereals policy is an 'ideal' model of a CAP market support system, the figure also shows the main policy instruments and as such provides a graphical illustration to the formal equations provided in Appendix 11B. The traditional support system included target prices, (variable) import levies and export refunds, and an intervention scheme. Mainly to cope with budgetary pressures this system was adjusted over time by making producers partly responsible for part of the budget costs by requiring them to pay a co-responsibility levy. Moreover, the lack of convergence in economic policy between the member states after the CAP was initiated, soon led to exchange rate realignments between member states. This ultimately resulted in the rise of a complex green monetary system for agriculture. As a result, the unity of market principle broke down and support prices began to differ over member states (see difference between common price and internal price). To avoid system-threatening good arbitrage monetary compensating border levies were introduced.

The MacSharry reform in 1993 replaced the traditional system. This alternative scheme reduced direct price support, but supplemented this by (indirect) per hectare payments. The new target price was lowered by roughly 30% relative to the intervention price in the old system (Commission, 1995a). The model includes all the policy instruments necessary to simulate the reform (see Appendix 11B for details).

With respect to oilseeds, a similar regime came into being. The "old" regime in its essence was a deficiency payments system, which operated by granting processing subsidies to the oilseed processors for crushing EU-based oilseeds. Similar

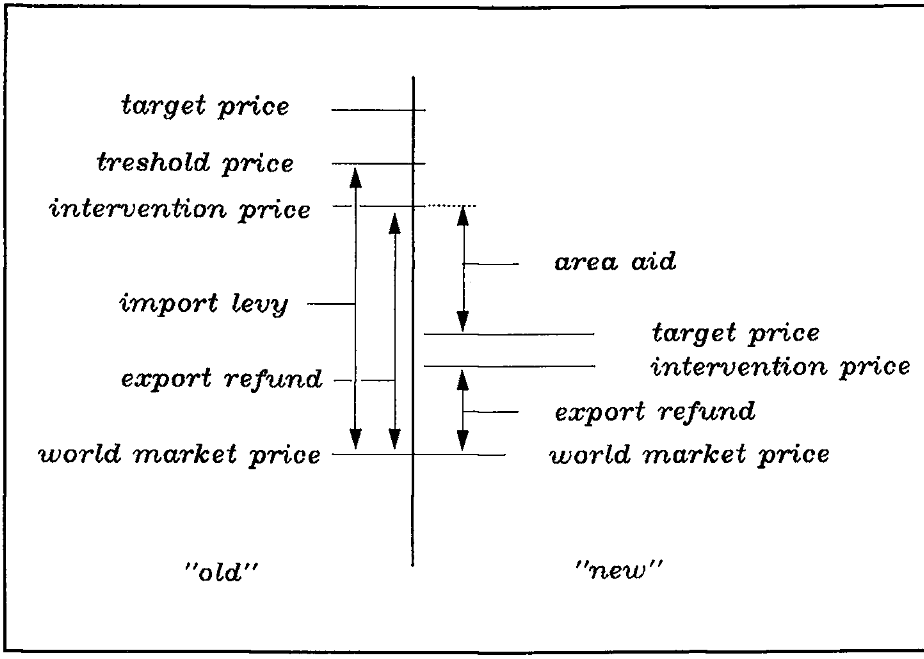

Figure 11.1 Cereals price support
Source: derived from Ritson and Harvey, 1997, p.99.

to the system for cereals, the "new" regime consists of per hectare payments, which are roughly sufficient to compensate farmers for the vanishing deficiency payment. At the same time, the institutional support price was reduced by about 45% (Commission, 1995a).

From its inception, the sugar regime limited support to domestic production within production quotas. The regime identified nationally based A-quota (basic quota) and B-quota (specialization quota) sugar which both received a decreasing price support, while production in excess of these quota, the so-called C-sugar, receives no support at all. Within the model, the quota and its associated prices are policy instruments. Moreover, the EU agreement to allow market access for a limited amount of so-called ACP-sugar is also included in the model.

The CAP regime for the cattle-dairy sector consists of a supply management scheme for milk (super levy introduced in 1984) and a co-responsibility levy system for the period 1977-1993. Besides, the internal price support instruments common to EU programme commodities are in place (Commission, 1995b). With respect to beef, a target price policy is mainly followed, combined with import levies and a limited intervention policy. Moreover, special premiums exist for male animals (granted up to 90 animals) per age bracket (10 and 22 month) per calendar year per holding, with the maximum premium payment level specified at the regional level. Besides, there is a suckler cow premium intended for producers who do not deliver milk or milk products, or only have a small dairy operation (below 120.000 kg milk reference quantity). Entitlement to this premium is limited by application of an individual ceiling per holding. Both premiums are made conditional on some extensification criteria. Besides the two premiums mentioned, some others exist, like a deseasonalisation premium, a calf processing premium, and an on-top premium on previously mentioned special and suckler cow premiums aimed at encouraging further extensification. These latter less important premiums are not included among the policy instruments (Commission, 1995c).

The pork, poultry and eggs sector are supported by a lightly structured common market organisation. This basically consists of export subsidies aimed at compensating for the competitive disadvantage that the EU's intensive livestock producers have due to the cereals suport regime (Commission, 1995c). Besides, a scheme of private storage aid exists, which is however not always in place but only functions in extreme situations. Within the model, export subsidies, import levies, and a storage facility are introduced as (potential) policy instruments.

Thus the model includes the main features of the agri-monetary system in the EU. National (institutional) farm prices and direct payments (measured in local currencies) are derived from central institutional prices (measured in ECU) multiplied by the appropriate green exchange rates (including switch-over). Monetary compensatory transfers are calculated by multiplying all country's net exports by their relevant monetary compensation amounts (MCAs).

11.4 Operational compensation measure and costs of public funds

The national welfare measures regarding the CAP follow the previously discussed balance of trade function (see chapter 3, section 3.4.2). Applying for example equation (30) of Chapter 3 to the EU-model, yields

$$B_h(p^c, p^i; z^i, U_h) = e(p^c, U_h) - R^a(p^a, z^a) - R^{d-c}(p^{d-c}, z^{d-c})$$
$$- R^p(p^p, z^p) - R^{plt}(p^{plt}, z^{plt}) - R^e(p^e, z^e) - \sum_i t^i m^i \qquad (1)$$

with p^i, z^i price and fixed input vectors associated with sector i *(i=1, c-d, p, plt, e)* denotes arable, cattle-dairy, pigs, poultry, and eggs. Variable m^i denotes (compensated) net imports (associated with sector *i*). (All *h* variable-subscripts have been suppressed for convenience of notation; for other variables see Chapter 3).

However, as it stands it need further modification. The upper right hand side term, which denotes the tariff revenues should be modified to account for the common european market (subsidized programme-commodities and storage). Moreover, a number of non-captured financial streams, like direct income payments and FEOGA contributions, should be taken into account.

$$B_h(p^c, p^i, dp^a, ba^a, sa^a, q^{c-d}, dp^{c-d},$$
$$sc^{c-d}, mc^{c-d}, mcb_{hj}, \Delta stock_j; z^i, U_h) \quad = \quad e_h(p^c, U_h)$$
$$+ \gamma^h(\sum_h dirpay_h^a(.) + dirpay_h^{c-d}(.)$$
$$+ \sum_j intcst_j(\Delta stock_j, \ldots; stock_{j,t-1}) + \sum_h \sum_j mcb_h m_{hj}) \quad - \ldots$$

continued on next page

$$R_h^a(p^a;z^a) - dirpay_h^a(dp^a, ba^a, sa^a)$$
$$- R_h^{d-c}(p^{d-c};q^{c-d}, z^{c-d}) - dirpay_h^{c-d}(dp^{c-d}, sc^{c-d}, mc^{c-d})$$
$$- R_h^p(p^p;z^p) - R_h^{plt}(p^{plt};z^{plt}) - R_h^e(p^e;z^e) - QTRF$$
$$+ \gamma^h \sum_j t_j \Big(\sum_h m_{hj} - \Delta stock_j \Big) \qquad (2)$$

where γ^h represents a coefficient expressing the h-th country's share in the costs associated with the CAP, mcb_{hj} denotes the monetary compensating border amounts (in Ecu/ton) for country h and product j, $intcst_j$ indicates the overall intervention costs associated with product j. Moreover, q^{c-d} represents the milk quota, while dp^a, ba^a, sa^a represent vectors of direct payments, base-areas, and set-aside for the arable sector, and $dp^{c-d}, sc^{c-d}, mc^{c-d}$ represents a vector of direct payments, and suckler and male cow numbers eligible for support for the cattle-dairy sector respectively. $QTRF$ represents potential tariff revenues due to WTO quota tariffs (further discussed in Chapter 12, section 12.2). Since the focus is on actual revenue changes (associated with actual equilibria), the measure is a so-called money metric welfare measure (See Chapter 3, subsection 3.4.2) and also a (second-best) excess burden (or efficiency) measure (*e.g.* Chapter 3, section 3.5). The country contribution shares γ^h are based on a weighted average of actual shares during the period 1989-1992 and are shown in Table 11.2.

The final term of (2) comprises the net tariff revenues (measured at EU-level and accounting for EU intervention). Subscript j refers to CAP program-commodities, like cereals, beef, etc. With respect to (1), the commodity range is narrowed, and it is implicitly assumed that other net imports are not related to the commodities considered here, or have free access (zero or nearly zero tariff) to the EU. (For details about the precise determination of the financial streams associated with the CAP see Appendix 11B). With respect to 'cereal substitutes' and oilseeds, the zero import tariffs weree part of the agreement between the initial EU member states and the United States. Having defined the balance of trade function for a member state participating in the EU's CAP, welfare measures follow easily along the lines suggested in Subsection 3.4.2. The CV_h measure is defined as $B_h(v^1;U_h^0) - B_h(v^0;U_h^0)$ with v^1 a vector of all the explanatory variables in B at

Table 11.2 Member states' contribution shares to CAP finance

Country	contribution %	GDP 1990 %	Country	contribution %	GDP 1990 %
Netherlands	6.44	5.11	Ireland	0.84	0.78
Belgium *)	4.34	3.73	United Kingdom	12.90	16.74
France	20.00	20.48	Portugal	1.20	1.15
Germany	27.52	25.71	Spain	8.18	3.93
Italy	15.28	18.73	Greece	1.30	1.42
Danmark	2.00	2.21	EU-12	100.00	100.00

*) includes Luxembourg;
Source Commission 1998 *The Community Budget: Facts and Figures*

the after-policy change-level. Likewise, the EV_h measure is $B_h(v^1;U_h^1) - B_h(v^0;U_h^1)$. Moreover, considering compensation measures in an EU-wide context (for example to evaluate WTO policy proposals) rather than EU-member state relationsips, the natural candidates are $CV_{EU} = \sum_h CV_h$ and $EV_{EU} = \sum_h EV_h$.

As was argued in previous chapters (see sections 3.5 and 4.4), using the deadweight loss measure in a second-best partial equilibrium (rather than a full general equilibrium context) requires the social costs of public funds to be taken into account. The MacSharry reform is expected to diminish the deadweight losses due to the general decrease in price distortions. However, at the same time more public funds have to be raised to finance the direct compensation payments. The distortionary character of raising funds by taxation should be corrected for. This is easily done by multiplying each γ_h in (2) by δ_h, a multiplicative factor denoting the marginal costs of public funds (see also final part of Section 3.5 and Section 4.4).

The marginal costs of public funds (MCF) are calculated using the formulas of Browning and Mayshar (see Section 4.4) and the estimates are presented in Table 11.3. Following Mayshar (1991, p.1333) the γ-coefficient in the Mayshar equation is approximated by $(1-\alpha)/\sigma$ with α the elasticity of output with respect to labour and σ the elasticity of substitution between labour and capital. The latter is assumed

Table 11.3 Marginal excess burden of public funds

Country	Income tax rates % average	marginal	progres-sivity	Value added tax	labour's product share	Marginal excess burden 'Browning'	'Mayshar'
Netherlands	29.8	61.9	2.08	17.5	67.6	0.68	0.30
Belgium	28.8	63.2	2.19	21.0	72.9	0.76	0.36
France	20.5	51.2	2.50	20.6	72.5	0.53	0.28
Germany	30.9	62.7	2.03	15.0	70.9	0.69	0.30
Italy	28.0	57.8	2.06	20.0	72.3	0.57	0.26
Denmark	37.2	62.4	1.68	25.0	74.4	0.56	0.20
Ireland	*18.8*	60.4	3.21	21.0	75.0	0.99	0.60
Un. Kingdom	20.5	43.9	2.14	17.5	73.4	0.34	0.16
Portugal	*18.6*	35.9	1.93	17.0	72.9	0.22	0.10
Spain	23.4	52.8	1.56	16.0	72.9	0.35	0.11
Greece	16.2	40.1	1.56	18.0	73.3	0.21	0.07
EU*)						0.56	0.25
USA	23.2	40.9	1.76	*7.5*	71.6	0.25	0.10
Japan	16.2	31.9	1.97	5.25	75.1	0.19	0.08

*) EU average computed using EU budget contribution shares as weights (see Table 11.2).
Source\Legend: own computations using formulas (14) and (15) from Section 4.4; average and marginal income tax rates (based on average income and including social security premiums) from Hagemann *et al* (1988, Tables 5 and 6); VAT (standard) rates (prevailing at 1997) from Cnossen (1998, Appendix), Labour's product shares (1981-1990-averages) from European Commission (1998, Statistical Annex, Table 32). Italic numbers are own estimates based on national account statistics. The USA has no (federal) consumption tax, but most states have taxes comparable to the VAT (level estimated at 7.5%). Within the EU member states, should satisfy a minimum (standard) VAT-rate of 15%. Note: VAT rates are not used in the computation of the MEB-measures.

equal to 1.00, as is also done implicitly by Stuart (1984). Under full competition and assuming constant returns to scale in (non-agricultural) production, α equals the labour's product share. Following Fullerton (1991, p.303), tax changes are assumed to maintain progressivity, so with t average tax rate and m marginal tax rate this implies $dm/dt = m/t$. Japan and the USA are included in Table 11.3 for the sake of comparison, and the marginal excess burden of the latter is in line with results found in other studies. Some further assumptions are made regarding the compensated and uncompensated labour supply elasticities (assumed equal to 0.2 and 0.0 respectively). As was already noted in Chapter 4, the Browning measure has a tendency to overstate the MCF, and therefore the Mayshar measure will be used in the simulations.

Table 11.3 also provides an overview of the (standard) value added tax rates (VAT), which show a rather uniform pattern across EU member states. More importantly, VATs are often seen as uniform taxes (equivalent to a uniform payroll tax and an equal rate profits tax) with a rather low distortive impact (Cnossen 1998). Since the EU public funds are to a significant degree (roughly about 50%) financed by 'neutral' VAT's, the marginal excess burden estimates presented in Table 11.3 seem still too high. In the simulation model, the cost of public fund factor δ_h is therefore approximated by

$$\delta_h = \frac{(1 + MEB^{Mayshar}) + (1 + MEB^{VAT})}{2} \qquad (3)$$

with MEB^{VAT} set equal to zero (assuming full neutrality and 50% source weights).

11.5 Concluding remarks

This chapter discussed the set-up of a simulation model based on the subsector models that have been estimated previously. Since the estimation results and sub-sector models are more or less directly incorporated into the simulation model, the main focus of this chapter has been on model closure, *i.e.* the linking of the EU GOLF-sector with the rest of the world and the rest of the economy, the agricultural policy framework (including both instruments and the generated financial streams), and on model calibration. With respect to this approach the following remarks are in order here:

- The model-closure by introducing net excess demands for the rest of the world (ROW) is the best that can be done from the current modelling perspective, which basically focuses on the EU. It allows us to assess the impacts of policy changes in the EU on world market (traded) quantities and prices (*ceteris paribus*). However, the *ceteris paribus*-clause is not very likely to hold.

- The discussion of the CAP focuses on the traditional CAP and the MacSharry reform. The Agenda 2000 reform is not explicitly discussed because it can be interpreted as an additional variation on the MacSharry-theme and as relying on more or less the same policy instruments. The switch to 'tarification', an outcome from the Uruguay Round, introduces some new elements (fixed tariffs, quota-tariffs, etc.), which are taken into account in the appendix, and will be discussed in detail in the next chapter.
- The connection of the GOLF sector with the rest of the economy is limited to the costs of public funds issue. Using the theory previously described, the costs of public fund measures have been calculated at the individual member state level. The other main linkage with the rest of the economy is via the exogenous assumed growth trends of GDP and the expenditure on food at the member state level.

Having presented the main structure of the simulation model, the next chapter will focus on the main scenarios and the corresponding simulation results.

Appendix 11A Base year data

This appendix contains the base-year data used for the model simulations. Table A-1 contains quantity data, while Table A-2 gives the initially assumed price structure.

