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Modelling the European Sugar Sector

- Incentives to Supply Sugar Beets and Analysis of Reform Options -

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Marcel Adenäuer
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Referent: Prof. Dr. T. Heckelei

Korreferent: Prof. Dr. E. Berg

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Abstract

Modelling the European Sugar Sector
– Incentives to Supply Sugar Beets and Analysis of Reform Options –

Marcel Adenäuer

The Common Market Organisation for sugar of the European Union has withstood major reform of any kind over the last three decades while other agricultural markets have been subject to far reaching reforms. Today, this 'invulnerability' is over. Reform pressure occurs from many sides. The sugar using industry objects to having to pay prices that lie three times above world market levels for European sugar, and recent global developments have made a reform of the European sugar market inevitable. (1) The *Everything but Arms* concession granting the Least Developed Countries a quota and duty-free access for all goods but arms into the EU including sugar as of 2009 makes a high-level of sugar imports from these countries likely. (2) Brazil, Australia and Thailand filed complaints against the European Union, arguing that C-sugar exports and re-exports of imported sugar have to be considered subsidised exports so that the current quantity limit of 1.3 million tons of subsidised exports is overshot by about 3 million tons. Since the EU lost the following WTO panel, sugar exports are to be reduced considerably in future. Consequently, European sugar production must also be significantly reduced.

This study analyses the impacts that a reform of the European sugar sector may have on European farmers. Since such an analysis is only possible if the observed supply behaviour in the past can be explained, this aspect is analysed first. Particular emphasis is given to the question, why European farmers supply sugar quantities considerably beyond their quota endowments for which only world market prices are paid. A number of behavioural hypotheses are introduced and evaluated using data from national statistics, farm data and own estimates of marginal production costs and of single farm quotas. The results from this analysis are then used to modify the agricultural sector model CAPRI with which possible reform options are evaluated. These adjustments help to analyse the supply response of European farmers to changes in the political environment of the sugar sector compared to other model approaches.

Keywords: *reform CMO Sugar, CAP, C-sugar, agricultural modelling, CAPRI, Everything but Arms, WTO panel, sugar beet supply response*

Kurzfassung

Modellierung des europäischen Zuckersektors:

- Anreize für die Produktion von Zuckerrüben und Analyse von Reformoptionen –

Die Gemeinsame Marktordnung für Zucker (ZMO) ist seit 1968 Bestandteil der Gemeinsamen Agrarpolitik (GAP) und enthält fast alle bekannten Marktregulierungsinstrumente: Produktionsquoten, Garantiepreise, Intervention, Exportsubventionen (teilweise finanziert über Produktionsabgaben), Importzölle, die praktisch prohibitiv wirken, sowie Präferenzabkommen mit einigen Staaten über den zollfreien oder zollermäßigten Import von Zucker. Obwohl andere Sektoren der Landwirtschaft in den letzten Jahren weit reichend reformiert worden sind, ist die ZMO bis heute unberührt geblieben. Diese „Unantastbarkeit" scheint nun ein Ende gefunden zu haben, denn eine Reihe globaler Entwicklungen bedrohen diese Marktordnung in ihrer Funktionalität:

- Das „*Everything but Arms*"-Abkommen (EBA) erlaubt seit 2001 49 Entwicklungsländern den zoll- und quotenfreien Export aller Produkte außer Waffen in die EU. Von dieser Regelung sind bisher nur Zucker und frische Bananen ausgenommen worden. Diese werden aber nach einer Übergangsregelung im Jahre 2009 vollständig miteinbezogen, so dass zusätzliche Zuckerimporte aus den begünstigten Ländern sehr wahrscheinlich sind und Teile der heimischen Zuckererzeugung verdrängen werden.
- Im April 2005 hat das WTO-Berufungsgremium („Panel") anlässlich einer Beschwerde, die von Australien, Brasilien und Thailand gemeinsam gegen bestimmte Aspekte der EU-Zuckerregelung erhoben wurde, entschieden, dass die EU deutlich mehr subventionierten Zucker exportiert, als es gemäß WTO-Abkommen erlaubt ist.
- Ein wesentliches Instrument der letzten GAP-Reform von 2003 ist die Umstellung von aktivitätsbezogenen Ausgleichzahlungen auf ein System von entkoppelten Prämien. Diese Regelung hat generell zur Folge, dass Anbauaktivitäten, für die bisher keine Ausgleichzahlungen gewährt worden sind, gegenüber den zuvor auch schon prämienberechtigten Anbauaktivitäten, an Wettbewerbsfähigkeit gewinnen. Da der Zuckerrübenanbau zur ersten Gruppe gehört, ist es wahrscheinlich, dass dieser zukünftig ausgedehnt wird, was erhöhte Exporte von C-Zucker zur Folge hätte.

Aus diesen Gründen kann eine Reform der ZMO nicht verhindert werden und die Analyse der Auswirkungen möglicher Reformszenarien auf die europäische Landwirtschaft, wie sie die vorliegende Arbeit leistet, gewinnt zurzeit stark an Bedeutung. Da eine solche Analyse nur in Kenntnis der Produktionsanreize für den Zuckerrübenanbau möglich ist, werden diese zunächst analysiert. Die C-Rübenproduktion erhält in diesem Zusammenhang eine zentrale Bedeutung, denn in Europa werden jährlich über drei Millionen Tonnen C-Zucker produziert, obwohl einige Analysen zeigen, dass die Erlöse aus der C-Rübenproduktion die von ihr verursachten Kosten nicht decken können. Daher können die beobachteten Zuckerrübenproduktionsmengen nicht mit der Gewinnmaximierungshypothese erklärt werden. In der vorliegenden Arbeit werden alternative Verhaltenshypothesen aufgestellt und anhand von INLB-Daten überprüft. Die daraus gewonnenen Erkenntnisse werden im Anschluss dafür verwendet, das Agrarsektormodell CAPRI so zu modifizieren, dass eine Politikwirkungsanalyse von Reformoptionen der ZMO möglich wird. Die detaillierte Abbildung des Zuckerrübensektors im CAPRI-Modell und die Analyse möglicher Bestimmungsgründe für den Zuckerrübenanbau bilden einen beträchtlichen Forschungsbeitrag zu den zurzeit vorhandenen Ansätzen zur Analyse des Zuckerrübenanbaus.

Schlüsselworte: *ZMO-Reform, GAP, C-Zucker, Agrarsektor-Modellierung, CAPRI, Everything but Arms, WTO-panel, Zuckerrüben-Angebotsreaktion*

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List of Acronyms

ACP countries	African, Caribbean and Pacific (ACP) countries
AT	Austria
BL	Belgium and Luxemburg
CAP	Common Agricultural Policy
CAPRI	Common Agricultural Policy Regional Impact Analysis
CEC	Commission of the European Communities
CES	Constant Elasticity of Substitution
CMO	Common Market Organisation
CoCo	Complete and Consistent database at national level
DE	Germany
DK	Denmark
EAA	Economic Accounts for Agriculture
EBA	Everything But Arms
EL	Greece
ES	Spain
EU	European Union
EU-15	Members of the EU since 1995 and before 2004
EU-10	New EU Member States
EC	European Community
FADN	Farm Accountancy Data Network
FEOGA	Le Fonds européen d'orientation et de garantie agricole (European fund for agricultural guarantee and orientation)
FI	Finland
FR	France
GAMS	General Algebraic Modelling System (software)
GVA	Gross Value Added
ha	hectare
IR	Ireland
IT	Italy
LDCs	Least Developed Countries
M	Million
MFN	Most Favoured Nations

MTR	Mid Term Review
MS	(EU-15) Member State
NL	The Netherlands
NUTS	Nomenclature des unités territoriales statistiques (Common classification of territorial units for statistics)
pdf	probability density function
cdf	cumulated pdf
PMP	Positive Mathematical Programming
PT	Portugal
SE	Sweden
t	tons
TRQ	Tariff Rate Quota
UK	United Kingdom
VaR	Value at Risk
WTO	World Trade Organisation

1. Introduction

1.1 Motivation

The Common Market Organisation for sugar (CMO Sugar) is part of the European Common Agricultural Policy (CAP). It protects European sugar production almost perfectly against any sugar exporter in the world. Only a few bilateral agreements with the African, Caribbean and Pacific (ACP) countries as well as with India and Brazil allowed for sugar imports into the European Union in the past. European sugar supply is regulated by a quota system with high guaranteed prices. Only sugar produced within these quotas can be sold on domestic markets, while sugar produced beyond them, so-called C-sugar, has to be sold on world markets at prevailing prices. Export subsidies allow for exports of quota sugar and re-exports of preferential imports. All these regulations turn the European sugar sector into one of the most heavily protected sectors of the CAP and in the world.

Most other sectors included in the CAP were subject to far reaching reforms in the last decades. The reform in 1992, known as the McSharry reform, was a milestone in this respect because it introduced direct farm payments, coupled to activity levels of production, and phased out the former predominant system of high guaranteed producer prices that had led to tremendous surpluses on European markets for agricultural products. This in turn induced high expenditures of the European fund for agricultural guarantee and orientation (FEOGA). In 1999 the so-called Agenda 2000 reform continued this reform process, by further decreasing support of the agricultural sector. The most recent reform took place in 2003 and was a result of the Mid-Term Review (MTR) of the Agenda 2000. Former subsidies that were coupled to activity levels were now transformed into decoupled payments.

Up to now, the CMO Sugar, however, has not been at all affected by these reforms for the following reasons: The main driving forces behind the CAP reforms were (1) to reduce expenditures of the European budget on agriculture and (2) to reflect the guidelines of the various WTO rounds. As the CMO Sugar did not cause high FEOGA expenditures[1] or conflict with WTO agreements, these two issues have so far not had an impact on the CMO Sugar.