Table 11A-1 Supply and demand quantities (1990 in thousands of tonnes)

	NETH	BEL-LUX	FRANCE	GERM.	ITALY	DENM.	IRELAND	U-K.	PORT	SPAIN	GRC.	EU
Sugar												
Sugarbeet production	8623	6866	27153	30366	11915	3685	1484	7902	23	7358	2739	108114
sugar %	0.142	0.153	0.179	0.142	0.130	0.148	0.153	0.157	0.111	0.129	0.105	0.141
A-quota	690	680	2996	2637	1320	328	182	1040	64	960	290	11187
B-quota	182	146	806	812	248	97	18	104	6	40	29	2488
C-sugar	353	225	1048	852	-21	119	27	97	-67	-48	-32	2553
sugar equiv.	1225	1051	4850	4301	1547	544	227	1241	3	952	287	16228
domestic consumption	628	428	1969	2844	1646	210	136	2341	305	1074	313	11894
human	603	419	1942	2800	1646	204	136	2336	302	1057	309	11754
non-human	25	9	27	44	0	6	0	5	3	17	4	140
net excess supply	597	623	2881	1457	-99	334	91	-1100	-302	-122	-26	4334
Cereals												
indigenous production	1359	2113	54877	37580	16074	9606	2109	22583	1229	17904	4042	169476
soft wheats	1359	2113	52982	37533	12445	9606	2109	22579	1199	17389	2942	162256
durum wheat	0	0	1895	47	3629	0	0	4	30	515	1100	7220
domestic consumption	4102	4471	19311	29846	17781	6608	2542	19926	2442	17694	3418	128141
human	2190	2203	6871	11060	9254	670	702	8799	1326	5031	1612	49718
durum wheat cons.	28	63	713	478	2767	0	11	140	81	217	698	5196
feed	1912	2268	12440	18786	8527	5938	1840	11127	1116	12663	1806	78423
change stocks	26	-9	147	2815	703	295	94	-488	-47	-23	-366	3147
net excess supply	-2769	-2349	35419	4919	-2410	2703	-527	3145	-1166	233	990	38188
durum wheat	-28	-63	1182	-431	862	0	-11	-136	-51	298	402	2024
Oils-fats												
indigenous production	35	33	4672	2174	2220	797	15	1301	62	1517	465	13291
rapeseed	24	21	1930	1720	34	794	15	1146	0	30	0	5714
sunflowerseed	0	0	2390	72	340	0	0	0	62	1314	29	4207
soybeans	0	0	247	5	1823	0	0	0	0	42	21	2138
other	11	12	105	377	23	3	0	155	0	131	415	1232
net imports	4823	1991	-1996	3762	856	-437	28	730	1080	2322	303	13462
soybeans	4104	1051	384	2714	661	51	13	762	854	2614	300	13508
usable production	4858	2024	2676	5936	3076	360	43	2031	1142	3839	768	26753
dir. feed use (soyb.)	761	52	376	60	563	-3	13	176	174	408	-52	2528
crushed/refined	4097	1972	2300	5876	2513	363	30	1855	968	3431	820	24225
soybeans	3343	999	255	2659	1921	54	0	586	680	2248	373	13118
Vegetable oils												
indigenous production	892	571	877	1775	577	135	12	619	236	875	247	6816
domestic consumption	346	213	807	1046	969	63	36	887	158	589	243	5357
net excess supply	546	358	70	728	-392	72	-24	-268	78	286	4	1459

Table 11A-1 continued

	NETH	BEL-LUX	FRANCE	GERM.	ITALY	DENM.	IRELAND	U-K.	PORT	SPAIN	GRC	EU
Meals												
indigenous production	3054	1339	1341	3915	1865	215	17	1174	704	2456	547	16627
soymeal	2616	447	686	1389	452	106	10	484	185	685	193	7252
other meals	438	892	655	2526	1413	109	7	690	519	1771	354	9375
domestic consumption	3078	1410	5481	5672	3402	1984	402	2952	833	4213	276	29701
soymeal	1979	1025	4063	3569	3086	1419	180	1730	625	3651	252	21578
other meals	1099	385	1418	2103	316	565	223	1222	208	562	23	8123
net excess supply	-24	-71	-4140	-1757	-1537	-1769	-385	-1778	-129	-1757	271	-13074
soymeal	637	-578	-3377	-2180	-2634	-1313	-170	-1246	-440	-2966	-59	-14326
other meals	-661	508	-763	423	1098	-456	-215	-533	311	1209	330	1252
Potatoes												
indigenous production	7136	1862	5474	13313	2338	1334	605	6306	1132	5219	947	45666
domestic consumption	4564	1277	6089	13454	2663	1376	744	6953	1392	5550	1033	45095
human	1300	1004	4021	5959	2235	317	526	5681	1110	4146	903	27202
non-human	3264	273	2068	7495	428	1059	218	1272	282	1404	130	17893
net excess supply	2572	585	-615	-141	-325	-42	-139	-647	-260	-331	-86	571
Beef and veal												
indigenous production [lw]	468	326	1912	1676	919	202	569	987	112	499	66	7736
domestic consumption	292	205	1685	1398	1471	97	63	1084	158	488	230	7171
change stocks	1	-2	42	57	33	13	99	74	4	10	-1	330
net excess supply	175	123	185	221	-585	92	407	-171	-50	1	-163	235
live animals	0	-52	4	159	-117	-245	0	55	-14	-5	-15	-230
meat	0	227	119	26	338	-340	92	352	-157	-45	16	628
Pork												
indigenous production	1904	747	1817	3142	1211	1208	160	953	278	1772	147	13339
domestic consumption	681	465	2101	3645	1814	330	124	1381	296	1834	213	12884
net excess supply	1223	282	-284	-503	-603	878	36	-428	-18	-62	-66	455
Poultry												
indigenous production	520	167	1665	449	1100	132	81	1043	185	834	160	6336
domestic consumption	278	171	1207	781	1118	60	76	1118	188	880	167	6044
net excess supply	242	-4	458	-332	-18	72	5	-75	-3	-46	-7	292
Eggs (total)												
indigenous production	652	186	992	692	597	82	35	721	94	668	128	4847
domestic consumption	193	153	922	982	627	80	38	783	93	693	132	4696
net excess supply	459	33	70	-290	-30	2	-3	-62	1	-25	-4	151
Raw milk (equivalent)												
indigenous production	11285	3895	26535	23672	12810	4742	5557	15251	1693	5752	716	111908
on farm use	507	635	2393	2198	4524	200	289	615	163	1250	183	12957
in % of prod	0.045	0.163	0.090	0.093	0.353	0.042	0.052	0.040	0.096	0.217	0.256	0.116
milk deliveries	10778	3260	24142	21474	8286	4542	5268	14636	1530	4502	533	98951
domestic consumption	4520	2649	20755	18157	12534	1652	1075	16129	1530	5405	2121	86523
net excess supply	6259	611	3388	3318	-4248	2891	4193	-1493	1	-903	-1588	12428
Compound feed												
indigenous production	15690	5209	16840	16591	11450	4576	2213	10170	3802	11950	1461	99952
dairy feed	4692	1397	4636	7672	4600	1555	1332	4190	1115	2650	300	34139
pigs feed	7690	3022	5214	5465	2470	2493	483	2260	1457	4850	580	35984
chicken feed	3308	790	6990	3454	4380	528	398	3720	1230	4450	580	29828
used inputs	21427	5209	16840	16591	11450	4576	2213	10170	3802	11950	1461	105689
cereals	1912	1376	6777	4138	3716	1216	1366	5170	1116	6904	771	34463
high protein feed	2597	845	4495	4843	3059	1335	234	1446	713	3130	472	23170
soymeal	2070	732	3368	3249	2683	870	199	1195	623	2722	428	18138
other meals	527	113	1127	1594	377	465	35	251	90	409	44	5032
other feed inputs	8017	1743	4883	6606	4627	1721	613	3282	1346	1755	207	34799
manioc	8901	1245	685	1005	48	305	0	272	626	160	10	13257

Table 11A-1 continued

	NETH	BEL-LUX	FRANCE	GERM.	ITALY	DENM.	IRELAND	U-K.	PORT	SPAIN	GRC	EU
Cattle / Dairy												
ind. production meat	468	326	1912	1676	919	202	569	987	112	499	66	7736
ind. production milk	11285	3895	26535	23672	12810	4742	5557	15251	1693	5752	716	111908
used compound feed	4692	1397	4636	7672	4600	1555	1332	4190	1115	2650	300	34139
land	1165	656	9737	4424	3155	553	4418	8603	887	1798	213	35610
nr. cows (total)	1991	1239	9085	5166	3390	845	3390	4490	591	2895	341	33423
milk cows	1917	890	5276	4765	2881	769	1387	2890	396	1593	242	23006
other cows	74	349	3809	401	509	76	2003	1600	195	1302	99	10417
Pork												
indigenous production	1904	747	1817	3142	1211	1208	160	953	278	1772	147	13339
used compound feed	7690	3022	5214	5465	2470	2493	483	2260	1457	4850	580	35984
used direct feed	0	892	4738	14648	4811	4722	474	3785	0	5472	242	39783
nr. pigs	13788	6425	12219	22035	8884	9282	1069	7379	2664	16176	1143	101064
Poultry / Eggs												
ind. production meat	520	167	1665	449	1100	132	81	1043	185	834	160	6336
ind. production eggs	652	186	992	692	597	82	35	721	94	668	128	4847
used compound feed	3308	790	6990	3454	4380	528	398	3720	1230	4450	580	29828
used direct feed	0	0	925	0	0	0	0	2172	0	287	792	4177
nr. slaughtering hens	319133	110835	676882	237577	399571	99457	44004	669976	110558	522127	78011	3268131
nr. laying hens	40248	10792	63590	44419	54728	4327	3163	50827	7837	47886	16597	344414

Table 11A-2 Price data (Ecu per farm equivalent ton)

	NETH	BEL-LUX	FRANCE	GERM.	ITALY	DENM.	IRELAND	U-K.	PORT	SPAIN	GREECE
Institutional price*)											
SUGAR	85.72	92.36	107.74	85.42	79.77	92.30	94.23	92.27	66.97	93.97	62.40
CEREALS-BR	191.81	191.81	194.36	191.97	267.79	191.81	191.81	182.70	265.44	271.11	259.61
OILS-FATS	186.98	186.98	216.01	189.17	206.94	186.98	186.98	192.13	239.38	233.79	226.85
BEEF-VEAL	1929.80	1929.80	1929.80	1929.80	1929.80	1929.80	1929.79	1929.81	1929.80	1929.80	1929.80
PORK	1368.30	1368.30	1368.30	1368.30	1368.30	1368.30	1368.29	1368.30	1368.30	1368.30	1368.30
POULTRY	1283.40	1283.40	1283.40	1283.40	1283.40	1283.40	1283.39	1283.40	1283.40	1283.40	1283.40
EGGS	820.15	820.15	820.15	820.15	820.15	820.15	820.15	820.15	820.15	820.15	820.15
RAW-MILK	299.46	278.77	288.78	312.88	419.30	335.49	276.94	274.89	337.69	309.52	384.97
Price at farm level											
SUGAR	33.83	22.88	15.13	33.34	38.74	26.07	30.73	19.29	13.94	38.76	23.90
CEREALS-BR	151.91	154.01	147.06	161.86	195.71	152.51	147.51	157.73	274.56	196.20	178.91
OILS-FATS	365.85	367.15	439.29	372.77	320.86	367.15	367.15	371.76	512.54	490.00	420.46
POTATOES	111.20	94.40	108.10	127.00	233.80	127.00	141.80	141.80	142.10	181.70	211.60
BEEF-VEAL	2192.44	2241.21	1646.75	2068.78	1990.07	2377.56	1976.61	1982.00	1646.75	1646.75	2423.86
PORK	1256.09	1459.72	1391.56	1330.91	1584.44	1225.89	1307.48	1402.51	1408.27	1408.27	1544.25
POULTRY	1258.00	1239.00	1027.00	1408.00	1300.00	1388.00	2186.99	1654.00	1058.00	1058.00	2091.00
EGGS	659.70	681.78	767.56	784.74	837.04	1036.30	937.33	869.48	899.71	899.71	1436.59
RAW-MILK	286.26	259.23	273.80	300.55	399.50	321.06	255.12	259.31	317.92	289.65	365.28

Table 11A-2 continued

	NETH	BEL-LUX	FRANCE	GERM.	ITALY	DENM.	IRELAND	U-K.	PORT	SPAIN	GREECE
World market price											
SUGAR	222.32	207.20	189.75	222.03	230.99	210.43	213.86	203.66	214.24	222.06	227.08
CEREALS-BR	60.04	62.14	52.64	69.84	28.24	60.64	55.64	74.06	109.25	25.75	18.99
OILS-FATS	134.81	136.11	131.72	135.78	131.12	136.11	136.11	146.25	125.40	113.88	134.71
POTATOES	111.20	94.40	108.10	127.00	233.80	127.00	141.79	141.80	142.10	181.70	211.60
BEEF-VEAL	1392.64	1441.41	846.95	1268.99	1190.27	1577.76	1176.82	1182.20	846.95	846.95	1624.06
PORK	981.09	1184.72	1116.56	1055.92	1309.44	950.89	1032.49	1127.52	1133.27	1133.27	1269.25
POULTRY	1258.00	1239.00	1027.00	1408.00	1300.00	1388.00	2186.99	1654.01	1058.00	1058.00	2091.00
EGGS	659.71	681.78	767.56	784.75	837.04	1036.30	937.33	869.49	899.71	899.71	1436.60
RAW-MILK	113.14	105.25	108.86	110.59	103.04	112.12	103.07	109.08	103.04	103.04	103.04
Consumer price											
SUGAR	325.84	359.01	307.74	370.77	789.62	582.85	385.35	225.25	452.76	405.00	381.87
CEREALS-BR	1058.30	879.44	1733.55	1792.86	1293.80	1474.27	920.73	956.29	796.70	932.43	422.76
OILS-FATS	1634.06	3479.45	4242.90	4664.81	3917.03	4739.56	4165.06	1746.04	2071.88	3800.53	2334.69
POTATOES	243.67	170.03	247.11	243.91	439.60	693.99	434.51	415.29	212.38	163.48	350.42
BEEF-VEAL	4375.75	12640.17	8615.54	9931.82	10545.57	6765.99	5320.77	5520.06	6166.45	10101.43	5746.86
PORK	2680.34	4261.36	3661.29	7910.48	4108.57	3764.73	3493.62	2261.52	3222.42	2665.13	6153.09
POULTRY	2036.76	3565.51	3953.26	6132.51	4625.08	4572.89	2315.22	2348.53	1896.19	2075.87	2933.07
EGGS	1900.53	1836.12	1451.69	2474.48	3009.14	2440.15	2547.56	1720.30	1640.63	1546.06	2245.67
RAW-MILK	533.69	656.90	580.41	672.39	981.31	577.11	424.54	399.23	572.01	1136.75	801.38
OTHER (normalized)	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Other prices											
Dairy feed	176.62	217.09	254.19	166.63	295.28	175.72	379.34	515.54	271.41	282.03	236.04
Pigs feed	203.59	245.67	255.45	211.36	273.71	215.36	254.46	265.58	298.15	293.37	266.50
Poultry feed	296.26	321.56	321.47	245.97	332.44	215.36	254.46	314.91	324.28fs	337.19	262.26
Soybean meal	206.40	213.50	215.40	219.40	261.40	218.40	225.50	212.50	216.40	229.40	235.50
Other meal	153.89	145.91	137.57	149.95	183.75	145.60	157.97	153.57	156.31	138.07	145.08
Other input	168.91	170.03	172.77	172.72	182.93	177.48	188.40	156.83	174.98	193.06	183.52
Manioc	154.20	161.20	163.30	167.20	209.20	166.20	173.30	160.30	164.20	177.20	183.20

*) For potatoes no institutional price exists.

Table 11A-3 Estimated revenues and variable input costs for subsectors

(in thousands of Ecu)

	NETH	BEL-LUX	FRANCE	GERM.	ITALY	DENM.	IRELAND	U-K.	PORT*)	SPAIN*)	GREECE	EU
Arable												
Revenues	1307826	745788	11676001	9623960	4812587	2053648	457428	5216483	501446	5487079	1190594	43072840
Fertilizer	130472	140362	1987667	1093978	798590	269620	61825	433144	0	1066883	165351	6147892
Plant protection	131920	147840	2286440	726670	663648	182797	44450	639168	312524	423548	126418	5685423
Seeds	303416	200640	2528275	771160	535200	110368	53340	429441	0	412402	103989	5448231
Tot. var. inp. costs	565808	488842	6802382	2591808	1997438	562785	159615	1501753	312524	1902833	395758	17281546
Profits	742018	256946	4873619	7032152	2815149	1490863	297813	3714730	188922	3584246	794836	25791294
Dairy												
Revenues	4256522	1740327	10413890	10581938	6946423	2002727	2542377	5911004	722671	2487818	421517	48027214
Fertilizer	172944	120118	1090233	418682	282514	58035	279551	565556	0	125739	12042	3125414
Other inputs	258830	161070	1181050	671580	440700	109850	440700	583700	76830	376350	44330	4344990
Tot. var. inp. costs	431774	281188	2271283	1090262	723214	167885	720251	1149256	76830	502089	56372	7470404
Feed costs	828716	303269	1178425	1278421	1358272	273248	505280	2160106	302626	747386	70811	9006561
Profits	2996033	1155871	6964182	8213255	4864936	1561594	1316845	2601642	343215	1238343	294334	31550250
Pigs												
Revenues	2391596	1090411	2528465	4181729	1918757	1480876	209197	1336595	548099	3493636	227005	19406365
Variable inputs	149600	71105	119319	241471	100245	100710	11715	74458	29193	177265	12526	1087605
Feed costs	1565583	879789	2028612	3526017	1617569	1257003	192852	1197136	434409	2496457	197931	15393358
Profits	676413	139516	380534	414242	200943	123164	4631	65001	84496	819914	16548	2925401

Table 11A-3 continued

	NETH	BEL-LUX	FRANCE	GERM.	ITALY	DENM.	IRELAND	U-K.	PORT	SPAIN	GREECE	EU
Poultry/Eggs												
Revenues	1084287	333724	2471371	1175236	1929711	268192	209953	2352023	392423	2076726	518444	12812090
Variable inputs pltry	22020	7801	42034	16557	28673	6863	3067	42992	7705	36387	5437	219535
Variable inputs eggs	2475	677	3520	2759	3500	266	196	2907	487	2974	1031	20793
Feed costs	980014	254030	2383118	849567	1456076	113708	101273	1514082	398876	1556835	293999	9901578
Profits	79778	71216	42698	306353	441461	147356	105416	792042	-14645	480530	217977	2670183
Tot. profits intensive livestock sector	756191	210732	423232	720595	642404	270520	110047	857043	69851	1300444	234525	5595585

*) *Sometimes fertilizer costs could not be clearly determined (Portugal). Profits need not necessarily be positive since firms may actually experiences losses, and revenues and costs may be incompletely measured. It was in particular difficult to get a clear picture of the accounts of the intensive livestock subsector for Portugal, Spain, and Greece. Their numbers should be carefully interpreted.*

Appendix 11B Modelling policy instruments

This appendix provides an overview of the way in which the policy instruments and financial flows generated by the CAP are modelled. Subscripts i and j refer to region (country) and product respectively. The regions cover the EU-12 and the products are cereals (CRLS), sugar (SUGAR), oilseeds (OLSD), milk (products) (MLK), beef and veal (BEEF), pork (PIG), poultry (PLTRY), and eggs (EGG). A table with explanatory labels for the symbols used is provided at the end of this appendix. Milk (MLK) is treated in a special way.

Table B-1 Product specific CAP costs (1992)

Product	Cost type	amount Ecu/t*)	Cost type	amount Ecu/t
Wheat	storage	13.5	entry/exit	1.6/1.8
Coarse grains	ibid	13.5	entry/exit	1.6/1.8
Sugar**)	ibid	28.0	entry/exit	
ibid	cost advancement exp.	50.0		
Beef & veal	storage	163.0	entry/exit	245.5/6.0
Butter***)	idem	87.0	entry/exit	10.2/87.1
Skimmed milk powder***)	idem	37.0	entry/exit	5.3/3.4

*) Cost are amounts per annum.
**) Sugar entry/exit costs assumed included in cost advance expenditure.
***) Computed storage costs per ton fat and skimmed component are respectively 3.93 and 3.26 Ecu/t. The associated entry plus exit costs are 4.39 Ecu/t fat component and 0.76 Ecu/t skimmed component.
Source: Estimates based on Matthews, 1996 (EU Agricultural Budget projection Model); own derived computations based on COM(91) 371 def. and base year data, and Blom (1995).

Storage costs are calculated in Ecu/t fat component (with storage costs derived from butter storage) and Ecu/t skimmed component (with price derived from storage costs of skimmed milk powder), which together determine the storage costs per unit milk equivalent. Where relevant, all variables are measured in Ecu. An overview of the several specific costs taken into account is provided in Table 11B-1 below. The main cost item is storage costs, while there are also entry and exit costs associated with intervention purchases and sales. Purchases and sales are only taken into account as far as net stock changes are concerned, which will introduce an error to the extent that sales and purchases not influencing the stock level are neglected.

The policy instruments and financial calculations with respect to the cereals and oilseeds regime largely follows Blom (1995), with as a main deviation the measurement of the intervention costs. Export refunds associated with cereals are calculated as

$$ERCRLS = \sum_{j} (PINTCRLS_j + 2.5MNTHINCR + FOBCST - PWMCRLS_j) * EXPCRLS_j$$

To the intervention price 2.5 times a monthly increment of 1.4 Ecu/t, and a fobbing cost of 8.5 Ecu/t are added.

Import levies (in particular for durum wheat) are calculated as

$$ILCRLS = (PTHLDCRLS - PWMCRLS) * IMPCRLS$$

where the import of special quality wheats is exogenously determined.

Intervention costs are calculated in a simplified fashion as compared to the FEOGA Guarantee budget method. Opening and closing stocks are policy instruments exogenously set. From these settings, intervention or sales and average stock levels are derived. Direct intervention costs are calculated as

$$STCSTCRLS = \sum_{j} AVINTCRLS_j * STORECST_j$$

with the average stock equal to

$$AVINTCRLS = \frac{1}{3}\mathrm{MIN}(OPSTCRLS, ENSTCRLS) + \frac{2}{3}\mathrm{MAX}(OPSTCRLS, ENSTCRLS)$$

The maximum of the opening or closing stock is given a higher relative weight in order to reflect that when stocks are increasing, additional purchases will take place in the early part of the crop year, while with decreasing stocks, sales are assumed to be concentrated at the end of the crop year.

Mainly following Matthews (1996), depreciation is approximated by a simple formula, which assumes that stock bought during the year is fully depreciated to the world price level in that year. Moreover, a correction is introduced to account for entry and exit costs (see remark before and Table 11B-1). Furthermore, budget gains or losses associated with a value change of the opening stock due to a world market price change between current and previous year are added. Thus

$$
\begin{aligned}
DEPCSTCRLS = &\sum_j OPSTCRLS_j * \Delta PWMCRLS_j \\
&+ \sum_j (PINTCRLS_j + 2.5*MNTHINCR + FOBCST - PWMCRLS_j + ENT\_EX_j) \\
&\quad *(ENSTCRLS_j - OPSTCRLS_j)
\end{aligned}
$$

The interest costs associated with storage are given by

$$RNTCSTCRLS = \sum_j (AVSTCRLS_j * PWMCRLS_j) * r_{ST}$$

The overall intervention costs can thus be given by

$$
\begin{aligned}
INTCSTCRLS = &ERCRLS + STCSTCRLS + DEPCSTCRLS \\
&+ RNTCSTCRLS - ILCRLS
\end{aligned}
$$

The (per country) direct payments associated with the cereals regime consist of payments related to set-aside and hectare premiums. Both the payments as well as the set-aside area are instrument variables. Set-aside payments are modelled as

$$
\begin{aligned}
SAPCRLS_i = &ARCRLS_i * (PAR_i * SAF) \\
&* NORMPRODCRLS * SAPCRLS
\end{aligned}
$$

while hectare payments are calulated

$$HAPCRLS_t = HACRLS_t * NORMPRODCRLS_t * COMPCRLS$$

Finally, there is a co-responsibility levy, which is modelled as

$$CORESCRLS_t = PINTCRLS * ARSUPCRLS_t$$
$$* SHARECORESCRLS_t * CORESLEVY$$

With respect to oilseeds, a distinction is made between set-aside payments, hectare payments and a co-responsibility levy. The set-aside payments are

$$SAPOLSD_t = AROLSD_t * (PAR_t * SAF)$$
$$* NORMPRODCRLS * SAPCRLS$$

The per hectare payments are

$$HAPOLSD_t = HAOLSD_t * NORMPRODCRLS_t * COMPOLSD$$

The co-responsibility levy is modelled as

$$CORESOLSD_t = PTARGOLSD * ARSUPCRLS_t$$
$$* SHARECORESOLSD_t * CORESLEVY$$

With respect to the sugar regime costs associated with subsidized exports, a distinction is made between storage costs, and revenues generated from levies. The export refund costs are

$$ERSUGAR = [(A\_SUGAR + B\_SUGAR) - DEMEUSUGAR$$
$$+ ACP\_SUGAR]$$
$$*(PINTSUGAR + CSTADVEXP - PWMSUGAR)$$

As the storage costs associated with sugar are financed by a levy on all sales (apart from sales to intervention) by beet processors and refiners of domestic sugar, the minimum domestic market price for sugar is the white sugar intervention price plus the storage cost levy. Storage costs are therefore approximated by

$$STCSTSUGAR = (A\_SUGAR + B\_SUGAR + C\_SUGAR)*STORECST$$

i.e. total sugar supply times levy, with the storage costs set at 27.5 Ecu/t.

The levy revenues are

$$LRSUGAR = \sum_i [(A\_SUGAR_i + B\_SUGAR_i)*(1 - GEN\_LEVY) + B\_SUGAR_i*(1 - B\_LEVY)]*PINTSUGAR$$

With respect to the cattle dairy sector, the (per country) milk quota is a policy variable. The budget costs associated with subsidised milk product exports (costs of export refunds), intervention costs and direct payments, follow from

$$INTCSTDAIRY = ERMLK + STCSTMLKPROD + DEPCSTMLK + RNTCSTMLK + ERBEEF + STCSTBEEF + DEPCSTBEEF + RNTCSTBEEF$$

with the components explained below. The export refunds associated with dairy products are

$$ERDAIRY = \sum_j EXPMLKPROD_j*(PINTMLKPROD_j - PWMMLKPROD_j)$$

The intervention costs for dairy products are equal to the sum of storage costs

$$STCSTMLKPROD = \sum_j AVINTMLKPROD_j*STORECST_j$$

with the avergae stock defined in the same way as with cereals intervention. The main products are skimmed milk powder and butter, with storage costs of 37 and 87 Ecu/t respectively.

Depreciation costs on dairy products are calculated as

$$DEPCSTMLK = \sum_j OPSTMLKPROD_j * \Delta PWMMLKPROD_j$$
$$+ \sum_j (PINTMLKPROD_j + FOBCST_j - PWMMLKPROD_j + ENT\_EX_j)$$
$$*(ENSTCMLKPROD_j - OPSTMLKPROD_j)$$

while the interest costs associated with storage are given by

$$RNTCSTDAIRY = \sum_j (AVSTMLKPROD_j * PWMMLKPROD_j) * r_{ST}$$

The co-responsibility levy on milk is modelled as

$$CORESMILK = PTMILK * MLKPROD * SHARECORESMILK * CORESLEVY$$

The export refunds associated with beef (and veal) are

$$ERBEEF = (PBEEF - PWMBEEF) * EXPBEEF * SHRSUBBEEF$$

with *SHRSUBBEEF* a reduction coefficient (set equal to 0.90) to take account for the fact that not all beef exports require the full rate of refund.

$$DEPCSTBEEF = OPSTBEEF * \Delta PWMBEEF$$
$$+ (PINTBEEF + FOBCSTBEEF - PWMBEEF + ENT\_EX_j)$$
$$*(ENSTCBEEF - OPSTBEEF)$$

while the interest costs associated with beef storage are given by

$$RNTCSTBEEF = (AVSTBEEF * PWMBEEF) * r_{ST}$$

Finally, the costs associated with direct payments are

$$DPDAIRY = \sum_i (SCOWPREM*SCOWRIGHT_i + MCPREM*MCOWRIGHT_i)$$

With respect to the intensive livestock subsectors, export refunds are given by

$$ERPIG = (PGUIDPIG - PWMPIG)*EXPPIG$$

$$ERPLTRY = (PGUIDPLTRY - PWMPLTRY)*EXPPLTRY$$

and

$$EREGG = (PGUIDEGG - PWMEGG)*EXPEGG$$

Agrimonetary costs arise from the differences between green and normal exchange rates, which cause farm prices to differ between various member states. The monetary compensating border levy is given by

$$MCB\_LEVY_{ij} = \frac{(IP_{ij} - CP_j)}{CP_j} - FRANCHISE$$

with the franchise factor (perunage) set to 0.1 (assumed equal for positive and negative MCA's). The monetary compensating amounts generated by this system are

$$MCA\_EU = \sum_i \sum_j MCB\_LEVY_{ij}*CP_{ij}*NETEXP_{ij}$$

with the common price *CP* denoted in green Ecu (commercial Ecu times a so-called switch-over factor, set at 1.137281397 for the base-year), and where the national intervention price (measured in Ecu) is equal to

$$IP_j = CP_j*GR\_EXRATE/NORM\_EXRATE$$

See Ritson and Harvey (1997, pp.115-137) and De Hoogh and Silvis (1994, pp.76-86) for a detailed discussion of the EU monetary system.

With respect to the general means available for the CAP, it is assumed that resources will be continued to be allocated to the FEOGA Guarantee budget on the basis of the agricultural guideline rule. This was introduced in 1988 as part of the inter-institutional agreement between the Council of Ministers and the European Parliament and extended in 1992 at the Edinburgh European Council till 1999. The agricultural guideline was fixed at 27,500 million Ecu for 1988, with an annual growth rate not exceeding 0.74% of the annual growth rate of nominal Community GNP (Matthews, 1996, p.499). At 1990 the guideline was estimated at 30,630 million Ecu. The guideline will develop as

$$GUIDELINE_t = 30630 + 0.75\Delta NOMGNPEU$$

with $\Delta NOMGNPEU$ equal to an assumed growth rate $GROWTHGNPEU$ times its value at the previous period $VALUEGNPEU_{t-1}$. At the same occasion, an additional facility was created to take care of the (additonal) costs of monetary disturbances, which is not explicitly taken into account here.

Table 11B-1 Variable legend

Variable name	Variable description
$ARCRLS_i$	Area cultivated with cereals in country *i*
$ARSUP_i$...	Supply of product ... by the arable sector in country *i*.
A_SUGAR_i	A-quota sugar for country *i*.
AVINT...	Average intervention stock of product ...
B_LEVY	Specific levy on B-sugar
B_SUGAR_i	B-quota sugar for country *i*
CORES...	Co-responsibility levy on crop ...
CP_j	Common (intervention) price for country *j*.
CSTADVEXP	Cost in advance expenditure on sugar
CORESLEVY	Co-responsibility levy perunage
DEMEUSUGAR	Aggregate EU demand for sugar
DEPCST...	Depreciation costs of product ...
DPDAIRY	Direct payments cattle-dairy sector
ENST...	End stock quantity of product ...
ENT_EX_i	Entry and exit costs on product *j*
ER...	Export refunds of product ...
EXP...	Net export quantity (extra EU) of product ...
GEN-LEVY	General levy on A-sugar and B-sugar

Variable name	Variable description
GR_EXRATE_i	Green exchange rate for country *i*.
GROWTHGNPEU	Yearly growth rate of EU's nominal GNP
GUIDELINE	The guideline of financial means available for FEOGA guarantee part.
HA...	Harvested acreage of crop ...
HAP...	Hectare premiums paid on crop ...
IL...	Import levies of product ...
MCA_EU	Aggregated monetary compensating amounts
MCB_LEVY_{ij}	Monetary compensating border levy on product *j* for country *i*.
NIP_j	National intervention price for product *j*.
NOM_EXRATE_i	Normal exchange rate for country *i*
FOBCST	Fobbing costs cereals
MCOWPREM	Male cow premium
$MCOWRIGHT_i$	Number of male cows eligible for the male cow premium in country *i*.
MNTHINCR	Monthly increments cereals
NOMGNPEU	Nominal GNP of the EU
$NORMPROD..._i$	Normative production for crop ... in country *i*.
OPST...	Opening stock quanitity of product ...
PAR_i	Set-aside participation rate for country *i*.
PGUID...	Guide price for product ...
PINT...	Intervention price of product ...
$PTARGOLSD_j$	Target price oilseeds *j*
PWM....	World market price (in Ecu) of product ...
r_{ST}	Interest rate used for stored commodities
RNTCST...	Interest costs associated with storage of product ...
SAP	Set-aside perunage for cereals and oilseeds
$SAPCRLS_i$	Set-aside payments on cereals in country *i*.
SCOWPREM	Suckler cow premium
$SCOWRIGHT_i$	Number of suckler cows eligible for suckler cow premiums in country *i*.
$SHARECORES..._i$	Share of crop subject to a co-responsibility levy for country *i*
$STORECST_j$	Storage costs of product *j*.
$VALUEGNPEU_{t-1}$	Value of EU's GNP at time *t-1*.

The changes imposed by the Uruguay Round agreement, in particular the tarification and minimum access elements, are integrated into the current structure following a rather natural order. Tarification changes the causality structure: EU prices become, at least potentially, dependent on world market prices, while in the framework sketched so far, world market prices are likely to be influenced by the fixed institutional prices at the EU level. Since the fixed tariffs are often prohibitive, the standard model structure remains largely in place, with export subsidies and intervention determining the EU price level. A new element is the so-called tariff-quota (with relatively low tariffs for within quota imports, and much higher tariffs for over quota imports). Within the model, the minimum access commitments show up as additional imports, which on the one hand generate some tariff revenues for the EU, and on the other hand increase the net exports, and the costs associated with that. For a more detailed discussion see Chapter 12.

Chapter 12

Policy Simulations and Conclusions

12.1 Introduction

Since its origin in the early 1960s, the CAP has been subject to almost continual adjustment. With increasing problems of surpluses and budget costs, the reforms required became more far-reaching. The freezing of support prices in the early 1980s was followed by the imposition of the milk quota in 1984. In 1988, 'stabilisers' (in the form of maximum guaranteed quantities) and a set-aside scheme were introduced. Persisting market imbalances and external pressure from the Uruguay Round, led to the MacSharry reform in 1993. The CAP has to face new challenges with the EU enlargement to include the Central and Eastern European Countries (CEECs and the WTO trade negotiations that will start in late 1999). Agenda 2000 was launched in 1997 and agreed upon by a special European Council of EU leaders held in Berlin 26 March 1999. It aims at further reforming the CAP by reducing price support and increasing the role of direct income support. The new WTO trade negotiations are likely to further add to this reform, by pressing world agriculture, in particular the EU's agriculture further along the market liberalisation path.

It is against this background that the policy scenarios simulated with the GOLF-model are motivated, described, and discussed in this chapter. Both the model potential and the process of adjustment the CAP faces allow for a host of interesting simulations. However, space and time require one to be selective and therefore only a limited number of simulations will be reported here. The simulations are chosen in such a way that a number of particular elements motivating this study, both theoretical and policy ones, are clearly illustrated. The theoretical ones are:

i) the appropriateness of using theoretically consistent welfare measures even when the general characteristics suggest that traditional single equation surplus analysis will give reasonable approximations (see chapter 3, section 2);

ii) the role of horizontally and vertically-related market spill-over effects and the need for a multiple market equilibrium model (see chapter 4);

iii) the decomposition of welfare measures in a related market context, in particular the split up of user surplus into real consumer surplus and surplus accruing to downstream industries (see chapter 4, section 3);

iv) the balance of trade function as a national compensation device and inclusive cost/benefit measure (see chapter 3, section 4);

v) the measurement of social costs (pure efficiency or deadweight loss effect) in a second best world, with particular attention paid to the costs of public funds (see chapter 3, section 5);

The policy relevant issues are:

vi) the impacts of the MacSharry reform on EU agriculture's production, net export and income levels, and its efficiency implications.

vii) the differences between (*ex ante*) planned effects and (*ex post*) actual realization of the MacSharry reform;

vii) the impacts of the Agenda 2000 agricultural agreement;

viii) the likely effects of a further liberalisation step as a consequence of the WTO trade negotiations;

These considerations lead to the analyses of three main scenarios: 1) the MacSharry reform, 2) Agenda 2000, and 3) a further (WTO-)liberalisation scenario. In particular with respect to the MacSharry reform some side issues will be examined, *viz.* the difference between initially assumed and actually realized world market prices, and the role of market spill-over effects.

This Chapter is organized as follows. Section 12.2 starts with a motivation for and description of the three selected policy scenario's. Subsequently, in Section 12.3 the simulation results are presented and discussed. Section 12.4 summarizes the main lessons learned and include some suggestions for further work.

12.2 Selected scenario's

12.2.1 MacSharry reform

The MacSharry reform came into force on 1 July 1993, and covers all cereals, oilseeds, protein plants and non-fibre flax seeds. For cereals, the institutional prices have been substantially reduced. From 1993/94 onwards, cereal prices were required to be reduced by about 35% over a 3 year period. For oilseeds, the previous deficiency payments support arrangements (at processor level) had already been abolished since the introduction of a transitional support scheme consisting of payments per hectare (from 1992/93) and free price formation. Dismantling the deficiency payment system implies roughly a 45% reduction in institutional prices[1]. Direct compensatory payments for cereals were set at 25 Ecu/t. (first year), 35 Ecu/t (second year) and 45 Ecu/t (third year) (*cf.* Regulation (EEC) 1765/92)[2]. The monetary amounts per ton have to be multiplied by (regionalized) normative production levels per hectare to obtain the per hectare payments. The compensatory amounts for oilseeds, which are dependent on the so-called 'equivalent cereal price' and the estimated world market prices for oilseeds, are determined by the Commission (according to the computation rule specified in COM(91)258).