[1] Only subsidised re-export of preferential sugar imports are currently financed by the FEOGA budget.

In fact, the costs for the CMO Sugar are borne by sugar producers who finance subsidised exports, sugar consumers who have to pay a price for sugar three times higher than on world market and finally, sugar exporting countries who suffer from lower market access. In the past, the lobby of sugar consumers was not as powerful as that of sugar producers, so that pressure from the consumer side had hardly any effect.

Pressure from the WTO did not rise in the past until Brazil, Australia and Thailand filed complaints against the European Union, arguing that C-sugar[2] exports as well as re-exports of imported sugar under preferential agreements have to be counted as subsidised exports and that the quantity limit of 1.3 million tons of subsidised exports is overshot by about 3 million tons. The WTO ruled this panel against the EU in May 2005 which threatens the basic principles of CMO Sugar. The lost WTO panel, however, is a very recent development while the European Commission has been considering a reform of the CMO Sugar for several years. The need to reform the CMO Sugar originated in the 'Everything but Arms' (EBA) agreement (Council Regulation (EC) No 416/2001 of 28 February 2001), which grants duty-free access to imports of all products, except arms and munitions, from least developed countries (LDCs) without any quantitative restrictions.[3] Sugar imports from the beneficiary countries into the European Union are therefore likely and threaten the functionality of the CMO Sugar.

Any proposal to reform agricultural policy triggers a demand for an economic impact analysis. HENRICHSMEYER et al. (2003) compiled a '*Study to assess the impact of future options for the future reform of the sugar common market organisation*' which was commissioned by the Directorate-General for Agriculture (DG Agri) of the EU Commission. It provides quantitative analyses on the impacts of several options for the future reform of the CMO Sugar. The results of these analyses were meant to strengthen the analytical basis for the preparation of the EU Commission proposal for the further reform of CMO Sugar. The author of this dissertation is co-author of that study which served as a first motivation to analyse the CMO Sugar. The study relies on impact analyses carried out with economic models that are able to analyse agricultural markets. Generally the parameters that control these models are derived from observed behaviour in the past. In the sugar or sugar beet sector, this derivation is not straightforward since there was hardly any change in the incentives that may influence the production quantities. Neither sugar quotas nor the prices for quota sugar show any variance in the past that would allow for econometric analysis. The

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[2] The surplus of sugar over production quotas is called C-sugar.

specification of these models with respect to a plausible supply response was therefore a major issue of the quoted study as well for this dissertation.

Recent literature addresses the CMO Sugar and impacts of its reform. The author of this dissertation has contributed to the discussion of these issues in the above-mentioned study and other papers (ADENÄUEr et al. 2004; ADENÄUER, HECKELEI 2005; ADENÄUER 2005). Some parts of this dissertation are summarised in these papers. Other more recent studies on the topic of C-sugar (WITZKE, KUHN 2004; MENSBRUGGE et al. 2003; FRANDSEN et al. 2003; CERNAT et al. 2003) are available as well. The results show large differences in the results – mainly with respect to the supply response of European sugar production to changes in sugar quotas or prices. These discrepancies can partly be explained by differences in model approaches or analysed scenarios, but they also result from different assumptions on the supply behaviour of European farmers.

In view of this background information, the following research questions are analysed in this study:

- What are the determinants influencing European farmers in their decision to cultivate sugar beets?
- Why is there so much C-sugar in Europe although production costs are said to be higher than world market prices for sugar?
- What are the marginal production costs in the sugar beet supplying regions of the EU?
- How can the findings of the previous research questions be implemented in an agricultural sector model?
- What are the likely effects of proposed reform options on the CMO Sugar?

1.2 Methodological Approach and Technical Implementation

Regarding the research questions, this study is divided into two major parts: the analysis of incentives to supply sugar beets in Europe, and the empirical analysis of selected reform options of the CMO Sugar. In order to analyse the first issue, we need to define several behavioural hypotheses that go beyond the classic profit maximisation assumption. These hypotheses are, whenever possible, assessed with respect to observed data (at farm and national level) and their contribution potential to the explanation of observed supply

[3] This agreement has been in place since 2001, but a transition period ending in 2009 was negotiated for sugar.

behaviour. In the second part, we use the results of the previous analysis to modify the agricultural sector model CAPRI[4] (**C**ommon **A**gricultural **P**olicy **R**egional **I**mpact Analysis) such that a comprehensive modelling of the European sugar market is achieved. With this version of CAPRI, we analyse selected reform options of the CMO Sugar. The technical solution of CAPRI is based in the programming language GAMS[5] (General Algebraic Modeling System). Most other calculations or estimations used in this study are carried out with GAMS as well. For the presentation of results, we make use of a graphic utility called GNUPLOT and Microsoft Excel as well.

1.3 Structure of the Study

First, an introduction to the European sugar market and the CMO Sugar is given in the next section in order to provide the reader with basic principles and figures that are essential to understand the rest of the study. We further analyse sugar beet production in the **F**arm **A**ccountancy **D**ata **N**etwork (FADN) in order to better understand the distribution of key indicators among farms within the EU.

In section 3, we provide a framework that allows the estimation of single farm quotas. This data is missing in the FADN sample. Next, we apply a method to define marginal costs of sugar beet production at farm level which was developed by VIERLING (1996) and also applied by HENRICHSMEYER et al. (2003) in a slightly modified way and show finally, that the observed sugar supply in Europe is unlikely to be the result of profit maximising farmers.

The examination of the FADN sample is followed by an analysis of incentives to supply sugar beets in Europe in section 1. In particular, we examine why there were huge amounts of C-sugar in a number of European countries in the past, although farm management specialists agree that sugar in those countries can hardly be produced at world market prices. The findings of this section are then used to modify the agricultural sector model CAPRI such that an analysis of reform options of the CMO Sugar results in a plausible supply response. In the same section, a small sensitivity analysis of the CAPRI model with respect to model parameters is given. Section 5 provides an analysis of selected reform options of European

[4] Further information can be found on the web page: www.agp.uni-bonn.de/agpo/rsrch/capri/capri_e.htm.

[5] Details on: www.gams.com.

sugar markets and a comparison of its results to other studies. The final section provides a summary of the whole analysis, shows the limitations of the study, and identifies fields for further research.

2. Specialities of the Sugar Sector

2.1 EU Commission's Introduction to Sugar

'*Sugar is not a staple food, yet it has seized the imagination of politicians and people around the world. It caused a sensation when European explorers first brought it home from their overseas adventures during the early modern era. It then counted heavily in many governments' foreign policies during the age of empire – until Europeans went to great lengths to start producing it at home at the end of the nineteenth century, initially in northern France. Sugar beet growing was introduced in order to break dependence on sugar cane from the colonies, the sole source of sugar at the time, which made it a rare and precious commodity. The crop gradually spread throughout Europe. From the 1920s on, with the development of maritime transport, sugar beet production faced competition from cane sugar and has survived largely as the result of tariff protection.*

Sugar (the proper term is sucrose, which breaks down into two components - glucose and fructose), is the most plentiful and economic sweetener. Sucrose can be found in many natural foods (e.g. fruits and vegetables) but can only be extracted economically from sugar beet and sugar cane. Sucrose is an important source of energy.

Sugar is often thought of as a single product – a granulated foodstuff to sweeten tea and coffee. Of course, most people realise that sugar is present in many other foods, in many different forms. But many overlook just how diverse the uses of sugar can be. Furthermore, there are other sweeteners in everyday use in our lives, and not just in foods. […]'

The European Commission provides this introduction to sugar on their web site[6] and makes the following points: (1) The European sugar production competes with cane sugar from oversees. The production process of cane sugar is clearly cheaper than that of sugar beets and this is not only due to lower wages and social standards in cane sugar producing countries. Therefore, *European sugar production survived largely as a result of tariff protection*. (2) Sugar is chemically identical regardless of whether it is processed from beet or

[6] http://europa.eu.int/comm/agriculture/capreform/sugar/infopack_en.pdf: *The European Sugar Sector – Its importance and its future.*

cane. *Cane- and beet sugar are therefore fully substitutable*. (3) The direct consumption of sugar plays only a minor role in the pattern of uses. *The biggest part of sugar consumption takes place in terms of other foods*.

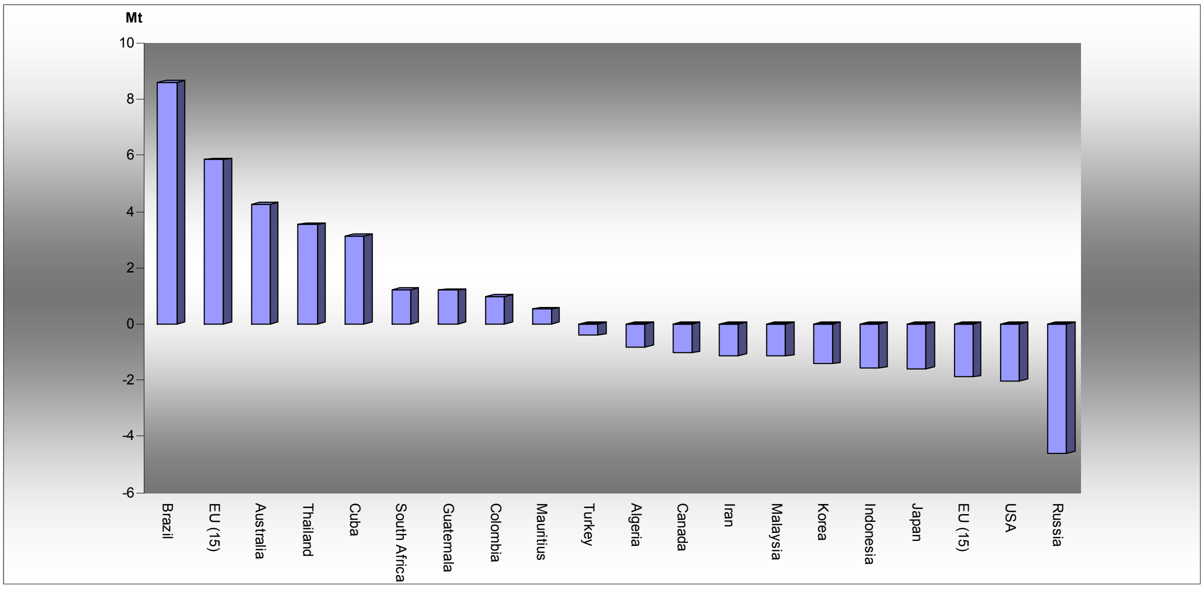
Those three points are some major characteristics of sugar supply and consumption in Europe. Especially the fact that European sugar production mainly survived through protection against cheaper sugar imports from other countries should be kept in mind when we give an overview on some global players on the world sugar market in the next section. After that, we summarise the main instruments of the CMO Sugar in the section 2.3. Next, some sugar statistics are presented to show the characteristics of European sugar supply. We make use of national, regional and even farm statistics in order to shed light on the importance of sugar beet production in Europe.