Base areas for cereals and oilseeds (defined based on the average of harvested areas during '89, '90, '91), are eligible for support (see Regulation (EEC) No

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[1] Besides the deficiency payments for oilseeds (about 262 Ecu/t), the co-responsibility levies for both oilseeds (65.2 Ecu/t.) and cereals (8.6 Ecu/t.) have also been abolished. (This makes the effective price decline at the farm level somewhat lower than noted in the text). For details about computing hectare premiums for oilseeds, see COM91(258). Note that since our simulations start at 1992 (base year), the oilseed (price) reform has already been implemented, with compensatory payments adjusted over time.

[2] Later on the 45 Ecu was changed to 53.3 Ecu because the switch-over system was abandoned in 1995. As a consequence of this pure monetary phenomenon, prices in Ecu's were adjusted, although the effective prices in national currencies remain unchanged due to a simultaneous compensatory green exchange rate adjustment.

845/93)[3]. If the sum of the areas which apply for compensatory payments is greater than the regional base area, then (1) during one and the same marketing year, the eligible area per producer is proportionately reduced for all types of aid; and (2) during the following marketing year, producers qualifying under the general scheme must, by way of extraordinary measure, set aside land without receiving any compensation. Moreover, for every percent the actual area of oilseeds exceeds the maximum guaranteed area or base area, the direct payments are to be reduced by 1 percent.

Each producer claiming compensatory payments under the general scheme is required to set-aside a certain percentage of the land on his holding. The set-aside obligations for marketing years 93/94, 94/95 and 95/96 are fixed at 15%, 15%, and 12% respectively. Small producers, *i.e.* those applying for compensatory payments not exceeding that needed to produce 92 tonnes of cereal equivalents, are exempted from the set-aside obligations. Participation rates for set-aside are estimated using farm structure data and knowledge about actual set-aside rates. Following Blom (1995, p.88), a slippage percentage of 20% is assumed for the whole EU[4]. The compensation for the set-aside obligation is set at 57 Ecu/t, and is multiplied by the normalized regional cereal yields to obtain the compensation per hectare fallow land[5].

Target prices for the marketing years 93/94, 94/95, and 95/96 are fixed at respectively 130, 120 and 110 Ecu/ton. The threshold prices, set at 175, 165 and 155 Ecu/t respectively, are considerably higher than the internal prices, which sustaines the community preference-principle. (In fact due to the tightness of the world market for cereals, actual cereal prices received by farmers have fallen less than might be suggested by the official price reductions). Finally, as a consequence of the so-called Blair House-agreement, the total area of oilseeds should not exceed 5.499 million hectares for 94/95 and not exceed 5.128 million hectares from 95/96 onwards.

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[3] The EU base areas also include other MacSharry crops, like protein crops and fibre flax, which are not taken into account here.

[4] Slippage is a phenomenon where production declines proportionally less than the imposed area reduction due to factors like the idling of land of inferior productive quality, the increase of average production due to a less intensive rotation scheme, etc.

[5] Later on this was changed in 68.83 Ecu/t. due the already mentioned monetary realignment.

With regard to cattle, intervention prices for beef are decreased (5% per annum during a three-year period) and partly compensated by increased premiums for suckler cows and young male cattle[6]. A special premium, is granted on up to 90 animals per age bracket (10 and 22 months) per calendar year and per holding. This premium was increased from 60 Ecu per male animal in 1993 to 75, and since 1994 is 90 Ecu. To qualify for this premium, each animal must be kept by the producer for at least 2 months for each age-bracket. At a regional level ceilings are set which restrict the maximum amount of special premiums to can be paid. In addition, there is a suckler cow premium intended for producers who do not deliver milk or milk products or who have a small dairy operation (under 120.000 kg milk reference quantity). In order to qualify for the premium, they should keep suckler cows for at least 6 months from the date of submission of application. The suckler cow premium was fixed at 70 Ecu per eligible animal in 1993, to 95 Ecu in 1994 and to 120 Ecu in 1995. Entitlement to the premium is limited by an individual ceiling per holding (corresponding to the number of animals qualifying for the premium during a certain reference year). Suckler cow premium-rights may be sold or transferred with or without farms. The national numbers of animals eligible for premiums used are shown in table 11A-2 (base year data)[7].

Beside these premiums, which are by far the most important, some other premiums exists, like a deseasonalisation premium (intended to establish an inter-temporal market equilibrium for male cattle slaughterings), a calf processing premium (intended to reduce beef production in dairy herds), and a so-called additional premium on top of the previously mentioned special and suckler premiums (aimed at encouraging extensification).

For the dairy sector, the MacSharry reform implies abandonment of the co-responsibility levy, a planned further quota reduction (2% over the marketing years 93/94 and 94/95) *cum* price reduction The butter price is phasedly reduced with 5%, *viz.* -3% in 1993/94 and -2% in 1994/95. The butter price decreases were

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[6] For dairy, see Regulation (EEC) No 3950/92 and 563/92, and for beef/veal see Regulation (EEC) No 2068/92.

[7] The reported numbers are potential numbers. In the computations it is assumed that 90% of these potential numbers ultimately appear to really qualify for the premium. (Number derived from *The Agricultural Situation*, 1996). Both premiums were made conditional on extensification criteria. For 1994, the stocking density factor was fixed at 3 livestock units (LU) per hectare forage area, while for 1995 it was set at 2.5 LU/ha.

intended to send a signal to producers that they should no longer aim to maximise the fat content of their milk[8]. As already noted before, for (small) cattle-dairy operations the price support cuts were compensated for by direct payments.

By accepting the tarification-agreement of the Uruguay Round in principle, institutional prices lose their significance, since the internal price level varies with world market price fluctuations[9]. However, since fixed tariffs were first implemented in 1995, for the simulation of this scenario, tarification is neglected and the old system is still assumed to be in place. Therefore, world market conditions are assumed to influence the GOLF complex only to a limited extent. The markets for sugar, cereals, dairy, and beef and veal are assumed to be still heavily regulated during the considered period 1992-1995, with the internal price formation mainly dependent on institutional (intervention) prices. With regard to the other (less regulated) markets like product markets for pork, poultry and eggs, and markets for feed ingredients (oilmeals), however, a direct linkage to world markets is assumed.

12.2.2 Agenda 2000

Agenda 2000, published by the Commission in July 1997, aims to respond to the major challenges facing EU agriculture at the beginning of the next century. More specifically, the EU enlargement will increase the EU's agricultural production capacity, creating a threat of surpluses, in particular with respect to sugar, milk, and meat. The new round of international trade talks, which tarted in 1999, will increase the pressure to continue the process of opening up agricultural markets. The limits on subsidized exports, already emanating from the previous round, will be more rather than less restrictive. Given the yield developments relative to domestic demand growth, there is a fear of growing intervention stocks, with the EAGGF bearing the brunt of the costs. More generally, the measures proposed are a further step on the route to substituting direct payments for price support. The policy

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[8] There is a clear tendency for the protein value of milk to become relatively more important. In the Netherlands milk is priced directly in terms of fat and protein, with both having an equivalent share in the final product value. Moreover, the Council has recently set a protein standard for skimmed milk powder (35.6%), with abatements for powder not meeting this standard. Powder which fals within the 31.4%-35.6% margin is subject to an abatement of 1.75% for every percentage point below 35.6%.

[9] The Commission proposed to abolish the target price from 95/96 onwards.

description used here is based on the global agreement reached by the Council of Ministers on 11 March, 1999, and the summit of 26 March, which deviates in a number of respects from the original proposal. The official EC Council Regulations describing these final decisions are 1253/1999 and 1251/1999 (arable: price suport, and direct payments conditional on set-aside), 1254/1999 (beef and veal), 1255/1999 (milk and milk products) and 1256/1999 (milk quota), which all date from 17 May 1999 (see OJ L160 26.6.1999).

With regard to the arable sector, the proposal is to cut intervention prices for cereals by 15% and lower (intervention) prices from 119.19 Ecu/t (in two steps) to 101.31 Ecu/t. in 2002. Export refunds will be adapted accordingly. Direct payments on arable crops will be increased from 54 Ecu/t. to 63 Ecu/t. for both cereals and oilseeds (including non-textile linseed). All specific oilseed provisions will be abrogated, which implies that the production area constraints imposed by the Blair House agreement are no longer applicable. The compulsory set-aside instrument is retained until 2006/07, and will be set at 10%. The small-producer excemption will be maintained as before. Compensation for set-aside is at the same rate for all arable crops, the rate being 66 Ecu/t. For potatoes intended for starch production, a compensation premium of 118 Ecu/t. was introduced.

With respect to the cattle-dairy sector, Agenda 2000 proposes extension of the quota system for dairy untill 2007/08 in combination with a gradual milk price reduction of about 15% (based on intervention prices for butter and skimmed milk powder)[10]. Moreover, for most countries, milk quotas will be increased by about 1.5% in three steps starting in 2005. Specific quota increases of 1389.7 thousand tonnes are granted to a group of member states, notably Greece (+70), Spain (+550), Ireland (+150), Italy(+600), and UK (Northern Ireland; +19.7). The specific quota grants start by April 2000 and will be fully implemented in April 2001, implying a milk supply increase of about 0.7%, while at the end of the implementation period the EU-12 reference quantity will increase by 2.5% (computed from Council Regulation EC 1256/1999, Annex I and II). The price reduction will also start in 2005 and will be imposed in three annual steps. The negative consequences for farm incomes will be compensated for by increasing the already existing animal premiums,

[10] The target price reduction of milk (standardized at 3.4% fat) is about 17%.

and introducing a new premium for milk production of 17.24 Ecu/ton for milk. Support will be sub-divided into a Community wide basic payment and an additional payment according to national provisions (national envelopes).

Table 12.1 Base year prices for Agenda 2000 scenario

Product	External reference price Ecu/t	Calculated fixed tariff 2000 Ecu/t	Actual world market price Ecu/t	Price EU based on tarification Ecu/t	Price EU based on CAP 2000 Ecu/t	Price reductions in Agenda 2000 %	Price EU based on CAP 2006/08 Ecu/t
Sugar	176.00	339.20	239.60	**578.80**	650.80	0	650.80
Cereals	89.80	95.17	85.00	180.17	**119.19**	15	**101.31**
Oils and fats	180.29	0.00	180.29	**180.29**	-	-	-
Potatoes	137.00	0.00	137.00	**137.00**	-	-	-
Beef	1526.00	1768.32	1130.00	**2898.32**	3475.00	20	**2780.00**
Pork	987.00	536.32	987.00	**1523.32**	-	-	-
Poultry	788.00	262.40	788.00	**1050.40**	-	-	-
Eggs	600.00	304.00	600.00	**904.00**	-	-	-
Dairy: butter	943.00	1895.68	947.84	**2843.52**	3382.00	15	**2789.70**
Dairy: SMP	685.00	1188.00	790.90	**1978.90**	2055.20	15	**1746.92**

Source: own computations; numbers based on Tracy (1997, p.74), Silvis and Van Rijswick (1999, pp.44 and 46), and EU's OJ L336 of 22.12.94, OJ L142 of 26.06.95, and press releases of DG6 about Agenda 2000 (cf. Internet: http://europa.int/en/comm/dg06). Numbers in bold type are effective prices used.

Furthermore, there will be a phased reduction in the effective market support for beef by totally 20%, *viz.* from 3475 Ecu/t. to 2780 Ecu/t. (3 times a 6.7% reduction over the period 2000-2006). Simultaneously, the intervention price is adjusted. Similar to what exists in the pig meat sector, private storage aid (fixed at 2224 Ecu/t) could be granted when the average Community market price is less than 103% of the basic price. Compensation payments will be increased to (partly) compensate for the price reduction. There will be a phased increase in special premiums for male animals will be phasedly increased from 160 Ecu/t. (2000) to 210 Ecu/t. (2002) for bulls and from 122 Ecu/t. to 150 Ecu/t. for steers. Moreover, the annual suckler cow premium will be increased from 163 Ecu/t. to first 182 Ecu/t. in 2001 and then to 200 Ecu/t. in 2002. However, a maximum of 20% of the suckler cow premium rights can be claimed for heifers; a measure aimed at reducing the total number of suckling cows. Not only will the premiums be increased, but also their coverage will be extended to include small dairy herds (reference quantity not exceeding 120,000 kg.). National ceilings will be maintained and updated (male premium) or introduced (suckler cow premium) (EC, DG VI, 199, p.4). Finally, support will be sub-divided into a Community wide basic payment and an additional payment according to national provisions (the so-called national envelope) (EC DG VI, 1999, p.5; Council Regulation EC 1254/1999). Following this, member states will be allowed to grant an additional suckler cow premium on top of the official one of 50 Ecu/animal, which may be partly paid by the Guarantee Section of the EAGGF.

In the simulations, the 1992 quantities and milk quota are used for the base year '2000'. Institutional prices and tariffs are based on estimations for 2000. Subsequently the model is simulated untill 2008 using the information described before. Since the tarification commitment made in the Uruguay Round is effective (see further below) for the concerned period 2000-2008, EU markets are linked to world market conditions for all products. This implies that the price level differences between EU and world markets are mainly determined by the effective import tariff levels or export subsidies. Which one is relevant depends on the market structure, as shown in Table 12.1. The table gives estimated (actual) world market prices, computed tariffs (associated with tarification), calculated EU prices based on tarification, EU internal institutional (intervention) prices and derived export subsidies. Bold faced numbers express the relevant ones given market conditions. Thus, for sugar, both in 2000 and 2008, the fixed WTO import tariffs are decisive for the internal price level that will actually prevail in the EU. For cereals, it is the EU export refunds which are decisive, while the calculated WTO tariff will be prohibitive. With regard to beef and veal and dairy, WTO bounds are decisive in 2000, but not in 2008.

12.2.3 WTO Liberalisation scenario

The WTO agreement about the liberalisation of world trade in agricultural products resulted from the Uruguay Round of the GATT. The agreement contains a number of commitments of the EU with respect to the reduction of internal support, increased market access for third countries, and limits on the volume of subsidised exports and/or expenditure on export subsidies. It focuses on the period 1995-2000. With regard to internal support, the EU promised to attain to a 20% support reduction, as measured in terms of the so-called aggregate measure of support (AMS)[11]. Concerning AMS reduction, various possibilities for 'aggregation' were allowed. With regard to market access, the variable import levies were replaced by fixed tariffs (tarification), which subsequently would be lowered by 36% (with a minimum of 15%) (See Figure 11.1 for a general overview). For some products Special Safeguards Clauses were introduced, which allows the EU to impose additional levies in special circumstances (used in case of sugar and poultry meat). Besides, minimum market access, ranging from 3% of domestic consumption in 1995 up till 5% in 2000, were imposed. For some products, where the existing tariffs still remained prohibitive, this has led the EU to create special import-quota at reduced tariffs, in particular for dairy, beef, poultry meat, and pork. See Table 12.2 (first two left columns) for the relevant quantities and tariff-rates, which will be held constant over the whole period till 2000.

With regard to export subsidies, it was agreed that the EU should reduce its budgetary expenditure on export refunds by 36% and/or the volume of subsidized exports by 21%. A distinction was made between 22 product categories, each of which should satisfy the requirements. The amounts relevant for the GOLF-sector, defined at the EU-15 level, are provided in Table 12.2. One should be cautious in comparing allowed exports with registrated (total) exports, since part of the exports may go unsubsidized. For example, EU-15 wheat exports in 1995/96 are 10.85 million tonnes, while the reported subsidized export in Table 12.2 is only 2.68 million tonnes, or about 25% of total EU exports. For coarse grains, however, the subsidized exports in the same year were 7.18 million tonnes which is about 90% of total EU exports. It should be noted that the simulation model generates total (net) exports at the EU-12 level, and does not provide export results by category, like subsidized and non-subsidized, food aid, etc, or for a complete set of derived products (which would be relevant for the dairy sector). As a consequence, to analyse

[11] See Schwartz and Parker (1988) for an overview of several effective protection measures including PSE and AMS.

the impact of agricultural policy changes on WTO issues, several translation steps are required, *i.e.* the switch from EU-12 to EU-15, and the conversion from total exports to subsidized exports. The main rule followed here is to project the pattern of actual (total) exports upon the subsidized exports of EU-15, using 1995/96 levels as base-year.

Table 12.2 EU export support: realizations and allowances

	Tariff quotum 95/96		Subsidised export 95/96		WTO maximum 95/96		WTO maximum 2000/01	
Product	1000t	Euro/t	mln. Euro	1000t	mln. Euro	1000t	mln. Euro	1000t
Wheat	50	95	119	2 679	2 309	20 408	1 290	14 438
Coarse grains	531	94	303	6 596	1 606	13 690	1 047	10 843
Sugar	1 433	339	379	856	733	1 556	449	1 274
Cheese	29	1 510	438	422	594	427	342	321
SMP	46	1 254	141	241	406	335	276	272
Butter(oil)	2	1 896	256	146	1 392	488	948	399
Other dairy	0	-	728	1 157	1 025	1 185	698	958
Beef	130	1 768	1 507	1 019	1 923	1 137	1 254	822
Pork	19	536	101	378	289	542	191	444
Poultry	2	1 024	116	418	136	435	91	286
Eggs	99	304	13	95	61	126	44	99

Source: WTO-notification, cited from Silvis and Van Rijswick, 1999, pp.44 and 46.

Several studies have been done to evaluate the impact of the WTO agreement, among them Silvis and Van Rijswick, 1999; FAO, 1995; FAO, 1999; OECD, 1997; Josling and Tangermann, 1997, and IATRC, 1997. With regard to internal support, it soon became clear that the price support reduction would not be a big problem. The EU CAP reform, with considerable price reductions for cereals, oilseeds and beef, created such a large AMS-support reduction, that more limiteed reductions on other products could suffice. Already in 1995/96 the EU's AMS (the so-called amber box) was below the WTO maximum standards for 2000 of 67 billion Euro (see Silvis and Van Rijswick, 1999, p.27, and Table 12.3 bottom row). Moreover, the general impression derived from the evaluation studies is that sofar tarification has had a limited impact on world trade flows in agricultural products. This is partly due to the still high tariffs. The tarified variable input levy was set equal to the difference between 110% of the EU intervention price and world market price in the reference period 1986-88. Over a period of 6 years this tariff had to be lowered by 36%. In particular for cereals and rice, which received special treatment in the Uruguay Round, the old variable import levy system is still in place and little has changed (Silvis and Van Rijswick, 1999, p.29).

Table 12.3 EU tarification and support reduction

Product	Internal reference price Ecu/t	External reference price 86-88 Ecu/t	Tariff equivalent Ecu/t	Reduction over 6 years %	Internal price 95/96 Ecu/t	Production 95/96 mln. t.	AMS 95/96 mln. Euro	Agenda 2000 price declines %
Common wheat	241.0	93.0	148.0	36	119.19	79.3	2 076.9	15
Coarse grains	238.5	89.8	148.7	36	119.19	87.4	986.4	15
Sugar	600.0	176.0	424.0	20	650.8	17.3	8 214.0	0
SMP	2 170.0	685.0	1 485.0	20	2 055.20	1.3	1 781.3	15
Butter	3 905.0	943.0	2 962.0	36	3 282.00	1.8	4 210.2	15
Beef	4 289.0	1 526.0	2 763.0	36	3 475.00	8.1	15 786.9	20
Pork			838.0	36	-	16.0	-	0
Poultry			410.0	36	-	7.8	-	0
Eggs			475.0	36	-	5.3	-	0
AMS GOLF prod.							33 055.7	
Other AMS							13 240.0	
Total AMS							46 295.7	
in % of WTO bound							69.1	

*) Evaluated at 95/96 production levels

Source: own computations; numbers based on Tracy (1997, p.74), Silvis and Van Rijswick (1999, pp.44 and 46), and EU's OJ L336 of 22.12.94 and OJ L142 of 26.06.95.

For products like cereals, oilseeds, and sugar, the minimum market access commitments are not likely to create any problems. For dairy products (cheese), beef, pork and eggs, tarification led to prohibitive tariffs and reduced tariff quota had to be introduced by the EU to satisfy the market access commitments. For dairy, beef, and poultry these quotas were fully met, but they were not for eggs, and definitely not for pork. The main focus of the GATT was on breaking down the trade distorting export subsidies. Nevertheless, Josling and Tangermann (1997, p.2) conclude that the constraints on export subsidies have been less restrictive than on forehand was expected. Partly, this was due to the incidentally buyoant world markets (cereals), with relatively high world market price levels, which in turn require relatively low export subsidies. With regard to dairy (cheese and other dairy products), beef and poultry meat, the limits on export support were binding.

As can be seen from Table 12.3 in 1995/96 the total AMS of agriculture is about 69% of its WTO-bound. The 20% reduction to which the EU had made a commitment is thus already realized at the outset. The Agenda 2000 agreement is expected to further reduce AMS support in 2006/7. Moreover, the price reductions for cereals, beef, and dairy will improve the EU's export position, and make export support limitations less binding. World market prices will remain an uncertain element, however. Most compensatory payments made within the EU are in the so-called blue box (and thus included in the AMS-measure), which mean that they are allowed for the time being, but judged to be not really decoupled. In contrast, by the FAIR-Act, most USA direct payments are already in the green box (decoupled measures), although this should still be formally acknowledged.

Looking at Agenda 2000, the EU makes it clear that it wants a carefull continuation of the liberalisation trend chosen in the last GATT Round. The EU probably wants sufficient compensation to realize the enlargement arising from inclusion of the countries of Central and Eastern Europe, which is likely to lead to an increase in the AMS measure. The general impression is that the EU will propose a limited further liberalisation, while other important players, like the US and the CAIRNS group, have already made it clear that they want a further liberalisation.

Based on this review of the actual impacts of the Uruguay Round agreement, and the current positions of the main players, the following WTO liberalisation scenario for the GOLF complex is simulated. Internal price support (AMS) is assumed to be reduced by 35%. Subsequently, it is assumed that market access obligations will be doubled as compared with the EU tariff quotas of 1995/96 (see Table 12.2), with limited aggregation allowed (in particular with respect to dairy). Moreover, the import tariffs are assumed to be further reduced by 25% over severla years (see Table 12.3). This implies that the EU sugar price will decline (from 578.8 Ecu/t.; see Table 12.1) to 494 Ecu/t. For cereals and beef, the Agenda 2000 price reductions lead to lower internal prices than those based on the new tariffs. So nothing will alter there. The new internal prices for dairy are 2369.6 Ecu/t (butter, fat component, -28%), and 1681.9 Ecu/t. (SMP, skimmed component, -19%). It is assumed that the milk quota system will remain in place in accordance with the decision made in Agenda 2000.

Finally, permitted volumes or expenditure on subsidised exports are assumed to be halved, as compared with the WTO 2000 levels (see Table 12.2). Because the WTO commitments are on an EU-15 basis, for the liberalisation scenario a correction is made for the three non-modelled countries Sweden, Finland, and Austria. For computational ease it is assumed that the production and price developments in the latter countries parallel the average of the EU-12.

12.3 Simulation results and discussion

Before presenting the simulation results, some general remarks are in order. Firstly, the simulations are done in two steps. The first step is the short-run optimization of economic behaviour. This leads to an optimal outcome, which is still conditional on the quasi-fixed capital inputs. In a second step the capital stocks are adjusted in a one shot-way based on the changes in institutional prices and feed input prices. The feed input prices are assumed to follow the cereals price pattern, be it in a limited sense since cereals are not the only ingredients used (relatively high cereals share in chicken feeds, but rather low in dairy feeds). Secondly, the presentation of the results is mainly in comparative statics-form (comparision with base year) rather than in the 'with' and 'without'-form. This choice is motivated by the emphasis on welfare (reference utility-level) and quantity changes with respect to the base year (financial variables are in constant prices of base year). Moreover, using *status quo* policy as a counterfactual is rather arbitrary, since it is evident, both with the MacSharry case and the Agenda 2000/WTO liberalisation case, that (external) pressure will induce some type of reform anyway. Thirdly, because of space limitations, the results are mainly presented in aggregate form, with limited attention paid to disaggregation. From a compensation perspective, a number of interesting details about member states, and groups within member states and regional markets, therefore remain hidden.

12.3.1 The MacSharry simulation scenario

A summary of the simulation results of the MacSharry scenario is shown in Table 12.4. The results are split up into five categories of interest: 1) impacts at the EU's agricultural subsector level; 2) implications for EU budget; 3) aggregate and national compensation measures (national costs/benefits); 4) the market situation, and 5) alternative welfare measure comparisons. In the following, these subjects discussed in the same order.

With regard to the EU level impacts, a distinction is made between effects on consumers, and effects on primary production operations. As the first row of Table 12.3 shows, over the 5 year evaluation period, (nominal) consumer expenditure on food increased by 3.7%. The expenditure increase appears to be the outcome of a decrease in implicit payments to farmers (-10%) and an increase in the payments for the non-agricultural inputs comprising final food (+4%). The second and third rows of Table 12.4 provide the EV measures corresponding to the 'with' and 'without'(status quo with price stabilization) reform scenarios. In the 'without'-case there is still a positive EV, which captures the gains from exogenous income growth and the price pressing effect of technological change. The (pure) gain of consumers (excluding changes in taxpayers costs) increases to about 7.3 million Ecu (1995) as compared with the status quo.

The combination of set-aside and price reductions leads to a profit (defined as revenue over variable costs, and equivalent with quasi-rents; see Chapter 3, section 3) reduction of about 20% for the arable sector. Moreover, despite the beef price reductions there is a small profit gain for the dairy-cattle sector (+2.5%). The direct compensations appear to be in general more than sufficient. The intensive livestock subsector with a more than 90% increase in profits. Their main cost item is significantly cheaper, with limited output price decline (increased margins).

Looking at the EU budget outlays, it follows that the public outlays for agriculture increase (+22%). The composition of public expenditure on agriculture, however, drastically changes. Export refunds decline due to the reduction in the difference between EU and world market price levels. Moreover, mainly due to a decrease in public intervention stocks, the storage costs are substantially reduced. Compensatory direct payments, however, increase sixfold. Nevertheles, the MacSharry reform shows the possibility of balancing amounts of compensatory payments on the one hand, and gains from reduced price *cum* intervention support on the other hand.

Summarizing changes in producer revenue and budget expenditure, and combining this with the EV measure gives an aggregated compensation measure, earlier discussed as the (modified) balance of (BOT) trade measure (see Chapter 11). In order to capture the 'pure' effect, the EV measure is corrected for exogenous income growth (which is largely due to developments in the rest of the economy). Doing this allows us to isolate the consumer gain from food price changes and combine it with changes in costs (budget outlays) and changes in (aggregated) producer revenues in agriculture. The BOT measure now gives the (hypothetical) amount of money that can be taken away (positive number) or should be given (negative number) to the 'representative' EU consumer in order to maintain him at his base year utility level. As was noted before, it is simultaneously the (second-best) excess burden measure (efficiency). As can be seen from Table 12.4, there is a net gain for the EU for all the years considered. However, the gain is rather small (less than 0.5% of total consumer expenditure on food).

The (money metric) BOT measure includes the social costs (welfare loss triangles) for both consumers and producers, but also for taxpayers since the changes in public budget outlays are weighed by the marginal costs of public funds (see also Chapter 11, Table 11.3). If the social cost of public fund correction would not have been incorporated, the gain would have been nearly 1.5 times higher, although still remaining small in relation to total consumer expenditure on food[12]. Note that, since a (discrete) shift from one distorted equilibrium to another distorted equilibrium is considered, the BOT-measure can be seen as an additional excess burden measure in terms of Chapter 3 (section 3.5).

[12] Without correcting for the costs of public funds, the BOT-values would be 671 ('93), 1,548 ('94) and 2,672 ('95).

Regarding the national cost/benefit discussions, the national trade balance measures are informative. Denmark, France and Ireland appear to be the main net losers. Denmark and France have very high self-sufficiency rates (significantly over 100%) in cereals, Denmark and Ireland in beef and veal, and France and Ireland (together with The Netherlands) in milk powders. Their producers lose implicit subsidy transfers by consumers from other EU member states. Countries strong in meat production have in general profited from the lowered feed ingredient prices. As was mentioned before, on aggregate the 'social welfare' gains are positive rather than negative. A point worth noting is that price reductions at the primary sector level only lead to very small reductions at the consumer level. The share of the final product value accruing to the intermediate food industry increases.

In the context of our model, with the intermediate food industry following a constant returns to scale technology, quasi-rents cannot arise, but in reality this is likely to happen (*cf.* Kinnucan and Forker, 1987). In one not reported simulation, the potential impact of imperfect competition is investigated by assuming the food industry follows a mark-up pricing rule. When the industry imposes an (initial) mark-up of 5% above real costs for all food products, and subsequently was allowed to optimize its position, the consumer gains as measured by the aggregate EV decline by 46%[13]. Also some further sensitivity analysis has been done by varying the substitution elasticities between agricultural and non-agricultural inputs in the food sector (also not reported in Table 12.4). When all substitution elasticities are set to zero (equivalent to assuming a Leontief or 'fixed proportions' technology), or are doubled, the EV estimates are about 2.4% higher or lower.

[13] See Chapter 6 equation (33) for the mark-up factor $1+\Theta_i/\eta_{ii}$, which is initially set to 1.05. Given known base year (own price) demand elasticities, market power parameters Θ_i are calibrated. Subsequently, the food industry is allowed to exploit its (calibrated) market power. Note from Chapter 6, subsection 6.2.2 that the demand elasticities are endogenous (dependent on prices and budget shares).

Table 12.4 Summary table of MacSharry reform simulation (EU-12)

	1992	1993	1994	1995	change w.r.t. base year (%)
Agregated indicators		Million Ecu			
Consumer expenditure	467 792	468 036	475 883	485 040	3.7
Equivalent variation (with reform)	-	3 679	12 991	22 816	
Equivalent variation (without reform)	-	249	8 093	17 244	
Profit arable sector	25 791	18 858	18 967	20 838	-19.2
Profit cattle-dairy sector	31 550	32 689	32 467	32 336	2.9
Profit int. livestock sector	5 595	9 482	10 604	10 854	94.0
EU finance					
Export refunds	6 726	3 707	3 460	3 425	-49.1
Direct payments	1 523	6 701	8 496	10 751	605.9
Storage costs	4 092	1 268	868	598	-85.4
Levy incomes *)	1 431	1 326	1 051	1 051	0.0
Total budget expenditure	10 841	10 175	11 773	13 272	22.4
Compensation (aggregate)					
Equivalent variation (corr.)	-	3 435	4 901	5 624	
△ Prod revenue	-	-1 907	-898	1 092	
△ Tot budget exp.	-	1 159	3 318	5 630	
△ Balance of trade	-	369	685	1 372	
Compensation (member state)	Million Ecu				
Netherlands	-	274	242	160	
Belgium-Luxembourg	-	193	177	140	
France	-	-1064	-1075	-655	
Germany	-	597	736	825	
Italy	-	382	354	285	
Denmark	-	-168	-132	-57	
Ireland	-	69	-103	-273	
United Kingdom	-	-10	111	272	
Portugal	-	111	153	177	
Spain	-	34	183	353	
Greece	-	43	83	129	

	92	93	94	95	change w.r.t. base year
Markets		1000 tonnes			
Cereals supply	169 476	137 689	137 096	144 685	-14.6
Cereals use	128 166	138 597	141 485	141 966	10.8
Beef and veal supply	7 736	7 735	7 736	7 682	-0.7
Beef and veal use	7 169	7 198	7 267	7 342	2.4
Pork supply	13 339	14 125	14 359	14 429	8.1
Pork use	12 882	12 913	13 073	13 163	2.1
Poultry meat supply	6 335	6 543	6 601	6 613	4.4
Poultry meat use	6 043	6 074	6 136	6 206	2.7
Eggs supply	4 847	4 976	5 044	5 059	4.4
Eggs use	4 679	4 689	4 694	4 699	0.4
Milk supply (raw milk)	111 908	110 789	109 670	109 670	-2.0
Milk use (milk equiv.)	86 516	86 548	87 513	88 685	3.2
Compound feed use	99 951	100 464	99 945	99 814	-0.1
cereals use	34 466	38 764	39 752	39 661	15.1
soymeal use	23 166	20 774	20 199	20 094	-13.3
other meal use	5 033	4 689	4 606	4 591	-8.8
other feed inputs use	34 799	33 778	32 890	32 661	-6.1
Direct feed use	43 959	49 867	51 617	52 088	18.5
Aggr. consumer 'welfare' measures		Million Ecu			
Equivalent variation	-	3 685	12 999	22 877	
Compensating variation	-	3 680	12 971	22 818	
Equivalent variation (corr.)**)		3 435	4 901	5 624	
Consumer surplus*) [SWOPSIM]	-	7 500	10 730	12 320	
CS as % of EV	-	218	219	219	
Consumer surplus*) [AIDS]	-	4 278	6 238	7 255	
CS as % of EV	-	125	127	129	

**) includes (constant) sugar levies and (declining) co-responsibility levies on dairy. **) Corrected for exogenous income change. Source: own computations. There may be slight differences between comparative numbers (e.g. tables in Appendix 11A) as a result of rounding errors and (multiple-round) simulation-effects.*

The market situation, shows, as might be expected, a significant reduction in cereals output and increase in domestic cereals use. Examining the underlying numbers shows that cereal use in compound feeds and increased cereals use on-farm bear the brunt of this increase in consumption. Beef and veal production nearly stabilize, which implies a structural break with the current growth trend. It is in particular the intensive livestock sector which profits from the feed cost reduction and mitigated consumer demand increase. Compound feed production remains nearly constant. Closer inspection indicates that a (about 6%) decline in dairy feed was compensated by increases in pigs (+3.5%) and poultry feed (+2.1%) consumption. Cereal ingredients improve their relative position in particular with respect to oil-meals, notably soymeal.

The bottom block of Table 12.4 is added in order to compare the 'true' EV measure with the so-called single equation approach. This latter approach follows the traditional consumer surplus measurement along a simple demand function, in which demand is modelled as a function only of its own price (and income). Since the cross price elasticities are impicitly assumed to be zero, the sequential measurement approach can be avoided, and surpluses measured in individual markets can be simply aggregated to get the overall measure. Marshallian demands are calibrated using the (relatively higher) own price elasticities associated with the so-called SWOPSIM-model (see also Chapter 11). In general the consumer surplus measure leads to significant over-estimation of the (true) welfare effects, as measured by the EV (and CV)[14]. This confirms the earlier noted result that in a multiple price and income change context, the consumer surplus measure looses its approximation properties (see Chapter 3, section 3.2.3). A clear pattern, like found here, is not necessary from a theoretical point of view. Since here, all price changes are in the same direction (multiple declining prices) and the cross-price effects are ignored, here the pattern is one of consistent over-estimation (including double-counting.

A second consumer surplus estimate is based on the same own price elasticities as those implicit in the almost ideal demand system. Setting the cross price elasticities to zero, gives an impression of the importance of substitution (or impact of market spill-over effects) for the consumer welfare measure. Like the SWOPSIM-based version, the consumer surplus measure shows biased estimation results, emphasizing that cross price effects, even when substitution possibilities look rather limited, play a significant role in computing an appropriate welfare measure.

In order to get an idea of the sensitivity of the results with respect to world market conditions, actual world market price and exchange rate patterns prevailing in the period considered are used in an alternative simulation. Under the tight actual world market conditions (in particular with respect to cereals), the direct income

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[14] The increase in the welfare gains over time is mainly due to increased exogenous income. Although it includes the impact of the policy change, the income effect clearly dominates.

compensation to arable farmers appears more than sufficient to compensate for the decline in institutional prices. The actual overcompensation to arable farmers seems to have been the result of rather incidental factors (higher than expected domestic feed demand and poor harvests in 1995-96), rather than being a result of the reform itself (large country-effect of distortion-reduction).

12.3.2 Agenda 2000

The main results of the Agenda 2000 scenario are presented in Table 12.5. The first row shows the EV measure for consumers. The measure includes the welfare gain due to the annual expenditure growth, as well as the gain due to reduced food prices. The profits of the arable sector initially appear to lag behind, but taking growing yields per hectare and direct income payments into account, they in fact increase by 3.6% as compared with the base year. The profits of the cattle/dairy sector ultimately decline by with about 18%. Whereas initially profits are kept high as a result of the special quota increase (which already increases profits from 15.641 million Ecu to 15.732 million Ecu in the base year), there is a downward pressure from both beef price reductions (-20%) and milk price (-15%) reductions. However, after accounting for the direct income compensations coming both from the EU directly and from the national governments (National Envelope funds), the profit situation of the dairy-cattle sector is improved (decline -11% instead of -18%), although the compensation is not full.