2.2 Global Payers on International Sugar Markets

The European Union has developed from a net sugar importer to the second largest sugar exporter on the world market. Figure 2.1 shows the sugar exports of the ten biggest exporters and the imports of the ten largest importers. More than 80 % of the world sugar exports are carried out by only ten of the most important sugar exporting countries (Brazil, EU, Australia, Thailand, Cuba, South Africa, etc.), whereas demand derives from many small importing countries. Brazil is by far the largest sugar exporter. As low cost producers, they benefit from favourable natural conditions that allow for a long processing campaign of up to nine months. Temperature, rainfall and land relief allows cane mechanisation and irrigation, if necessary. Favourable economic conditions such as low factor costs (especially wages), low social and environmental standards, subsidies for ethanol production facilities and ethanol use are responsible for the international competitiveness of the Brazilian sugar industry.

Australia, the third biggest sugar exporter, achieves its competitiveness through the extremely high productivity of farmers and processing industry. In contrast, the sugar industry in Thailand is characterised by a rather low labour and land productivity with very low factor prices and social and environmental standards. In this group of sugar exporters, South Africa is faced with the worst natural conditions (low temperature, distribution of rainfall, land relief) which often do not allow cane mechanisation and irrigation. But the low wage level as well as an extremely long processing campaign helps to reduce the natural disadvantages and to maintain competitiveness to a certain extent.

Figure 2.1: World sugar trade (raw sugar equivalent), average values 1997-2000



Source FAOSTAT

The Russian Federation is one of the greatest sugar importers of the world. Here, the high domestic demand of sugar cannot be satisfied with domestic production due to production and processing technologies. In the United States, there are only small areas with natural and economically favourable conditions for sugar production. Whereas beet sugar production in California has to fight with droughts and highly competitive alternative crops, sugar cane production in Louisiana suffers from land drainage demand and low temperatures. Despite very low factor prices and environmental and social standards, the Indian sugar industry is characterised by structural and productivity deficits. Additionally, the sugar industry suffers from extended political regulations restricting structural improvements and increasing production costs through rather high minimum prices for cane as well as maximum prices for a certain sugar volume (compare HENRICHSMEYER et al. 2003).

While the examination of total imports and total exports provides an overview of the importance of a few global players on the world market, it does not reveal much about the importance of imports and exports for individual countries. A small country that satisfies its domestic sugar demand completely with imports is probably more affected by changes in the world market price of sugar than a big country that imports a large amount of sugar in absolute terms but where imports only make up a small part of the total domestic demand.

The group of Least Developed Countries plays only a minor role on world sugar markets in terms of imports and exports. Sugar production amounted to about four million tons, exports to about million tons and imports to circa two and a half million tons of raw sugar equivalent in 1997/1999 (FAOSTAT). The situation is similar for the ACP group of states. Their production amounts to about four million tons, the exports sum up to about two million tons and they import circa 500 thousand tons. Nonetheless, these two country groups play a major role in the European CMO Sugar today and will do so in future. As mentioned before, the ACP countries benefit today from preferential access to the European sugar market and the LDCs will obtain quota and duty-free access to the European markets for almost all products including sugar in course of the EBA agreement. This increases the pressure on the CMO Sugar as the equilibrium described in Figure 2.3 will be disturbed. A thorough analysis of the EBA agreement is a major part of the analysis of reform options in chapter 5, so we will come back to this point later on.

The only country that is found on both sides of Figure 2.1 is the EU which is a result of the distorting effects of the CMO Sugar. Under free trade conditions, it would not be possible to be a major sugar exporter and a major sugar importer at the same time. To understand those distorting effects, we provide an overview on the CMO Sugar in the next section.

2.3 The EU Common Market Organisation (CMO) for Sugar

The CMO Sugar is a part of the Common Agricultural Policy that was established by the treaty of Rome in 1957. The Sugar sector was added in 1967 and since then, the policy instruments have remained almost unchanged. The elements of the CMO Sugar are well documented in other places (LINDE et al. 2000, BLUME et al. 2002) and the legal text can be found in COMMISSION OF THE EUROPEAN COMMUNITIES (CEC) (2004a). Therefore, we will only examine the main instruments in order to provide the reader an overview of the CMO Sugar.

Each year by the first of August, an intervention price for white sugar is fixed by the EU Council of Ministers of Agriculture., This is a minimum price at which the EU is obliged to buy quota sugar, if the EU sugar market price falls below this level. In fact, intervention was only rarely necessary , since EU market prices stayed well above 105% of the intervention price in the past[7] (LINDE et al. 2000, p 9). Since 1993, the intervention price has stayed constant at 631.9 €/t white sugar. Since intervention only seems to be a theoretical instrument

[7] BLUME et al. (2002) explain the fact of the high market prices in the different Member States as well as price differences between them with imperfect competition and tacit collusion. The most important aspect of tacit collusion is that firms can succeed in charging a price that far exceeds marginal cost, as long as the other firms do the same.

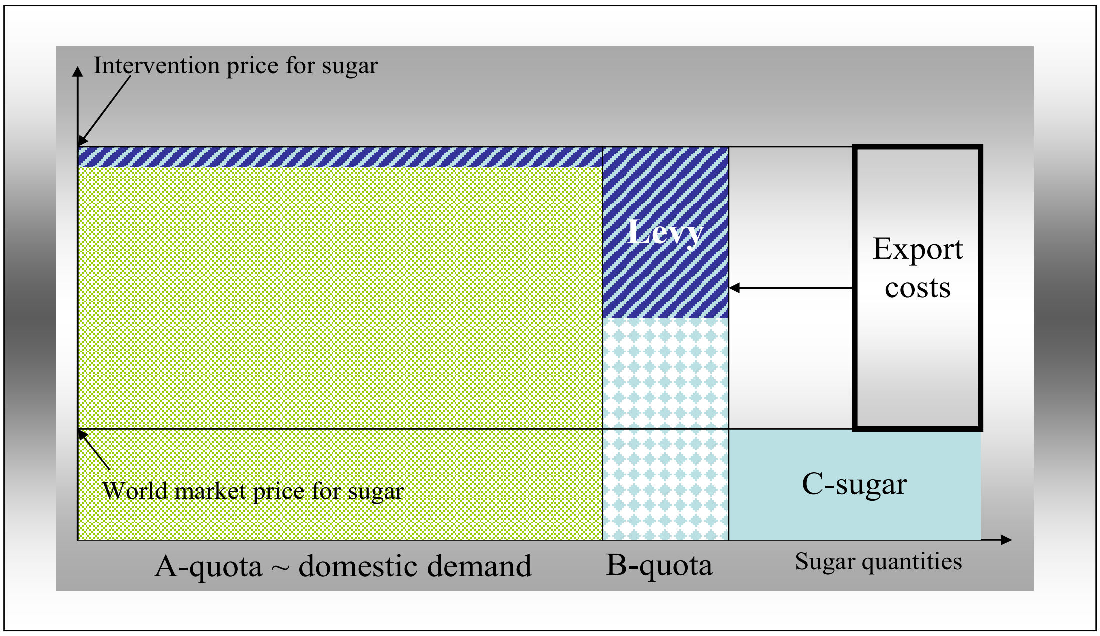
of the CMO Sugar, the main use of the intervention price is to derive a minimum, base price for sugar beets. This is done in the following way:

[	Intervention price	631.9	€/t white sugar
-	Processing costs	243.6	€/t white sugar
+	Value of by-products	22.5	€/t white sugar
-	Transport costs of beets	44.1	€/t white sugar]
*	13% sugar per ton of beets		
=	basic sugar beet price	47.67	€/t sugar beets

This basic sugar beet price is used to derive a minimum beet price which sugar processors must pay to the farmer for sugar beets produced within the production quotas. The calculation of minimum beet prices is explained below but first, the quota-levy mechanism needs to be explained.

The quota-system in the sugar sector distinguishes between A- and B-quotas. The farmer is also allowed to produce above these quotas but does not receive any price support in this case (so-called C-sugar). It is often said that the CMO Sugar is budget-neutral and self-financing. This is due to the levy mechanism. In other words, the sugar processing firms must finance the exports of quota sugar as shown in Figure 2.2.

Figure 2.2: The quota-levy mechanism



Source: Author's calculations

The A-quotas allocated to each EU Member State were originally intended to meet the domestic demand in each country. Since human consumption has risen since the days the

CMO Sugar was established, about a third of B-sugar is sold on the EU market today. Therefore, the part of the domestic sugar production that has to be exported with subsidies is about 2/3 of the B-quota. The necessary funds are provided by collecting a basic levy of 2 % of the intervention price for both A- and B-quotas and a variable levy on B-quota sugar with a maximum of 37.5% of the intervention price from the processing firms. The sum of both levies must equal the export costs of quota exports. Those are calculated as the difference between the real domestic demand and the total quota production multiplied by the differences between the intervention price and the world market price for sugar. If the levies are not sufficient to cover the export costs, additional levies are collected on both types of quota sugar. In Figure 2.2 we assume for the sake of simplicity that the A-quota corresponds to the domestic demand and it shows how total levies are calculated.