Not-surprisingly, the budget outlays on export refunds strongly decrease (-45%) between 2008 and 2000. However, this 'gain' is more or less compensated for by increased expenditure on direct income payments. The levy incomes comprise sugar levy revenues (remain constant over time), and tariff-quota revenues. Comparing first and last year total budget, expenditure on the GOLF-complex appears to be nearly stabilized, but in between much higher expenditures are realized. This is partly a result of the delay in dairy reform which was planned earlier in the initial proposal.

Table 12.5 Summary table of Agenda 2000 simulation

	2000	2002	2004	2006	2008	change w.r.t. base year (%)
Agregated indicators			Mill. Euro			
Equivalent variation	-	2 099	19 437	42 478	64 356	
Profit arable sector	23 092	24 216	23 370	22 484	23 234	0.6
idem + compensation	33 055	35 834	34 707	33 539	34 252	3.6
Profit cattle-dairy sector	32 617	32 342	32 054	28 284	26 708	-18.1
idem + compensation	35 271	35 585	36 352	32 961	31 385	-11.0
Profit intensive livestock sector	8 493	9 057	9 812	10 646	10 914	28.5
EU finance			Mill. Euro			
Export refunds	5 245	5 032	4 269	3 144	2 831	-46.0
Direct payments	13 442	15 930	16 242	16 344	16 296	21.2
Storage costs	612	509	509	509	509	-16.8
Levy incomes	2 393	2 393	2 393	2 393	2 393	0.0
Total budget expenditure	17 751	19 922	19 472	18 457	18 088	1.9
Compensation						
Equivalent variation (corr.)	-	1 430	2 789	6 989	8 539	
△ Prod. revenue	-	3 658	4 053	328	-267	
△ Budget exp.	-	3 564	2 956	1 579	1 085	
△ Balance of trade	-	1 507	3 886	5 738	7 186	
Markets			Mill.t.			
Cereals supply	156 035	160 446	164 975	169 596	178 903	14.7
Cereals use	129 101	131 531	134 516	137 558	138 527	7.3
Beef and veal supply	7 981	7 929	7 865	7 818	7 820	-2.0
Beef and veal use	7 169	7 177	7 287	7 425	7 522	4.9
Pork supply	13 390	13 546	13 750	13 972	14 056	5.0
Pork use	12 888	12 777	13 042	13 408	13 762	6.8
Poultry meat supply	6 348	6 386	6 443	6 507	6 534	2.9
Poultry meat use	6 046	6 024	6 121	6 256	6 376	5.5
Eggs supply	4 854	4 881	4 931	4 979	5 004	3.1
Eggs use	4 697	4 693	4 705	4 714	4 715	0.4
Milk supply (raw milk)	113 298	113 298	113 298	113 734	114 629	2.4
Milk demand (milk equiv.)	86 521	86 250	88 053	91 343	93 911	8.5

Markets continued	2000	2002	2004	2006	2008	change w.r.t. base year (%)
Compound feed use	100 609	100 053	99 803	99 841	100 704	0.7
cereals use	34 953	35 935	37 019	38 177	38 550	10.3
soymeal use	22 955	22 269	21 646	21 035	21 030	-8.4
other meal use	5 013	4 891	4 791	4 672	4 659	-7.1
other feed inputs use	35 267	34 271	34 309	34 094	34 611	-1.9
Direct feed use	44 393	45 772	47 371	49 045	49 515	11.5
Trade (subs. exports)			Million t			
Cereals	9 275	9 957	10 489	11 033	13 904	49.9
Beef	822	762	585	398	302	-63.2
Pork	378	579	533	425	221	-41.4
Poultry	116	139	124	96	61	-47.7
Eggs	95	114	137	160	175	84.0
Dairy (fat comp.)	15 259	15 566	13 528	10 245	8 235	-46.0
Dairy (skim comp.)	11 893	12 183	10 257	7 142	5 218	-56.1
AMS (percentage change)	0.0	-1.5	-3.1	-14.0	-18.1	

Source: Own computations

**) Milk supply already includes part of the specific quota increase.*

Under the heading of 'compensation', again a balance of trade (BOT) (hypothetical) compensation or excess burden measure is computed analogous to the MacSharry scenario. It can be interpreted as an overall aggregate compensation measure for the EU. Initially (2002-04) the EU as a whole experiences a loss (it requires a positive amount of money to achieve the reference utility level), while later on (2006-2008) the gains increasingly outweigh the losses. If the social costs of public funds are not taken into account, BOT-values of 2,429 ('02), 4,644 ('04), 6,136 ('06) and 7,455 ('08) million Ecu would have been obtained. With the declining role of budget expenditures (decreasing export refunds and (nominally) fixed direct payments), the role of the social costs of public funds correction becomes smaller.

Looking at Agenda 2000 as an eight year project and aggregating the BOT amounts over time yields a net gain of 28,029 Mill. Euro (net present value in 2000, with a discount rate of 2.5%, all years taken into account), which is less than 1% of total consumer expenditure (see Table 12.5), but is about 19% of the total budget expenditures in that period.

Looking at the selected market developments, it appears that the Agenda 2000 policy succeeds in letting supply growth lag behind demand growth for most animal products (excluding eggs). With regard to beef and veal market, balance between demand and supply is not achieved. However, when the initially planned price reduction of 30% would have been imposed, balance would have been achieved in 2005, with a slight positive EU net excess demand for beef in the years thereafter[15]. For cereals, the supply increase still outruns demand growth, although demand for specific categories (cereals use in compound feeds and direct cereals feeding) strongly increases. Compound feed demand nearly stabilizes. This result is the outcome of a number of forces. On the one hand, feed prices decline over time, mainly due to declining input prices (which is partly nullified by declining output prices). On the other hand, direct (on farm) cereals feeding considerably increases at cost of compound feed use. Total direct and indirect feed use increases by 8.72 million tonnes (+11%). The increased cereals use in compound feed (+8%) (due to increased compound feed consumption (+1%) and increased share of cereals in compound feed from 34.7% to 37.6%), and the increased direct feeding (+12%), significantly increase the EU's cereals consumption. Human consumption of cereals, however, only slightly increases (+1.2%, not reported).

To assess the potential impact of Agenda 2000 on the EU's external trade position, the net exports pattern is projected on the subsidized export position of the EU-15 in year 2000. (Base year net exports of this scenario are not comparable to those of the MacSharry scenario, since they may now have changed due to imposed WTO minimum access commitments). Subsidized exports are assumed to be the minimum of actual subsidized exports in 1995/96 and the maximum WTO allowment in 2000/01. Thus when the EU finds the subsidized exports to be lower than the WTO commitment, it is assumed that the EU maintains that position. But when WTO commitments are exceeded, net exports are assumed to be adjusted to the WTO 2000 maxima (for example by market intervention). As can be seen from Table 12.5, with regard to cereals and beef, the calculated subsidized exports remain within the WTO bounds. The subsidized export volume for eggs shows a projected

[15] This shortage-result crucially depends on the conversion factor from live weight to product weight.

increase of 84%, which creates a severe problem to satisfy any WTO bounds. With respect to pigs, the projected net exports of 221 thousand tonnes in 2008 is about half of the WTO bound of 444 thousand tonnes (see Table 12.2).

Besides cereals and beef, the dairy sector is the third most important sector with respect to the EU's external agricultural trade relationships. As can be seen from Table 12.5, the net dairy exports fall by 46% for the fat component and 56% for the skimmed component. Moreover, the EU's starting position for both fat and skimmed component is estimated to be about 88% of the maximum allowable exports due to the WTO commitment (estimate based on main products butter, WMP, SMP, cheese, and concentrated milk). As a result of this reduction in the net exports of milk components, world market prices for fat component and skimmed component show a slightly (real) price increase of 1.4% and 2.7% respectively (compared with base year).

Concluding, whereas Agenda 2000 succeeds in creating a significant reduction in support, nearly -20% as measured by the AMS, satisfying the subsidized export commitments (see Table 12.2 two most left columns) may create problems, at least for some markets. For pork the GATT commitment for 2000 will be under-utilized in 2008 by about 220,000 tons. For eggs, however, the WTO bound is exceeded by 75,000 tonnes. When evaluated in fat and skimmed component terms, the GATT commitments (fat 17.3 and skim 13.4 Mill. tonnes) for dairy should be satisfyable for all years. However, this does not rule out the possibility that for some dairy products, export limitations may become binding, although this model is not really suited to answer questions at the individual product level. Moreover, if the Commission decides to further reduce the export restitutions and the amount of total exports eligible for export subsidies as it has done during the last few years, the WTO targets might still be within reach without creating many problems. For example in 1995, subsidization was already reduced to about 45% of EU-15 total pork exports, while for eggs an increasing number of destinations are unsubsidized (Silvis and Van Rijswick, 1999, pp.115 and 117). Note that the foregoing results are conditional on an assumed non-active intervention policy.

12.3.3 WTO liberalisation

The simulation results of the liberalisation scenario are presented in Table 12.6. As was already noted when the scenario was discussed, this scenario is comparabel with the Agenda 2000 scenario. The main differences are a more pronounced price reduction in the dairy sector, which becomes effective earlier in time, and a doubling of the minimum access (at reduced tariff rates). The consumer gain as measured by the EV without or with a correction of changes in taxes is somewhat higher as compared with the Agenda 2000 scenario. This is mainly due to the additional reforms imposed on the dairy sector. The income-decline for the cattle dairy sector is -27% without compensation and -19% with compensation. This decline is due to the milk output price decline, but also caused by a stronger decrease in livestock capital. As compared with Agenda 2000 the final income decline is doubled. The results for the arable sector remain comparable with the Agenda 2000 scenario. Due to the direct compensation payments, the loss from the cattle-dairy operations is halved.

Using the change in the balance of trade value as a summary statistic of aggregate changes in EU consumer surplus, social costs of public funds, and quasi-rents accruing to producers, the total gain from the WTO-liberalisation project is 27,061 billion Euro, which is about 22% of the total budget expenditure over the eight year period (computed under the same assumptions as Agenda 2000). It is about 968 Million Euro less than was realized with the Agenda 2000 scenario. The main explanation for this difference is the additional producer income loss, as compared with Agenda 2000. In terms of additional excess burden for the EU-12 (see the balance of trade indicator), the Agenda 2000 reform performs somewhat better than the WTO liberalisation scenario.

With regard to the EU's external position, there is not only the effect of imposed support and tariff reductions, but also of the increased minimum access (implicitly assumed to be binding). The main effect of the latter is to increase the pressure on EU prices. But since WTO tariffs or EU export subsidies (of which the lowest one is effective) are fixed, and the additional access to the EU implies a simultaneous supply reduction in the ROW, its final impacts on prices are limited. The main impact is an increase in the surpluses the EU has to export with subsidies.

Table 12.6 Summary table of WTO liberalisation scenario

	2000	2002	2004	2006	2008	change w.r.t. base year
Agregated indicators			Mill. Euro			
Equivalent variation	-	3 634	22 596	44 619	66 831	
Profit arable sector	23 092	24 211	23 371	22 484	23 235	0.6
idem + compensation	33 055	35 829	34 708	33 539	34 253	3.6
Profit cattle-dairy sector	32 617	30 361	28 091	25 705	23 805	-27.0
idem + compensation	35 271	33 604	32 389	30 382	28 482	-19.2
Profit int. livestock sector	8 493	9 056	9 809	10 643	10 911	28.5
EU finance			Mill. Euro			
Export refunds	5 245	4 775	3 833	2 944	2 675	-49.0
Direct payments	13 442	15 930	16 242	16 343	16 296	21.2
Storage costs	612	509	509	509	509	-16.8
Levy incomes	2 393	2 827	3 261	3 695	4 129	72.5
Total budget expenditure	17 751	19 666	19 036	18 248	17 931	1.0
Compensation						
Equivalent variation (corr.)	-	2 948	5 949	9 130	11 139	
△ Prod. revenue	-	1 671	88	-2 254	-3 172	
△ Budget exp.	-	3 217	2 367	1 302	874	
△ Balance of trade	-	1 402	3 670	5 574	7 093	
Markets			Mill.t.			
Cereals supply	156 035	160 445	164 972	169 594	178 900	14.7
Cereals use	129 101	131 512	134 472	137 522	138 484	7.3
Beef and veal supply	7 981	7 929	7 864	7 817	7 820	-2.0
Beef and veal use	7 169	7 180	7 291	7 428	7 525	5.0
Milk supply (raw milk) *)	113 298	113 298	113 298	113 734	114 629	2.4
Milk demand (milk equiv.)	86 521	86 867	89 194	91 978	94 474	9.2
Trade (subs. exports)			Million t			
Cereals	9 275	9 962	10 502	11 044	13 917	50.1
Beef	822	759	581	394	299	-63.6
Dairy (fat comp.)	15 259	14 927	12 356	9703	7832	-48.1
Dairy (skim comp.)	11 893	11 698	9 388	6 989	5 316	-55.3
AMS (percentage change)	0.0	-7.2	-14.3	-21.2	-26.3	

Source: own computations. Note: meats converted from live weight to product weight.
*) *Adjustement of specific quota increase already partly included in the 'first' year.*

Compared to the Agenda 2000 scenario, the liberalisation scenario saves more on budget outlays (export refunds). Moreover, the milk price reduction creates some additional internal demand in the EU. This leads to a further reduction of net exports from the dairy sector. Combined with the lower prices, this contributes to a support reduction of more than 26% (as measured by the AMS). Note that the AMS reduction due to MacSharry already goes much further than the Uruguay Round commitment for the year 2000. Further, above this an additional 26% reduction is realized with the simulated liberalisation. However, the score on 'external position' is largely paid for by the cattle-dairy sector, since they face further output price reductions without additional compensation.

Considering the Uruguay agreement and the WTO liberalisation scenario as a two-step reform, it is interesting to estimate the overall reduction in the support level. Assuming, the EU actually realizes 30% support reduction (while it was only committed to a 20% reduction) in the first round, with a second step of 26%, this liberalisation scenario would lead to a 48% overall AMS reduction as compared with the initial situation[16]. Agenda 2000, however, with a second step support reduction of 19%, in the corresponding case realizes an overall AMS reduction of about 43%. If the policy package implicit in the liberalisation corresponds to the final WTO Round agreement, Agenda 2000 would not suffice but some further adjustments will be necessary. (A non-reported scenario showes that if the EU had not delayed reforms in the dairy sector, the AMS target in the WTO scenario would have been nearly achieved). On aggregate, however, the EU then needs some 613 million Ecu compensation from the Rest of the World to maintain their reference welfare level.

The regional impacts (not reported in the Tables) of both the Agenda 2000 and WTO liberalisation scenarios are rather comparable, although differences in dairy interests plays a diverging role. Consumer gains are quite equaly distributed, with Irish consumers gaining most and the Spanish ones gaining least. Some interesting

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[16] The required overall AMS reduction is 48%, namely a first round reduction of 20% (while 30% is realized), with a second round reduction of 35%. Or, assuming the initial position to equal 100, the first round means 100-20=80, and the second round 80-(0.35*80)=52. For the WTO scenario this is 100-(0.30*100)= 70 (first round) and 70-(0.26*70)=52 (second round). If the EU would have kept to the initial Agenda 2000 proposal (beef prices -30% and no lag in dairy reform), the AMS reduction would have been over 40% (from not reported simulation).

other patterns are the following. Regarding the arable sector, on average the (calculated) share of cereals in total arable declines by about 3%, while potato areas increase and oilseeds slightly decline (except for Denmark where the oilseed area increases). In beef and veal, it is in particular Italy which falls back, while Ireland succeeds in maintaining a strong position. The cereal price decline influences the cost structure of the intensive livestock sectors of the EU member states in different ways, while output price shows a general tendency to decline. Countries which rely relatively more on cereals improve their relative benefit/cost position. In the pigs industry Denmark is the strongest gainer (output increase of +14%). Spain and the UK are the leading gainers in poultry meat (+5%), while Denmark and Portugal are leading in eggs (+9%).

Regarding the compound feed market, Denmark shows the strongest increase in the demand for compound feed ingredients (followed by Spain). On avereage the use of cereals increases by 9.0%, with high protein feeds declining with 7.8%. Soybeans decline even more strongly, so that the position of EU oilseeds in the high protein group is indirectly strengthened. There are also differences between the countries. In particular in Italy, the UK and Spain, the relative share of soybeans in total compound feed ingredients declines (much less so in the Netherlands). The composition of total compound feed output, changes with dairy feed decreasing (-1%) and pigs (1.6%) and chicken feeds (1.7%) increasing. Direct (on-farm) feeding gains significant importance.

12.4 Lessons and conclusions

In this last section some evaluative remarks of a more general character are made, without reiterating what is said before. Of course it should be remembered that the simulations presented in the previous section have a stylized character. This refers to both the policy presentation and implementation (a number of policy details could not be included in the policy reference framework as shown in the appendix to Chapter 11), and the base year choice. Nevertheless some lessons from this analysis can be learned. Firstly, the empiricaly estimated elasticities still support the basic assumptions of the so-called *farm problem*-model (see Chapter 2, section 2.2). Unless there is a drasticall change in the government objectives, significant policy intervention in agriculture will remain.

A second comment is regarding the order of magnitude of numbers. In general it can be said that the ultimate real direct consumer gains of the Macsharry CAP reform lie somewhere in the range between 0.25% and 0.75% of national disposable income. This estimate is rather low when compared to others (in particular Kol and Kuipers, 1996). One reason for this difference is that other studies often work with some kind of user surplus rather than a real consumer welfare measure. Also those studies fail to reveal some interesting distributional implications of the CAP, in particular those between consumers and the food industry.

A related comment relates to the results found with respect to the compound feed ingredient markets. Combining pseudo-data (derived from least cost programming models exploited by the compound feed industry) with agregate market data, it has been possible to estimate a behavioural model of the transformation proces which converts feed ingredient into compound feeds. This method leads to somewhat higher substitution possibilities between various ingredients than that found with traditional time series analysis. The simulation results make it clear that under significant price reductions, cereals will significantly improve their use in (both direct and compound) animal feeds. This seems in line with observations on actual developments.

More generally, relying on a mixed estimation procedure to obtain the necessary parameter estimates, has been shown to be a reasonable method for constructing this type of simulation model. Models of this magnitude are often calibrated based on a quick-scan of the literature and plausibility considerations. The mixed estimation procedure is an enriched calibration procedure combining prior-beliefs with actual data. Positively formulated, mixed estimation represents a relatively simple procedure to combine prior information both from economic and non-economic sources with sample information. As such it (potentially) increases the efficiency of the inference procedure and the plausibility of the results found. Moreover, it provides a procedure to cope with data-mining.