The total levies calculated at EU level are distributed among Member States according to their quota sugar production. Those are then collected by national paying agencies from the sugar processors. But sugar processors only bear 42% of those levies. The rest is passed on the sugar beet farmers by reducing the prices for A- and B-beets. The following example shall illustrate this mechanism.

Total quota sugar production	14.1	Mt
Domestic consumption	12.7	Mt
Difference	1.4	Mt
EU sugar price	720	€/t
Sugar world market price	215	€/t
Difference	505	€/t
Total export costs = 505€/t*1.4 Mt = total levies	707	M€
Total A-levy = 2% * intervention price * total A-sugar		
= 2% * 631.9 €/t * 11.7 Mt =	147	M€
Total B-levy[8] = 707 M€ - 147 M€ =	560	M€

Both levies are now expressed in €/t of produced quota beets and multiplied by 58% to obtain the part of the levies that is taken by the farmer

A levy = 147 M € / 90 Mt sugar beets * 58%	=	0.95	€/t of sugar beets
B levy = 560 M € / 18.5 Mt sugar beets * 58%	=	17.6	€/t of sugar beets
Minimum price A-beets = basic beet price – A-levy	=	46.62	€/t of beets
Minimum price B-beets = basic beet price – B-levy	=	30.07	€/t of beets

For several reasons, the effective prices paid to a farmer can differ considerably from the minimum beet prices. First of all, the effective price generally depends on the real sugar content of the delivered beets and not on an average as was used in the calculation of the basic beet price. Since the calculation of this price has not changed since the early days of the CMO Sugar, it is likely that the effective beet prices are higher today because sugar yields per ton of sugar beets have increased due to technical progress, on the one hand, and to losses during processing having been reduced, on the other hand. Additionally, effective beet prices are calculated on the market price for sugar which is well above the intervention price, leading to higher prices as well.

Some EU Member States do not distinguish between A- and B-quotas and pay a mixed price for both to the farmers. A survey carried out in HENRICHSMEYER et al. (2003a) have shown that only Germany, France, Austria, Portugal, Greece, Denmark, Finland and Sweden apply the classical two-quota system, while the others use a pooled price system. Since 1995/96 in some countries the CMO has fixed premiums on top of the intervention price in order to compensate for comparative disadvantages of sugar production in those countries. These regions are Ireland, Finland, Portugal, the United Kingdom, Italy and Spain (LINDE et al. 2000) – a further reason for higher beet prices. Price mark ups can also be received for a higher qualities, early delivery, etc. Transportation of sugar beet to the factory is further to be financed by the processing firms. Hence, farmers often take over this job and get compensated. Sugar processing firms and farmers sign contracts known as inter-trade agreements, in which beet delivery rights, purchase prices, delivery periods, transportation compensation and quality are laid out. Sugar quotas and beet delivery rights are not tradable, neither between farmers, nor between processing firms or EU Member States, which leaves space for efficiency gains as they are well known from micro theory.

Sugar beet producers have the further possibility of making C-sugar become a part of the next year's sugar quota. This so-called *carry forward mechanism* can help to smooth out the effects of good and bad harvests, but it has become less attractive since the storage costs have not been financed by the EU budget since 2000/2001. *Carry forward possibilities* are limited to 20% of the A- quota and were not fully used in the past years.

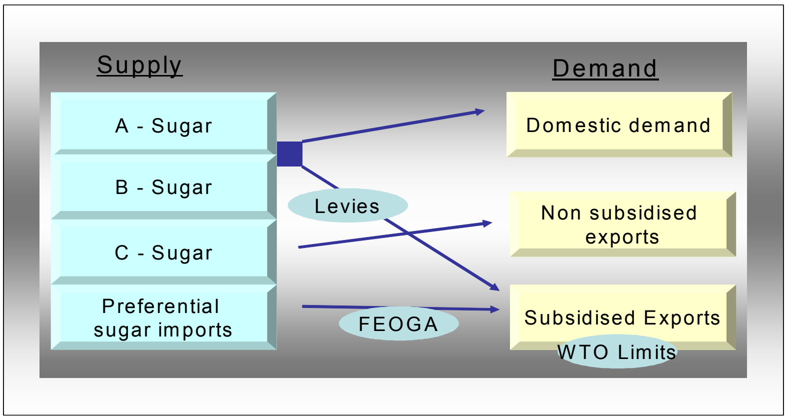
The EU sugar market is protected from the world market by a system of prohibitive import duties and export refunds. Imports can enter the EU only by preferential agreements because

[8] If the total B-levies exceed 37% of the intervention price multiplied by the B-sugar production, an additional levy is charged on both A- and B-sugar.

tariffs are so high that it is financially unattractive to export to the EU in spite of the fact that tariffs were reduced according to the agreements negotiated in the *Uruguay round*. The unattractiveness is even enhanced by a special safeguard clause that allows for additional duties if either the import quantities exceed or the price of the imported products falls below certain trigger thresholds. As a consequence, hardly any non-preferential sugar was imported in the past.

The EC was a net importer of sugar when the CMO was established. But it soon became a net exporter although this may seem surprising given that quotas didn't change. But the possibility to produce C-sugar and the fact that some B-quotas were not fully used in the first years of the CMO allowed for an extension of European sugar production. Today, the EU is the second largest exporter of sugar after Brazil and supplies about five million tons of raw sugar equivalent on the world market yearly. Those exports consist of three types of sugar: (1) Quota sugar exports that are subsidised by the levy mechanism. The total quantity depends on quotas and domestic demand. (2) Re-exports of preferential imports which are also eligible for subsidised exports but financed by the FEOGA budget and (3) C-sugar exports sold at world market prices without export refunds. C-sugar is not allowed to be exported with subsidies, because subsidised exports are limited by WTO commitments (about 1.4 Mt). Re-exports (additional 1.6 Mt) and C-sugar were not counted within that limit in the past. Figure 2.3 summarises the possible sugar supply and demand sources on the European sugar market.[9]

Figure 2.3: Origins and destinations of EU sugar



Source: Author's illustration

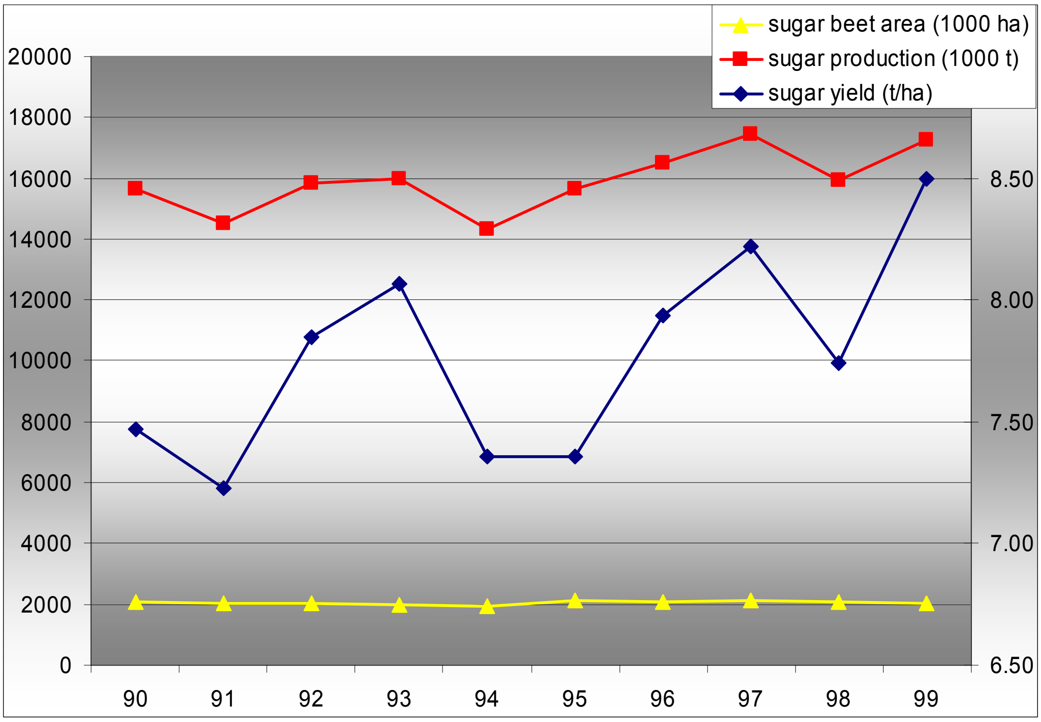
[9] We find the three different sugar types produced on the domestic market and preferential sugar imports on the supply side, while the demand consists of domestic demand, subsidised and non subsidised exports. Subsidised exports are limited by WTO commitments and partly financed by producer levies and the FEOGA budget.

2.4 Key Indicators of the European Sugar Market

This section will focus on key indicators of sugar supply demand and trade in the EU. In particular, attention will be given to the last decade (1990-1999).

Sugar quotas allocated to each EU Member State did not change during this time period. Consequently, it is likely that European sugar supply did not change much either apart from yield fluctuations. The only obvious kink in supply and sugar beet area is found in 1995 when Sweden, Finland and Austria joined the Community, as can be observed in Figure 2.4. Even the McSharry reform in 1992 did not seem to have influenced the sugar sector on the production side.

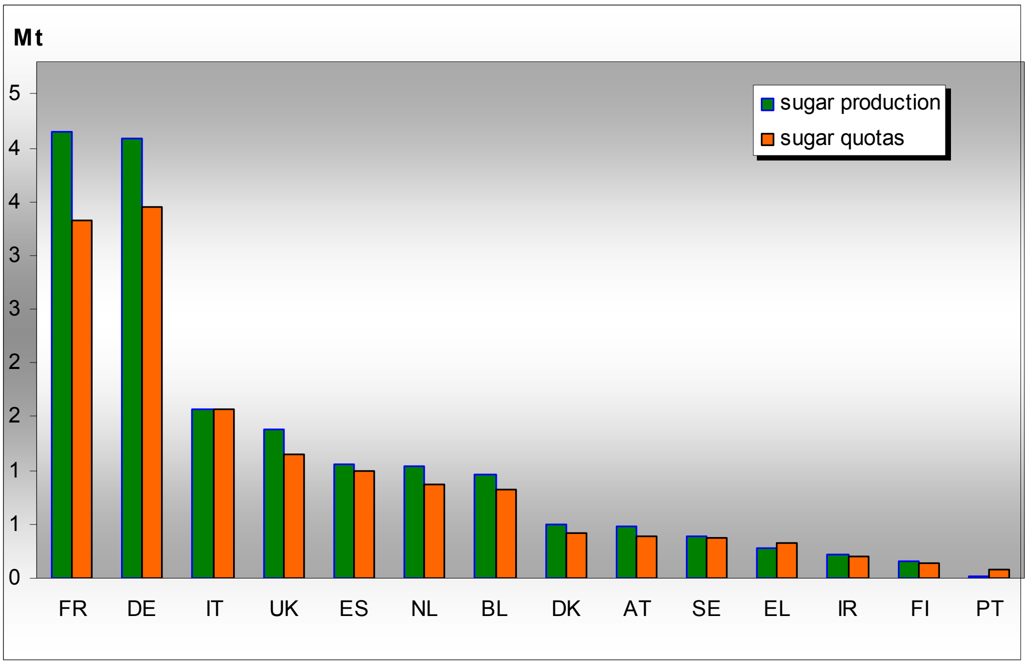
Figure 2.4: European sugar production, sugar beet area and sugar yield 1990-1999



Source: CAPRI data base

The average European sugar yield is clearly increasing due to technical progress. Reversely, the quota restriction leads to slightly decreasing sugar beet areas. All in all, it becomes apparent that the quota system prevents huge fluctuations in sugar supply and sugar beet allocation since farmers can almost perfectly plan their revenues from producing sugar beets – at least within the quota – because prices and delivery quantities are fixed in the inter-trade agreements mentioned in the previous section. However, farmers do not know what their revenues from producing C-sugar will be, as they depend on the “free” world market price for sugar. The farmers’ incentives for producing C-sugar are one of the major questions analysed in section 4. The average sugar production over the last decade and the quota endowment of each individual EU Member State are given in Figure 2.5.

Figure 2.5: Sugar quotas and average production (1990-1999) per EU Member State



Source: CAPRI data base

Three countries produce less sugar than their quotas allow. In Italy, sugar supply amounts to only 99.6% and in Greece to 88% of total quotas. In Portugal, the average production is only a very small fraction of total quotas. Portuguese statistics – especially for sugar – are very unreliable. We therefore eliminated Portugal from further analysis. By this, we do not lose significant information with respect to the European sugar sector since Portugal's sugar production amounts to less than 1% of total European sugar supply. The most important sugar producing countries (according to their share in total EU sugar supply) are France[10] and Germany who together account for about 50% of European sugar production. The importance of C-sugar in the European Union is apparent from the difference between sugar production and sugar quotas. France, the United Kingdom, Austria, Germany, Belgium, the Netherlands and Denmark produce on average more than 115% of their sugar quotas.

The importance of sugar beet production at regional level is apparent from Figure 2.6. The graphic on the left hand side shows the importance of a NUTS 2 region[11] for the European

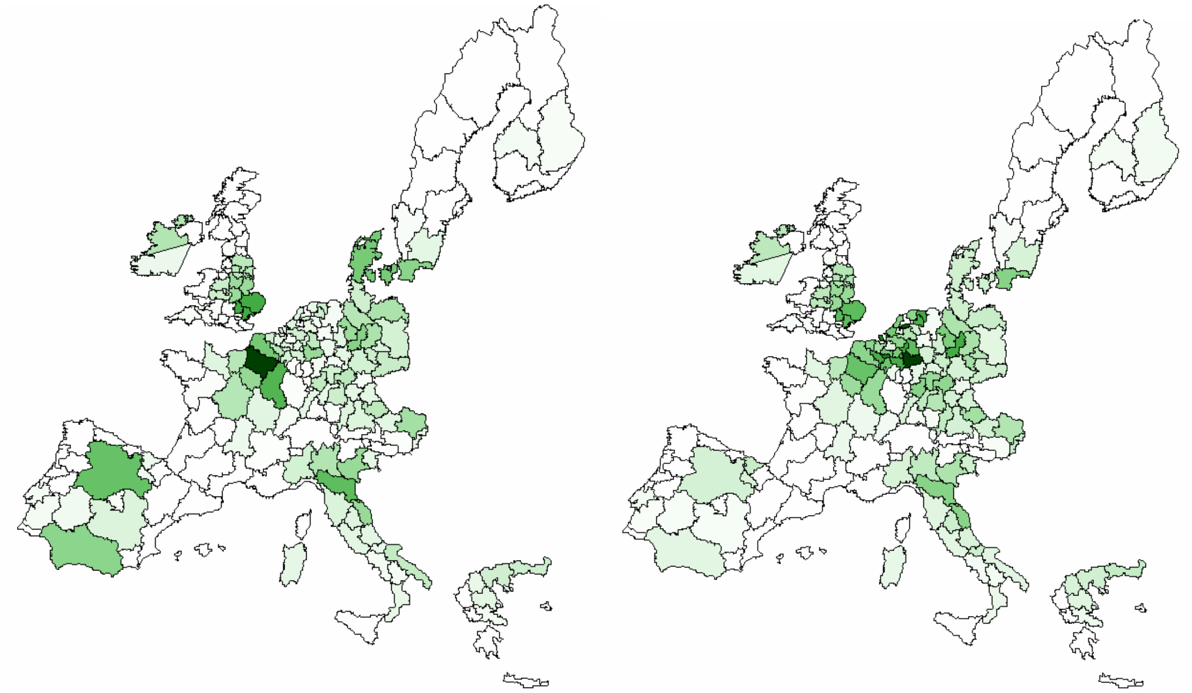
[10] French Overseas territories are not included.

[11] NUTS is the common classification of territorial units for statistical purposes of the European Union. More information is given on the website http://europa.eu.int/scadplus/leg/en/lvb/g24218.htm.

sugar supply. The darker a region is shaded, the larger the area allocated to sugar beets. We see that the *Picardie* in France is the biggest sugar beet supplier (162 000 ha). Graphic I is on the one hand a good indicator of the importance of a region for the European sugar supply, on the other hand, it makes no predication about the importance of sugar beets within a region since the total beet area depends on its geographical size. Therefore, graphic II presents the share of sugar beet acreage in percentage of total crop area, ranging from below 1% to 28%. The region *Koeln* in Germany has the largest share of sugar beet acreage. The average share in the EU is only about 5%.

Figure 2.6: Regional share of sugar beet acreage (I) and share of sugar beet acreage in total crop area (II) – three-year average 1997 - 1999 (in %)[12]

I II



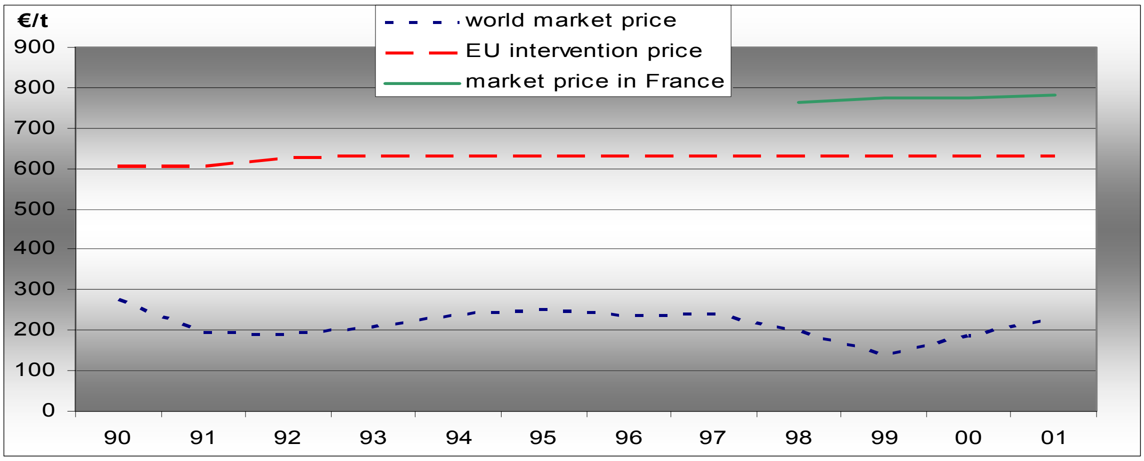
Source: CAPRI database

It has already been noted that the EU market price for sugar is well above the intervention price. In fact, it is not easy to obtain prices for raw sugar in the EU. It seems that no one has an interest in publishing the prices at which industrial users can buy raw sugar from the processing firms. Due to this lack of information about EU sugar market prices, the EU Commission decided to include a section in the 2004 reform proposal (CEC, 2004b) of the sugar sector that introduces a price reporting system. To our knowledge, the only reliable

[12] Some results in this study are presented in terms of maps similar as Figure 2.6. For a better orientation we present in the appendix starting on page 170 the names of the regions and their NUTS codes.

source is CAOBISCO[13], in LINDE et al. (2000) and BLUME et al. (2002). We tried to contact CAOBISCO in vain so that we can use the figures presented in BLUME et al. (2002) for the years 1998 – 2001 only. All prices presented there for the different EU Member States at different periods in a year lie clearly above the intervention price. The lowest price (698 €/t) is found in Greece (1998) and the highest (847 €/t) in the United Kingdom (2000). The differences between world market prices, intervention prices and EU prices for sugar are illustrated in Figure 2.7.