A fourth lesson concerns the modelling approach. Other studies regularly follow an approach based on direct estimation of (simple) demand equations, which usually do not satisfy the integrability criteria and therefore can not be linked to a preference ordering. So, as was argued from a theoretical point of view in Chapter 3, it is not clear how the money measures thus obtained should be interpreted. Moreover, no clear welfare bound conditions can be formulated for incompletely modelled supply and demand systems. Our simulations indicate that the usual arguments raised in favour of this approach (like low expenditure shares, and low own-price, cross-price and income elasticities) are not enough to guarantee a reliable approximation of the 'true' welfare measures.

A fifth lesson is that, in a second best world, where a certain amount of income redistribution from the rest of the economy to agriculture takes place, there exists a trade off between the gain realized by lowering distortions in agricultural markets and the loss due to increased reliance on distortionary taxation. In other words, in a second-best world, there is some validity in the argument for revenue raising by taxing products, like food products, which are inelastically demanded. Our analysis suggests that accounting for the marginal costs of public funds (in a rather conservative way) results in 'efficiency' gains, which are already limited, further shrinking away (in the MacSharry-case it nearly halves). With the increased reliance of the CAP on direct payments to farmers, the social costs of public fund ought to be included in policy analysis. So from a consumer/taxpayer point of view, the concern for reduction of export subsidies and direct transfers is perfectly understandable.

A sixth and related lesson concerns the preconceptions about efficiency or deadweight losses. Going from a first-best to a second-best world, there is an inherent efficiency loss and the deadweight loss concept has some appeal. In a second best world, gains obtained in one direction usually have to be balanced against losses in other directions. A more general and appropriate concept then is an inclusive measure comprising these different effects. Preferably, concepts like marginal and additional excess burden should be used (see Chapter 4, section 4.4). Our (modified) balance of trade measure provides a theoretically consistent welfare measure for evaluating the overall gains/losses of CAP reform at EU (and member state) level while allowing for the inclusion of complex market interactions and a wide variety of multiple distortions. The simulation results show that, even under second-best considerations which (by accounting for the social costs of public funds) increases the costs relative to the benefits, further CAP reform is possible, with the gainers being able to compensate the losers.

There are some other points also worth of drawing attention. This analysis provides a strong argument for taking the intermediate industry into account, even within a context of limited data availability and uncertain substitution elasticities. In particular when the focus of the analysis is on distributional issues, which is an essential aspect of cost/benefit studies of the CAP, sufficient disaggregation is a prerequisite for a balanced analysis. In one simulation, which allowes for imperfect competetion (a market power coefficient with a 5% mark-up), a consumer surplus share in total user surplus of about 45% has been found. Therefore, the welfare impacts of policy reforms on industry deserves specific attention, a line not further exploited here.

Another point relates to the open economy of EU agriculture. Even when (mixed) estimation methods are used aimed at reducing uncertainty about elasticity estimates, the uncertainty about actual price developments (specific market conditions) is still a factor of significant importance. Based on simulation results using actual world market price developments (MacSharry scenario), it appeares that incomplete compensations under stationary world market conditions, can easily lead to overcompensation if actual world market conditions are buyoant with respect to agricultural products. Although this study partly endogenizes world market prices, the followed approach is considered inadequate to claim any predictive power. It merely sketches some likely patterns if world markets react in an undistorted way. This is a restrictive assumption, which, however, could not be improved upon within the context of this study.

One of the aims when starting this analysis, was to obtain more precise welfare measures of the policy impacts of CAP reform. A theoretically neat approach has been followed, which has consistently linked welfare measures to (incomplete) demand and supply systems. Subsequently an informative inference procedure has been applied to obtain efficient parameter estimates. The welfare estimates obtained are nevertheles still subject to on uncertainties of various kinds. All the statistical properties inherent in the estimated models transfer to the welfare measures based upon these measures. Moreover, following a multiple market equilibrium model, which is still not yet a general equilibrium model, already complicate things a lot. Demand and supply of several subsectors should be linked, trend patterns for exogenous variables should be assumed, etc. Eliminating uncertainty is not achievable: reducing one type often results in increasing the other type. It would have been interesting to analyse the sensitivity of the welfare measures with respect to uncertainty.

Another aim of the analysis has been to further apply the social transfer efficiency-approach (STE) (see Bullock *et al*, 1999 for a recent review). The framework developed here fits in perfectly with that approach. However, recapturing 'transfer curves' requires a host of numerical simulations, which goes beyond the current excercise. Whereas the STE-literature focuses in particular on compensatory transfers from the consumer/taxpayer to agriculture, this study emphasizes that policy changes generate important transfers, not only between producers and consumers, but also within agricultural subsectors. The STE-analysis should therefore take market interlinkages and spill-over effects into account.

In contrast with the positive policy analysis of for example Van der Zee (1997), this study clearly belongs to the normative realm. (See the the Josling-paradigm or instrument-objective approach discussed in Chapter 2). The emphasis has been, however, more on evaluating agricultural policy reform than on simple ranking of policies. In particular the focus has been on issues of compensation in a second-best context. Although it is then difficult to formulate general policy reform rules as in a first-best world, one of the results of this study is that both the MacSharry and Agenda 2000 reforms satisfy the (potential) compensation criterion. That is not necessarily sufficient to legitimize these reforms to the EU policy maker. He will take other interests into account, but it is still one important piece of information required in the policy process. The more so if a rather detailed picture can be obtained of the implicit and explicit transfers both between agriculture and the rest of the economy, as well as between different groups within agriculture.

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Summary

Most countries, among them both developed and developing ones interfere with their agriculture. As long as agricultural policies have been in place, they have been criticized for their inefficiencies. Implicitly, often so-called first-best world arguments played a strong role in this reasoning. Criticism and changing circumstances forced continuous adjustment and reform of agricultural policies, albeit usually in a slow and piecemeal manner. Analysing the economic impacts of agricultural policy reform, using theoretical concepts and an empirically based modelling framework is the main contribution of this thesis.

This study focuses on the grains, oilseeds, livestock and (compound) feed-complex (GOLF) of European agriculture. It is a complex of heavily interrelated markets comprising several subsectors like the arable sector, the dairy-cattle sector, and the intensive livestock sector. Consumer demand for GOLF-products, and the intermediating role of the compound feed industry also influence this complex in critical ways. The complex accounts for more than 50% of total common agricultural policy (CAP) expenditures and the total final product value of EU agriculture. Moreover, the complex comprises conflicting interests of various groups of farmers, while its products (cereals, beef, and dairy products) are important in the EU's (external) trade relationships. Jointly, the political sensitiviy and the structural complexity make this sector an interesting phenomenon for further investigation.

Several reseach questions come up, some of which have a theoretical/methodological background and others are of a more empirical nature. The first group of issues concerns welfare economics, which is the main economic toolkit for analyzing policy issues. Issues raised include the appropriate measurement of welfare effects, in particular in a (horizontally and vertically) related market-context (spill-over effects) and when the economy and/or the economic behaviour of various producer

and consumer groups is incompletely modelled. This raises the question: what is the meaning of the efficiency concept in a second-best world, characterized by a multiplicity of distortions, of which many are unalterable?

An important empirical issue relates to the modelling of economic behaviour, given the availability of both sample information (aggregate time series) and non-sample information. The latter information may be of an uncertain (stochastic) nature (derived from previous empirical economic and/or agronomic research) and may also have a deterministic character (physical/technical balance restrictions). What is a reliable and efficient inference procedure given that this information is derived from various sources? A second empirical issue relates to the modelling of financial streams associated with the EU's common agricultural policy. Which streams are there? In what direction? Of what magnitudes? To the benefit of whom?

A third group of empirical questions relate to policy analysis. What light can a constructed simulation model spread on important past and future policy reforms? More in particular: What are the economic impacts of the MacSharry reform? In what sense is Agenda 2000 likely to alter the current situation? How will further significant liberalisation resulting from the WTO negotiations affect the EU's position?

Chapter 2 explains why governments intervene in their agriculture, and reviews the contribution of welfare economics to agricultural policy analysis. A number of factors, like price and income inelastic demands, inelastic and unstable supply, relative to demand strong growth of supply, factor fixity and specifity (land), all incorporated in the so-called farm-problem model, explains why agriculture belongs to the relatively contracting sectors, with associated declining farm incomes and adjustment problems. As do most other empirical studies, the empirical results in this study also sustain the farm-problem model. The EU's CAP aims at supporting farm incomes by means of encouraging productivity increase. To this productivity growth policy, general price support policies were added in order to guarantee a fair distribution of the productivity gains between producers and consumers of agricultural products.

Welfare economics, here understood as the study of the economic impacts of alternative policies on different social categories, and/or the attainment of different economic goals, supplies an essential, albeit not the only, ingredient for the policy making process. The theory of economic policy reveals that it is important for cost, benefit or compensation measures to be tied to the desired or intended effect of policy. Moreover, the second-best character of the real world should be taken into account. Whereas this complicates the deriving of simple (deduced) rules (as in first-best welfare economics), it still yields helpfull insights into policy reform issues. However, the results in general depend on demand and production interrelationships between markets that are subject to multiple distortions. So quantitative-empirical investigation is a prerequisite for arriving at the results.

Chapter 3 discusses welfare measurement. Traditional consumer surplus and compensating and equivalent variation (*CV*, *EV*) measures are discussed and linked with each other. It is argued that in general (in particular when multiple prices and income change) the Marshallian consumer surplus measure is inferior to *CV* and *EV* measures and that even its approximation error may be significant. While the *EV* and *CV* measures are perfect welfare measures, only the *EV* is also a true compensation measure (*money metric*), and as such superior to the *CV* measure. Producer surplus is better achieved as a quasi-rent, and linked to the dual (restricted) profit function. Since the economic rent interpretation depends on the presence of quasi-fixed factors, the measure is studied at various length of run. Regarding technical change, it is argued that the producer rent is superior to the traditional producer surplus measure. The final part of Chapter 3 focuses on aggregate welfare measures. Aggregation is rather straightforward on the producer side, but requires specific assumptions at the consumer side. Assuming the latter are satisfied, the balance of trade function is derived as a national welfare measure. Based in this, we develop the subsequently treated (marginal and additional) excess burden measures and their characteristics in a second-best world.

Chapter 4, which closes part I of the thesis, focuses on applied welfare analysis in the context of multiple distorted related markets. A central result in this field is the so-called Harberger rule, which is used to defend a multiple market equilibrium (MME) *cum* shadow price of public funds model, against both a strict partial equilibrium (PE), and an intractable general equilibrium (GE) approach. In order to clarify welfare measurement in a multiple distorted related market context, welfare measurement along GE demand and supply curves is examined. The MME approach is found to be the most suitable one, both from the perspective of the distributional insight it offers as well from the perspective of reliable empirical estimation. The chapter further provides a shadow price rule for the cost of public funds, and a discussion of welfare measurement in incomplete consumer demand and producer supply systems. The conditional measures associated with incomplete systems appear to have a nice upperbound interpretation when measuring gains and an underbound interpretation when measuring losses.

Part II provides the empirical models of various sub-sectors. Chapter 5 starts with a concise introduction to the GOLF-complex. Moreover, this chapter discusses the general modelling approach followed. The modelling approach relies strongly on micro-based dual profit and expenditure functions applied to aggregate time series data. A mixed estimation inference procedure is used, which is able to simultaneously handle sample and non-sample information of various kinds (economic theory, previous economic research, agronomic research, physical balance constraints). Mixed estimation is the recommended estimator because of the way it deals with information (avoiding *data-mining*), and its simplicity (as compared with Bayesian estimation). It is also an efficient estimation procedure, although it might be sensitive to bias.

Chapter 6 presents a consumer final demand model for agricultural products. For each member state an almost ideal demand model is calibrated based on previous economic research and a normalized base year. Consumer demand is linked to an agricultural input and a non-agricultural input, implicitly assuming a simple food and processing industry characterized by constant returns to scale. The model allows for a stylized investigation into market power. Substitution elasticities between agricultural and non-agricultural inputs are also derived from previous research.

Chapters 7, 8 and 9 provide subsector models at member state level for the arable sector, the cattle-dairy sector, and the intensive livestock sector respectively. Each chapter starts with a concise description of the main empirical and policy characteristics of the concerned subsector. Subsequently, formal models are derived, which are potentialy able to explain the main phenomena. Next, a discussion of the available prior information, the estimation method, and the estimation results follows. Specific issues considered include the animal production dynamics (explaining livestock capital behaviour) and the use of nutrition requirement schemes to get a more complete view of the feed intake of the intensive livestock subsectors.

Chapter 10 focuses on the linkages between the arable sector and the livestock sector, *i.e.* the compound feed industry. After a brief description of the industry, a separable cost function framework (for feed and non-feed cost) is used to describe the sector's behaviour. Moreover, constraints following from the material balance constraints are imposed. The model is estimated using prior information on elasticities derived from previous research, and pseudo data generated using least cost linear programs for four types of Dutch feed rations. Via the pseudo-data a lot of technical and nutritional restrictions, which will influence substitution possibilities between various ingredients, are 'imported' into the compound feed model.

Part IV of the thesis is formed by chapters 11 and 12. Chapter 11 discusses the calibration of the GOLF-simulation model based on previous estimation results for subsector models and (1990) base year data. Moreover, model closure, in particular the linkage of EU agriculture with the rest of the world (net excess demand functions) and the rest of the economy (shadow price functions reflecting the cost of public funds) is treated. Besides, considerable attention is paid to the modelling of the CAP and its related financial streams.

Chapter 12 provides the results of three scenarios: *i)* the MacSharry reform, *ii)* the Agenda 2000 reform, and *iii)* a WTO liberalisation scenario. All three appear to satisfy the compensation criterion, implying that the benefits accruing to the 'winners' are more than enough to compensate the costs to the 'losers'. In that sense no compensation from outside the EU is required.

The efficiency or excess burden effects are small when related to total consumer expenditure or disposable national income (order of magnitude of 0.5 to 1.0%). If the social costs of public funds are not taken into account, the calculated savings on excess burden significantly increase, in particular in the MacSharry scenario. But even then, they remain relatively small in magnitude. Allowing for market power in the food industry may lead to a significant change in the distribution of the user surplus between final consumers and the food industry. Further research on this area is, however, beyond the scope of this study.

Agenda 2000 leads to a support reduction of about 18% when measured in terms of the aggregate measure of support (AMS). This is still not sufficient to achieve the hypothetical compromise implied in the WTO liberalisation scenario.

In particular the delay in reforms in dairy and the smaller beef price reduction (as compared to the initial Agenda 2000 proposal) in the dairy sector plays a crucial role here.

Some general lessons and conclusions can be drawn from this study (see Chapter 12 section 12.4 for more details). From the study of welfare measurement (Chapters 3 and 4), it turns out that even when the behaviour of actors (consumers or producers) is incompletely modelled, derivative welfare measures still have a meaningful application since upper bound or lower bound interpretations are attached to them. Single curve GE analysis has improved the insight into the role of market spill-over effects, but it appears to have limited applicability if the research focus is on distributional impacts of policy changes. Added to this, reliable estimation of GE curves is troublesome. As noted before, in this study a multiple market equilibrium-approach has been chosen. As our simulation results have confirmed, incorporating the cost of public funds in such a model is necessary if one aims to make a balanced analysis of costs and benefits arising form agricultural policy reform. Ignoring the cost of public funds leads to substantially overestimating of the net benefits from all the analysed reforms.

Another finding from the empirical work done (Chapters 6 to 10) is that the elasticities obtained support the farm problem-model in Chapter 2. Unless there is a drastic change in the government policy objectives, significant policy intervention in agriculture will remain necessary. This holds not only for policy intervention but also for policy analysis. A further result is that the consumer gains of the MacSharry reform have been estimated to lie somewhere in the range between 0.25-0.75% of disposable income. While these gains at present are small, they will be further reduced if we allow for market-power in the intermediate food industry. Although imperfect competition in upstream and downstream industries linked with primary agriculture is not the focus of our analysis, further research on this topic is recommended, since it significantly influences the distribution of benefits and costs arising from policy changes.

The substitutability of feed ingredients, in particular with respect to cereals, is an important issue in the policy reform debate. It turns out from our analysis that the CAP reforms have significantly increased the home-consumption of cereals in the EU even at the cost of the highly valued soymeal. The methodology used in this study, which combined time series with pseudo data (derived from least cost programming models of the kind often actually used by feed compounders), has contributed to a reliable modelling of the substitution possibilities for cereals. Studies that only rely on time series data have usually under-estimated these possibilities.

Continuing with the estimation methodology, mixed estimation has been found to be a very helpful approach in an applied modelling-context, where available time series are often relatively limited, but at the same time several other pieces of information (previous economic research, agronomic information, physical balance conditions, etc.) are known, albeit with uncertainty. Mixed estimation has been shown to allow for the inclusion of various sources of information and so has contributed to an 'enriched' inference.

All analysed (stylized) reform scenarios satisfy the compensation criteria, even when the cost of public funds are taken into account. So, taking second-best considerations into account still leads to positive net benefits. Moreover, when comparing the Agenda 2000 scenario and the WTO trade liberalisation scenario, there is a small but negative 'efficiency' gain (as measured in terms of additional excess burden). This implies that as compared with the initial situation, Agenda 2000 has been found to be more attractive than the WTO liberalisation scenario, according to the compensation principle. In other words, having undertaken the step of Agenda 2000, the EU-12 will need about 968 million Ecu 'outside' compensation to remain at its achieved utility level while accepting the simulated WTO liberalisation. Whereas the arable sector has been the big loser with the MacSharry reform, the dairy sector has been found to be the most negatively affected in the Agenda 2000 reform, and also likely to suffer most from a new WTO agreement. Budget expenditure on the EU-12's market and price policy, which has still grown with the MacSharry reform, has been found to be more or less under control in the other scenario's.

Samenvatting

In de meeste landen, zowel ontwikkelde als ontwikkelingslanden, grijpt de overheid in in de landbouw. Zolang als er landbouwbeleid wordt gevoerd valt er echter ook kritiek op dat beleid te horen. Vaak wordt dan gewezen op de inefficienties van het bestaande beleid. Impliciet valt men daarbij terug op wat economen *first-best* argumenten noemen. De kritiek en meer nog de veranderende omstandigheden leiden tot een continue aanpassing en hervorming van het beleid, zij het dat dit vaak langzaam en met kleine stapjes tegelijk gaat. Dit proefschrift levert een bijdrage aan de kwantitative analyse van de hervorming van het gemeenschappelijke landbouwbeleid (GLB) in de EU.