Figure 2.7: Sugar prices



Source: CAPRI database, CAOBISCO, LINDE et al. (2000). World market prices are FOB of the Paris Stock market

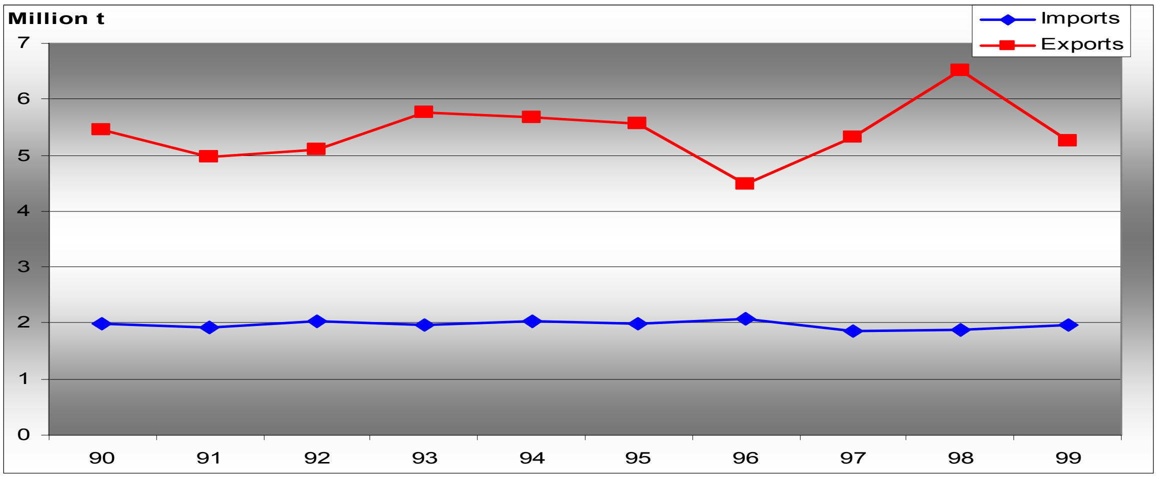
France was chosen as an example here since it is the most important sugar supplier in the EU and has, in turn, a great influence on the aggregated EU sugar price. Sugar trade in past years has been heavily influenced by the CMO Sugar as well. On the import side, it is determined by several preferential import agreements with the ACP countries, some Balkan states and India. Therefore, it is not surprising that sugar imports have stayed almost constant at a magnitude of about two million tons.

Sugar exports consist of re-exports of preferential imports, subsidised B-sugar exports and exports of C-sugar. The first two components do not vary much because they are fixed by the CMO, while the latter fluctuates with the yield variation in the EU and due to the decisions of sugar beet producers to cultivate C- beets. Consequently, the export curve follows the shape of the production curve in Figure 2.4. Given this small overview, the sugar sector is one of the most distorted in the EU. It uses almost every imaginable market intervention mechanism.

[13] CAOBISCO is the Association of Chocolate, Biscuit and Confectionery industries of the European Union.

Consequently, efficiency losses are more than likely as identified by MAHLER (1994), for example.

Figure 2.8: Sugar imports and exports of the EU-15 (raw sugar equivalent)



Source: FAOSTAT

One major goal of this study is to analyse the supply behaviour of European sugar beet farmers. Given that there has been hardly variance in aggregate sugar production, prices or quotas over the last decades, we cannot learn from observed supply response. Time series data on aggregated level is therefore useless for our purpose. Therefore we use the panel dataset from FADN to derive more information on European sugar beet production in the next section.

2.5 Sugar Beet Production in FADN

The FADN provides data on activity levels, production quantities, and revenues for a huge number of agricultural production activities. It further includes information on premiums, costs and farm structures. Unfortunately, it does not provide satisfactory information on farm sugar quotas or sugar beet delivery rights. Such data is only found for a number of farms in the Netherlands and Belgium. Additionally, variable costs are not allocated to single production activities. Both are essential variables for the analysis of sugar beet production. Sections 3.1 and 3.3 will provide estimation frameworks for both variables. But before we deal with missing data in the sample, we would like to give an overview of key indicators of sugar beet production in the FADN- database in the years 1990-1999[14] in order to shed light on the importance of sugar beet production for European farmers.

[14] FADN data was only available for these 10 years.

Our FADN dataset distinguishes 1001 main regions in the EU-15.[15] In about half of them (546) sugar beets are cultivated. In the observed period of ten years (1990-1999), in each year an average of about 56000 farms is included in the sample. Of these, only about 7000 (12%) produce sugar beets. This indicates that the sugar sector is only a small one compared to agriculture as a whole. Each farm has a certain weighting factor in order to ensure that the FADN sample represents sectoral statistics. Although sugar beet production seems to play a minor role for total agriculture, at farm level, it is extremely important for the farm income, if sugar beets are cultivated. In order to examine this further, it is useful to look at the share of sugar beets in the crop rotation and that of their revenues in total and in crop output given in Table 2.1. It is difficult to draw conclusions from the share of revenues in total revenues because costs are omitted. Unfortunately, farm costs are not allocated to production activities in FADN so that a comparison of income from different activities is not possible. Some plausibility thoughts on the correlation of profits and revenues will be given later on. For now, we can conclude that a share of 25% in total farm output and 33% in total crop output on EU average is quite high. In Table 2.1 μ is the average value over farms and years and σ its standard deviation. The Italian sample is by far the largest, followed by France and Spain. Surprisingly, in Belgium and the Netherlands we find the highest share of sugar beet farms in total farms, followed by Germany, which implies that in these countries many agricultural budgets are dependant on sugar beet production to a certain extent. In the third column, we find means and standard deviations of the share of sugar beets in crop allocation. The means vary between 25% in Italy and 11% in Austria while the standard deviation takes its maximum and minimum in the same two countries. Although means and standard deviations provide an overview on the importance of sugar beet production in crop rotation, the shape of the distribution of that indicator among farms within a Member States is unknown. Although the United Kingdom and Denmark show similar values for μ and σ, the distributions may look completely different. There are some general characteristics of the distribution of the share of sugar beets in crop rotation over farms and time. They are truncated at 0 and 1 because either a farmer produces no sugar beets at all or – as the maximum – uses the total area for sugar beets, which can only be considered a theoretical solution, since the cultivation of beets as a

[15] As the sample size of sugar beet farms in Portugal is very low and national statistics are inconsistent as well, Portugal was not included in our sample. As Luxembourg does not supply any sugar beets, it has also been excluded.

monoculture is said to be impossible with respect to rotational restrictions.[16] Nonetheless, this case also appears in the sample. This could either be a result of data errors or it is possible that a farmer who only grows sugar beets might exchange his fields each year with neighbours not producing sugar beets. Generally, plant cultivation specialists recommend growing sugar beets on one field every third year, at most, because of phytosanitary problems due to nematodes and other diseases.

Table 2.1: Indicators on sugar beet production in FADN

	Total number of farms*	Number of sugar beet farms*		Share of sugar beets in crop rotation**		Share of sugar beet revenues in total farm output**		Share of sugar beet revenues in total crop output**	
				μ	σ	μ	σ	μ	σ
EU	56152	*12%*	7017	0.18	0.13	0.25	0.18	0.33	0.19
BL	1455	*31%*	451	0.17	0.09	0.16	0.12	0.38	0.17
DK	2107	*14%*	300	0.16	0.10	0.17	0.16	0.32	0.24
DE	5389	*24%*	1287	0.14	0.10	0.18	0.14	0.33	0.18
EL	5305	*9%*	456	0.20	0.14	0.28	0.17	0.30	0.18
ES	7036	*12%*	814	0.22	0.18	0.41	0.22	0.42	0.22
FR	7627	*11%*	851	0.12	0.07	0.20	0.13	0.27	0.14
IR	1209	*7%*	81	0.12	0.08	0.22	0.15	0.49	0.22
IT	17463	*9%*	1579	0.25	0.14	0.30	0.20	0.32	0.19
NL	1440	*26%*	375	0.21	0.11	0.17	0.11	0.30	0.22
AT	2076	*18%*	365	0.11	0.05	0.20	0.12	0.33	0.13
SE	792	*15%*	119	0.16	0.08	0.26	0.16	0.42	0.27
FI	968	*10%*	101	0.24	0.19	0.34	0.28	0.52	0.27
UK	3286	*7%*	238	0.16	0.08	0.23	0.13	0.31	0.15

* Average number per year in observed period

** Only sugar beet producing farm

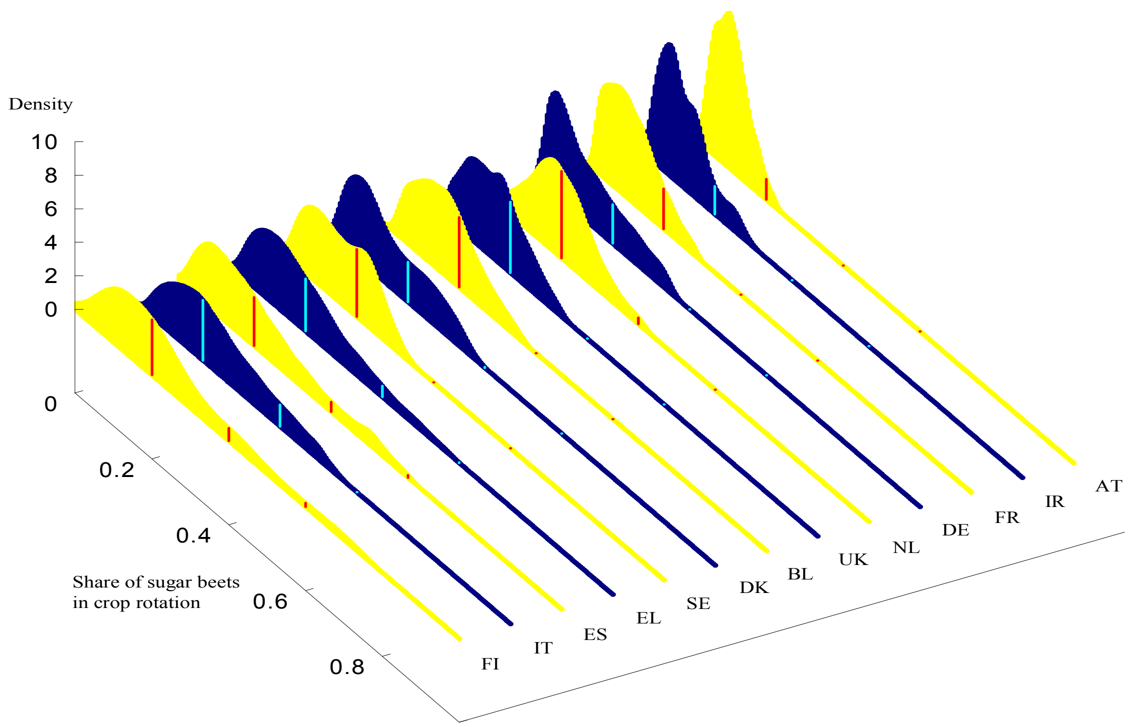
Source: FADN and author's calculations

To visualise the distributions of the rotational shares of sugar beets, we carried out Kernel density estimates (LEWIS et al, 1988, see section 8.2) for each of the selected Member States. The results are summarised in Figure 2.9. A three-dimensional Figure has been chosen in order to concentrate as much information as possible into one Figure and to allow a better comparison among Member States. To help the reader understand Figure 2.9, we have

[16] Note that we use only farms that produce sugar beets. Therefore, the distribution is not truncated at zero but at zero + eps.

highlighted in each density function a rotational share of 20%, 40% and 60% with a different coloured bar and we have sorted the functions by their highest value so that narrow and high functions are plotted on the right side and less high, wide functions are found on the left. Additionally, we show in Table 2.2 how many farms cultivate less than 20% (40%) of their usable area with sugar beets.[17]

Figure 2.9: Kernel density estimates of sugar beet rotation shares in the EU



Source: FADN and author's calculations

It is apparent that in Italy and Finland and the Netherlands as well, there are many farms with a rotation share of sugar beets greater than 20%. In most EU Member States, only a small number of farms produce sugar beets at a greater intensity than 40% but in Finland, Greece, Spain and Italy, we find about 10% of farms doing so. While we should treat the results for Finland cautiously as there is only a very small number of farms in the sample, it is worth noting that the three other regions are the southernmost in our sample. There are probably other cropping procedures in central and northern Europe or the economic environment is more heterogeneous compared to southern regions.

[17] Whenever we present results for FADN observations, we only deal with the 95% quantiles of the selected variable in order to minimize the influence of outliers on aggregated results.

Table 2.2: Cumulative percentage of farms cultivating less than 20% (40%) of their usable crop area with sugar beets.

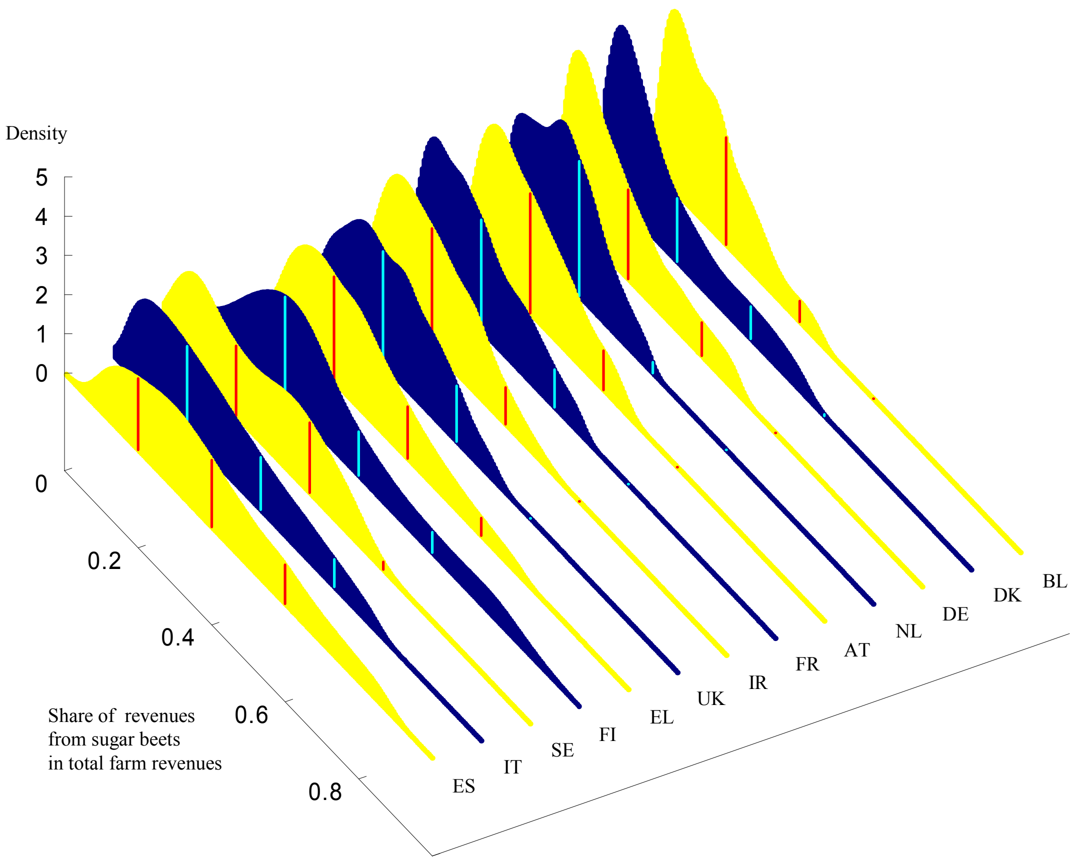
	share in rotation < 20%	share in rotation < 40%
AT	96%	100%
IR	88%	99%
FR	87%	100%
DE	75%	99%
UK	73%	99%
BL	69%	98%
DK	68%	98%
SE	65%	100%
EL	60%	92%
ES	60%	87%
FI	53%	85%
NL	53%	97%
IT	43%	86%

Source: FADN and author's calculations

We assumed that the probability density functions (pdfs) of sugar beet rotational shares in the United Kingdom and Denmark might look different, although their means and variances are very similar. Figure 2.9 confirms this assumption because the shape of both functions is very different.

The share of sugar beets in crop rotation gives us an idea of the importance of sugar beets in individual farm crop rotations, but it is of less significance regarding the importance of sugar beets for the farm income, although there is likely to be a high correlation. Table 2.1 provides information on the share of revenues from sugar beets in total farm revenues and total revenues from crop products. Figure 2.10 and Table 2.3 complete the picture of sugar beet revenues compared to total farm revenues. Again we find that the southern European regions and Finland have more farms where sugar beet revenues take a higher percentage of total revenues.

Figure 2.10: Kernel density estimates: Share of sugar beet revenues in total farm revenues in the EU



Source: FADN and author's calculations

In contrast, there are fewer farms in France, Germany and the UK where the sugar beet revenue is higher than 40% of total revenues. The bars in Figure 2.10 are again set at sugar beet revenues of 20%, 40% and 60% of total revenues. Obviously many farms at least in the left half of Figure 2.10 have higher sugar beet revenues than 20% of their total revenues. If we assume that farms where sugar beet production provides a high level of revenue rely stronger on the production of sugar beets, this confirms the hypothesis that reductions in sugar beet support will have a major impact on the income structure of sugar beet farms in those countries. One might further argue that those farms where sugar beet revenues amount to less than 20% of total revenues can survive even if they were forced to stop sugar beet production, because they can easily switch to other crops, so that the revenue losses would be even lower.

Table 2.3: Cumulative percentage of farms where sugar beet revenues are less than 20% (40%, 60%) of total farm revenues.