Het onderwerp is het zogenaamde granen, oliezaden, veehouderij en krachtvoer-complex (in het vervolg aangeduid met het acronym GOLF) van de EU landbouw. Het gaat hier om een complex van nauw aan elkaar gerelateerde markten en verschillende subsectoren, zoals de akkerbouw, de melk- en vleesvee sector, de intensieve veehouderij en ook de consumentenvraag. Meer dan 50% van de uitgaven aan het GLB gaat naar het GOLF-complex. Het aandeel van het GOLF-complex in de totale finale produktiewaarde van de landbouw ligt eveneens boven de 50%. Het complex omvat conflicterende belangen van diverse groepen agrariërs (opbrengsten voor akkerbouw zijn vaak weer kosten voor veehouderij), terwijl produkten zoals granen, rundvlees en zuivelprodukten, een centrale rol spelen in de handelsrelatie van de EU met de rest van de wereld. Zowel de politieke gevoeligheid als de structurele complexiteit maken deze sector een interessant object voor nadere analyse.

In deze studie komen een aantal onderzoeksvragen aan de orde, waarvan sommige een meer theoretisch karakter hebben en andere meer empirisch van aard zijn. De theoretische raken met name de welvaartstheorie, het belangrijkste instrument binnen de economie voor beleidsanalyse. Vragen die zich daarbij voordoen zijn: Hoe meet je de welvaartseffekten van het landbouwbeleid? Hoe hou je daarbij rekening met de horizontale en verticale onderlinge relaties die er tussen markten bestaan (*spill-over* effekten)? Wat stellen de welvaartsmaatstaven voor als de economie en/of het gedrag van groepen maar beperkt te modelleren is? Hoe ga je om met het gelijktijdig voorkomen van verstoringen op meerdere markten, waarvan sommige bovendien niet echt te veranderen zijn (*second-best* situatie)? En wat is de betekenis van efficientie eigenlijk in zo'n *second-best* wereld?

De empirische vragen hebben allereerst te maken met de modellering van economisch gedrag, gegeven dat zowel tijdreeksen (informatie uit steekproef) als andere typen van informatie beschikbaar zijn. Bij dat laatste gaat het om informatie uit eerder empirisch economisch onderzoek en agronomische informatie. Deze informatie kan zowel een zeker (balansvergelijkingen) als een onzeker karakter hebben. Hoe combineer je deze heterogene vormen van informatie in één schattingsprocedure? Een tweede empirische puzzel was om de financiële stromen die samenhangen met het GLB in kaart te brengen. Vragen die kunnen worden gesteld zijn dan: Welke stromen zijn er? In welke richting? Van welke omvang? Ten gunste van wie?

De derde groep van empirische vragen raakt het landbouwbeleid zelf. Wat kunnen we leren van een simulatie analyse van recente en toekomstige hervormingen van het landbouwbeleid? Meer specifiek: Wat zijn de economische gevolgen van de MacSharry-hervorming? Hoe zal met Agenda 2000 de situatie veranderen? Wat zal een verdere liberalisatie van het GLB in het kader van de komende wereldvrijhandelsbesprekingen (WTO) voor effekten hebben?

In hoofdstuk 2 wordt nagegaan waarom overheden in hun landbouw interveniëren. Eveneens wordt ingegaan op de bijdrage vanuit de welvaartstheorie aan de analyse van het landbouwbeleid. Een aantal faktoren, zoals prijs- en inkomensinelastische vraag naar voedsel, inlastisch en instabiel aanbod van de landbouw, de rol van grond als specifieke én vaste produktiefactor (samengevat in het zogenaamde *farm problem*-model) verklaren waarom het economisch belang van de landbouw in de economie als geheel voortdurend terugloopt. De in dit onderzoek gevonden resultaten ondersteunen de hypothese van het *farm problem*-model.

Het GLB probeert vooral door het stimuleren van de produktiviteitsontwikkeling de inkomens van de boeren te ondersteunen. Daaraan werd een algemene prijssteun toegevoegd om tot een faire verdeling van de produktiviteitswinst tussen producenten en consumenten van landbouwprodukten te komen. Algemene prijssteun is overigens een weinig specifieke vorm van ondersteuning.

De welvaartstheorie speelt een essentiele rol in de analyse van beleid omdat het één van de ingredienten levert die nodig zijn voor verantwoorde beleidsontwikkeling. In het bijzonder de *instrument objective*-benadering waarbij kosten, baten en compensatiemaatstaven worden gerelateerd aan gewenste beleidsdoelen geeft een vruchtbaar analysekader. Omdat de reële wereld complex is en een *second-best* karakter heeft is het meestal niet mogelijk om eenvoudige welvaartsregels te hanteren. De simpele regels die via deduktie uit de *first-best* analyse voortvloeien zijn in de praktijk ontoereikend. De welvaartseffekten zullen in het algemeen afhangen van de specifieke vraag- en aanbodscondities en de hoogte van de bestaande verstoringen. Kwantitatieve analyse is daarom een noodzakelijk voorwaarde om tot resultaten te komen.

Hoofdstuk 3 gaat in op de welvaartsmeting. Het traditionele consumentensurplus en de *equivalent variation* (*EV*) en de *compensating variation* (*CV*) maatstaven worden besproken en onderling vergeleken. Aangegeven wordt dat als er sprake is van meerdere prijs- en inkomensveranderingen, het Marshalliaanse consumentensurplus inferieur is ten opzichte van de *EV* en de *CV*. De empirische analyse bevestigt dit later. Hoewel de *EV* en *CV* beide perfecte welvaartsmaatstaven zijn is de *EV* eveneens een goede compensatiemaatstaf (*money metric*) en daarom in zekere zin superieur aan de *CV*.

Het producentensurplus is eigenlijk geen echt surplus in economische zin, maar een *quasi-rent*. De economische *rent*-interpretatie draait om de aanwezigheid van vaste, d.w.z. niet qua inzet aan te passen, produktiefaktoren. Nagegaan wordt hoe tijdshorizon (van korte tot steeds langere termijn) de *quasi-rent*-maatstaf beïnvloed. Ook de rol van technische ontwikkeling wordt bekeken. De *quasi-rent* maatstaf, die in direkte relatie met de zogenaamde (gerestricteerde) duale winstfunctie staat, blijkt dan superieur te zijn aan het traditionle producentensurplus.

In het slot van het hoofdstuk wordt de (aangepaste) betalingsbalansfunctie besproken. De functie is afkomstig uit de literatuur van de internationale handel en heel geschikt als een geaggregeerde compensatie- en efficiency maatstaf op het niveau van lidstaten en/of de EU. Deze functie leent zich niet alleen uitstekend als *over-all* maatstaf in een *second-best* wereld, maar is ook handig in de daarmee verbonden efficiency-analyse in termen van marginale en additionele *excess burden*.

In hoofdstuk 4, dat Deel I van het proefschrift afsluit, wordt ingegaan op de toegepaste welvaartsanalyse in een context van meerdere aan elkaar gerelateerde en verstoorde markten. De bekende regel van Harberger wordt besproken en gebruikt om te pleiten voor een zogenaamd multiple markten evenwichtsmodel (*MME*) met een schaduwprijs voor de sociale kosten van publieke middelen. Deze benadering is enerzijds meer realistisch dan de stricte partiële evenwichtsbenadering (*PE*) en anderzijds beter haalbaar dan een echte algemene evenwichtsbenadering (*GE*).

Om de rol van *spill-over* effekten en compensatie beter in beeld te krijgen wordt de meting van welvaartseffekten langs zogenaamde algemene evenwichts vraag- en aanbodscurves besproken. Hoewel conceptueel verhelderend, wordt beargumenteerd dat de *MME cum* schaduwprijs-methode voor de in dit onderzoek geanalyseerde vraagstelling het meest geschikt is. Die laatste aanpak biedt meer detail als het gaat om de verdelingseffekten en is bovendien beter vanuit een econometrisch gezichtspunt. Het hoofdstuk besluit met een analyse van schaduwprijsregels voor sociale kosten van publieke middelen en de interpretatie van welvaartsmaatstaven in incomplete vraag- en aanbodssystemen.

Deel II van het proefschrift concentreert zich op de modellering en schatting van individuele landenmodellen voor de verschillende subsectoren. In hoofdstuk 5 wordt een beknopte introductie van het GOLF-complex gegeven. Voor de modellering wordt gebruik gemaakt van de sterk micro-economische winst- en kostenfuncties, die worden geschat op basis van geaggregeerde tijdreeksen. Tot slot wordt ingegaan op het gelijktijdig meenemen van verschillende vormen van *sample-* en prior-informatie in een gemengde schattingsprocedure (*mixed estimation*). De gemengde schattingsprocedure wordt aanbevolen als middel tot verantwoord data gebruik (ter voorkoming van *data-mining*) als vanwege haar eenvoud (voordeel op de Bayesiaanse methode). Gemengd schatten is ook efficient, al wordt dat voordeel soms gekocht met extra kans op *bias*.

Hoofdstuk 6 gaat in op de consumptieve vraag naar de produkten van het GOLF-complex. Voor elke lidstaat wordt een *almost ideal demand*-model gecalibreerd op basis van de resultaten van eerder empirisch onderzoek. De vraag naar finale produkten wordt gerelateerd aan de vraag naar landbouwprodukten via een CES-aggregator functies, die steeds een landbouwinput combineren met een niet-landbouw input om zo een finaal produkt te produceren. Op deze wijze wordt geprobeerd de voedingsmiddelenindustrie te benaderen. Het model biedt mogelijkheden om het effekt van verschillende substitutie-elasticiteiten tussen landbouw- en niet-landbouwinputs te analyseren en maakt eveneens stylistische analyse van marktmacht bij de voedingsindustrie mogelijk.

De hoofdstukken 7, 8 en 9 beschrijven de subsector modellen voor respectievelijk de akkerbouw, de melk- en vleesveehouderij en de intensieve veehouderij. Elk hoofdstuk start met een beknopte beschrijving van de empirische en beleidskarakteristieken van de betreffende subsector. Er worden formele modellen afgeleid, die zo goed mogelijk recht kunnen aan de eerder beschreven karakteristieken. Vervolgens wordt de beschikbare prior informatie geïnventariseerd en met de verzamelde tijdreeksen gecombineerd in de schattingsprocedure. Daarna volgt een bespreking van de resultaten. Specifieke onderwerpen zijn de dynamiek van de dierlijke produktie (*livestock capital*) en de veevoedkundige behoefteanalyse nodig om een gecompleteerd beeld van de voedselopname van m.n. de intensieve veehouderij te krijgen.

De verbindende schakel tussen enerzijds de akkerbouw en anderzijds de dierlijk produktie is de mengvoederindustrie (hoofdstuk 10). Het gebrek aan data maakte het noodzakelijk om inventief met de economische theorie en overige informatie om te gaan. Met behulp van separabiliteitsveronderstellingen en balanscondities werd een eenvoudige gerestricteerde kostenfunctie afgeleid. Deze werd vervolgens geschat op basis van *cross-sectie* data en zogenaamde *pseudo*-data. Die *pseudo*-data werden gegenereerd met behulp van door de mengvoederindustrie ook daadwerkelijk gebruikte *least cost* programmeringsmodellen. Op deze wijze konden impliciet een heel aantal mengvoedertechnische restricties in het uiteindelijke model worden 'geïmporteerd'.

In het laatste deel van het proefschrift, Deel IV, worden de eerder verkregen resultaten samen gebracht in een simulatiemodel van het GOLF complex (*GOLF-SIM*). In hoofdstuk 11 wordt aangegeven hoe dit gebeurt en hoe het model wordt 'gesloten', d.w.z. wordt verbonden met enerzijds de rest van de wereld en anderzijds de rest van de EU-economie. Uitgebreid wordt ingegaan op de modellering van het GLB en op de kosten van publieke middelen.

In hoofdstuk 12 worden drie beleidsscenario's besproken, doorgerekend en geanalyseerd. Het zijn achtereenvolgens het MacSharry scenario, het Agenda 2000 scenario en het WTO liberalisatie-scenario. Alle drie blijken ze aan het compensatiecriterium te voldoen. Dat houdt in dat de baten voor de 'winnaars' groter zijn dan de kosten voor de 'verliezers' en de laatste dus in principe schadeloos kunnen worden gesteld. In principe is daar zelfs geen compensatie van buiten de EU voor nodig.

De efficiency of *excess burden* effekten zijn wanneer gerelateerd aan de totale bestedingen door consumenten of aan het nationaal inkomen niet zo groot (in de orde van 0.5 tot 1.0%). Als geen rekening wordt gehouden met de kosten van publieke middelen nemen de berekende efficiency-voordelen significant toe, al blijven ze ook dan beperkt. Marktmacht van de voedingsmiddelenindustrie kan de verdeling van het *user surplus* over consument en industrie potentieel fors beïnvloeden, maar werd hier niet verder onderzocht.

Agenda 2000 blijkt tot een forse reduktie van de steun, zoals gemeten in de *aggregate measure of support* of *AMS*-maatstaf. Toch is het niet voldoende om het hypothetische WTO compromis van het WTO liberalisatie-scenario te halen. Zou de uitstel van aanpassingen bij zuivel niet zijn doorgevoerd dan komt Agenda 2000 dicht in de buurt van het WTO liberalisatie scenario.

Uit dit onderzoek kunnen een aantal 'lessen' en conclusies worden getrokken (zie Hoofdstuk 12 voor details). Uit de analyse van de welvaartsmeting (Hoofdstukken 3 en 4) blijkt, dat zelfs wanneer het gedrag van economische actoren (consumenten en producenten) slechts onvolledig kan worden gemodelleerd, de afgeleide welvaartsmaatstaven toch een zinvolle betekenis hebben. Dit komt omdat er een interpretatie in termen van bovengrens of ondergrens aan kan worden gegeven. 'Single market' algemene evenwichtsanalyse geeft weliswaar extra inzicht in de rol van spill-over effekten, maar is slechts beperkt toepasbaar als het er om gaat inzicht in de verdelingseffekten van beleidsveranderingen te krijgen. Bovendien is het moeilijk om GE-vraag- en aanbod curven op een betrouwbare manier econometrisch the schatten. In deze studie is een multiple market partieel evenwichts-benadering gekozen. Zoals onze simulatieresultaten hebben bevestigd, is het belangrijk om de sociale kosten van publieke middelen in zo'n model op te nemen. Als dat niet wordt gedaan worden de netto baten van al de geanalyseerde hervormingsscenario's overschat.

Een ander resultaat van het empirische werk (Hoofdstukken 6 tot en met 10) is dat de verkregen elasticiteiten het *farm problem*-model van Hoofdstuk 2 ondersteunen. Dit betekent dat, tenzij de doelstellingen van de beleidsmakers drastisch veranderen, nadrukkelijke overheidsbemoeienis met de landbouw nodig blijft. Ook beleidsanalyse blijft daarom nodig. Een volgend resultaat is dat de consumentenbaten voortvloeiend uit de MacSharry hervorming ergens in de range van 0.25-0.75% van het beschikbare inkomen liggen. Hoewel deze baten nu al relatief gering zijn, zullen ze verder afnemen als er rekening wordt gehouden met marktimperfectie in de voedingsindustrie. Hoewel analyse van marktimperfecties in de aan de landbouw toeleverende en de verwerkende industrie niet het doel van deze studie was, is verder onderzoek op dit terrein aan te bevelen. Marktimperfectie kan de verdelingseffekten van kosten en baten sterk beinvloeden.

De substitueerbaarheid van mengvoedergrondstoffen, in het bijzonder met betrekking tot de granen is een belangrijk beleids-issue. Uit onze analyse blijkt dat de hervormingen van het landbouwbeleid tot een significante toename van de binnenlandse graanconsumptie leiden, waarbij zelfs het gewaardeerde sojaschroot wordt verdrongen. De schattingsmethodiek die in deze studie met betrekking tot de mengvoedersector is gevolgd (het combineren van tijdreeks gegevens met pseudodata afkomstig van *least cost* programmeringsmodellen die ook door de mengvoederindustrie zelf worden gebruikt) draagt er aan bij dat de substitutiemogelijkheden goed in kaart worden gebracht. Studies die alleen met tijdreeks gegevens werken onderschatten over het algemeen de mate waarin granen andere grondstoffen kunnen verdringen.

Doorgaand op de gevolgde schattingsmethodiek, is gebleken dat het gemengd schatten een heel nuttige methodiek is voor situaties waarin de beschikbare tijdreeksen vaak relatief kort zijn, maar waar er wel tegelijkertijd allerlei andere vormen van informatie beschikbaar zijn (afkomstig uit eerder economisch onderzoek, agronomische gegevens, fysieke balansbeperkingen, enzv.). Het gemengd schatten maakt het mogelijk hier rekening mee te houden.

Alle drie geanalyseerde hervormingsscenario's voldoen aan het compensatie-criterium, zelfs wanneer rekening wordt gehouden met de sociale kosten van publieke middelen. Ook als rekening met *second-best* overwegingen wordt gehouden is er dus nog steeds spraken van positieve netto baten. Wanneer het Agenda 2000 scenario en het WTO liberalisatie scenario met elkaar worden vergeleken is er sprake van een negatieve additionele excess burden van het laatste scenario ten opzichte van het eerste. Dat betekent dat bezien vanuit de optiek van het compensatiecriterium (en ten opzichte van de initiële situatie) Agenda 2000 de voorkeur verdient boven het WTO liberalisatie scenario. Als de stap naar Agenda 2000 eenmaal is gezet, zou de EU ongeveer 968 miljoen Ecu compensatie van 'buiten' nodig hebben om op hetzelfde nutsniveau te blijven. Waar bij de macSharry hervorming de akker-bouwsector de grootste 'verliezer' was, zal bij Agenda 2000 de (melk)veehouderij de grootste klappen krijgen. Een nieuw WTO akkoord zal naar verwachting eveneens de zuivel raken. De overheidsuitgaven voor het markt- en prijsbeleid, die onder de MacSharry hervorming nog stegen, zijn in de beide andere scenario's min of meer onder controle (berekend voor EU-12).

Curriculum vitae

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