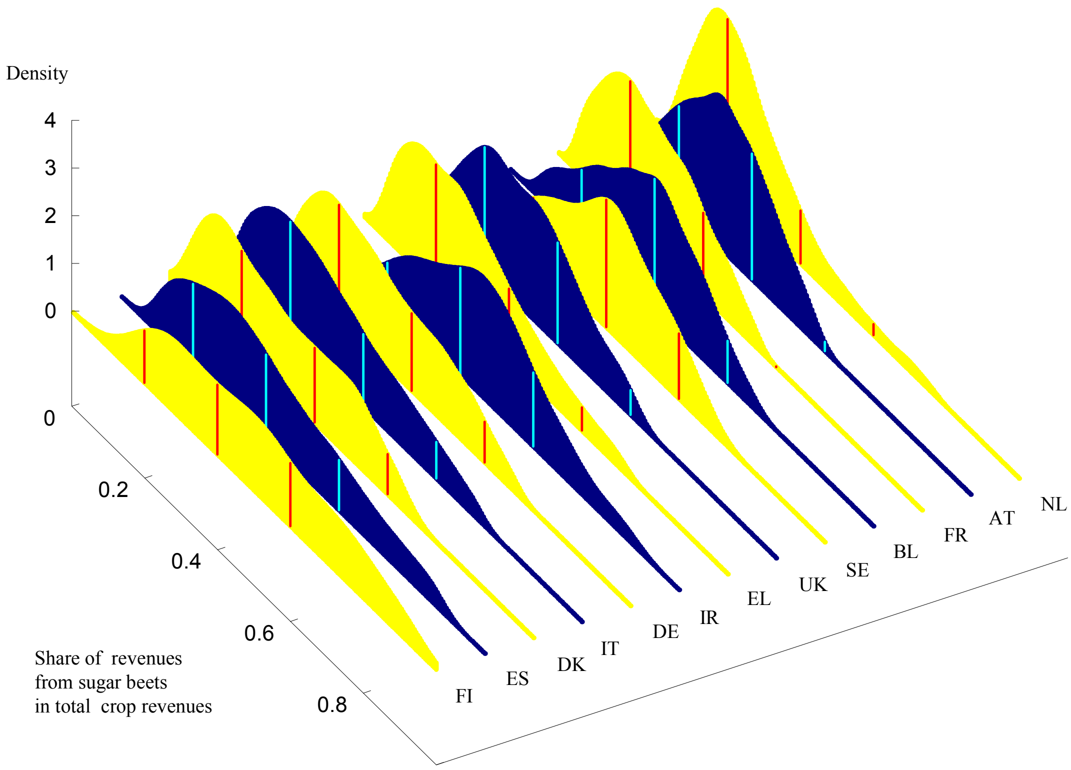
	share in total revenues < 20%	share in total revenues < 40%	share in total revenues < 60%
BL	70%	95%	100%
DK	68%	87%	98%
NL	66%	98%	100%
DE	65%	90%	100%
FR	58%	92%	100%
AT	55%	92%	100%
IR	52%	92%	98%
UK	44%	89%	99%
SE	44%	78%	99%
EL	39%	79%	94%
IT	38%	72%	91%
FI	32%	71%	84%
ES	19%	56%	80%

Source: FADN and author's calculations

The last column in Table 2.1, Figure 2.11, and Table 2.4 provides an overview of the importance of sugar beets for the cropping sector. While the previous section compared sugar beet revenues to total farm revenues, we now compare them now to total crop revenues. Of course, means and variances are higher than before, but the EU Member States are affected differently.

In countries where intensive animal production activities play a major role, like in the Netherlands, Belgium and Ireland, sugar beet revenues account for a high share of total crop revenues, although the share in total revenues when compared to other countries is relatively small. In contrast, in Spain and Italy, where animal revenues play a minor role – at least for sugar beet producing farms in our sample– sugar beet revenues make up almost the same share in crop revenues as in total ones. But all in all it becomes apparent that sugar beet production plays a major role with respect to revenues in cropping activities. In Figure 2.11 the density functions are again marked with bars at revenue shares of 20%, 40% and 60%.

Figure 2.11: Kernel density estimates: Share of sugar beet revenues in total crop revenues in the EU



Source: FADN and author's calculations

Table 2.4: Cumulative percentage of farms where sugar beet revenues are less than 20% (40%, 60%) of total crop revenues

	share in total crop revenues < 20%	share in total crop revenues < 40%	share in total crop revenues < 60%
NL	40%	88%	97%
FR	35%	84%	100%
EL	34%	78%	96%
DK	34%	67%	96%
IT	30%	71%	93%
DE	27%	68%	95%
UK	24%	74%	99%
ES	15%	54%	81%
AT	15%	72%	100%
BL	12%	56%	96%
SE	9%	47%	92%
FI	5%	36%	66%
IR	3%	36%	81%

Source: FADN and author's calculations

In each country a minimum of about 12% up to about 60% of all sugar beet producing farms have sugar beet revenues that amount to more than 40% of total crop revenues. Only in the Netherlands, France, Greece and the United Kingdom do we find that less than 26% of farms have revenue shares of above 40%. Considering this, it is not surprising that European sugar beet farmers fear a reform of the CMO Sugar because a key part of their revenues and consequently their profits would be lost. On the other hand, there are other sugar beet farmers who are expected to easily survive adjustments in the CMO Sugar, because sugar beet production on their farms does not play a major role.

The question now is to what extent these results of the revenue comparison can be applied to a comparison of profits. Generally, the picture would be the same, if the correlation between costs and revenues were the same for each production activity. But generally the CMO Sugar allows for higher margins between costs and revenues for the production of sugar beets compared to competing crops. Comparisons of the costs of sugar beet production (e.g. SCHMIDT, 2003, HENRICHSMEYER et al., 2003a) show that sugar beets produced within the B-quota have a gross margin that is comparable to that of soft wheat. Generally it can be assumed that A-Sugar beets take the highest share in total beet production of a farm, which in turn means that average gross margins of sugar beet production are notably higher than those of soft wheat, which is the dominating crop at least in Germany and France. If this situation is applicable to other countries and alternative crops – and the CMO Sugar implies this – it can be concluded that a comparison of profits among production activities will increase the importance of sugar beets compared to the revenue comparison evaluated above.

2.6 Summary

We have shown in this section that sugar beet production is of minor importance for European agriculture as a whole but many European sugar beet farmers receive a major part of their income from producing beets. Consequently, they would suffer from a reduction in support to the sugar sector. The magnitude of this support is apparent from the overview on the CMO Sugar. European sugar prices are three times above world market levels, guaranteed through tariff protection against cheaper imports. We identify Germany and France as the major sugar producers in Europe and show the importance of C-Sugar production in many EU countries. To identify the importance of sugar beet production on farm level and its distribution among farms we use the FADN dataset. We find that sugar beet production contributes considerably to single farm income, while the sugar sector is relatively small compared to agriculture as a whole.

In the next section we further exploit the FADN dataset in order to shed light on the costs of sugar beet production, single farm quotas and their fill rates.

3. Farm Quotas and Marginal Costs of Sugar Beet Production in FADN

Single farm quotas and marginal costs of sugar beet production are necessary for our analysis in section 4. Incentives to supply sugar beets cannot be analysed on farm level without knowing those two variables. Also, the estimates derived in section 3.2 and 3.3 will serve as inputs for the specification of the agricultural sector model CAPRI in section 5. The importance of both variables can further be strengthened if we remember the implications of profit maximisation for the two quota system of the CMO Sugar, what is done in the next section.

3.1 Sugar Beet Production and Profit Maximisation

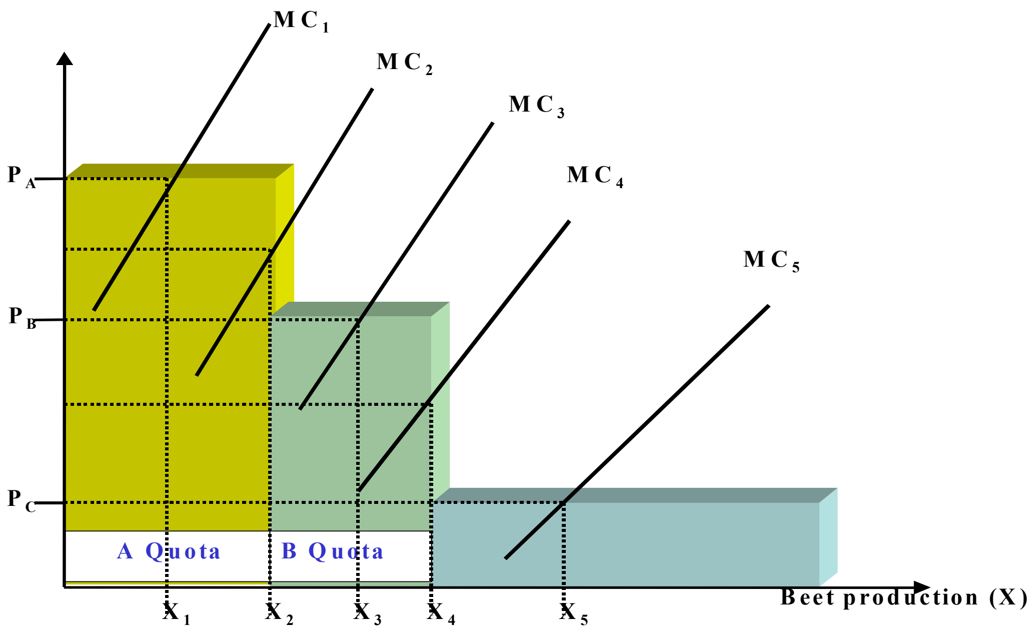
First, we need to examine how a profit maximum is characterised in dual theory. In general, we know that such an optimum is achieved where the profit function takes its global maximum, which means that a farmer cannot increase his profits by changing the land allocation at given prices. For a multi-output farm where all crop production activities compete in the input factor land, the dual value of this factor is equal among production activities. That means an additional unit of soft wheat returns the same profit as an additional unit of sugar beets. In a profit maximum it is further guaranteed that within each production activity the rule *marginal revenues = marginal costs* holds, where the marginal costs contain all shadow values of binding restrictions.

Let us now concentrate on the special aspects of the sugar beet production where farmers face production quotas and guaranteed prices for quota beets. The farmer, as a price taker, expects a certain price for his products, based on market regulations and his experiences in past years. Therefore, prices in the planning phase can only be expected prices. For sugar beets (at least for quota beets), prices are not that uncertain compared to other products such as potatoes, because the inter-trade agreements (see section 2.3) regulate the prices for quota beets in detail before sugar beets are seeded. Only prices for C-beets are dependant on world market developments and thus uncertain. Prices for sugar beets, laid down in those agreements, are generally based on an average sugar content of 16% and a standard quality.

Deviations from those standard values affect the effective prices per ton of beets. The same accounts for beet delivery rights. In fact, prices and quotas are fixed on the basis of sugar rather than of beets. Therefore we define in the following costs, revenues, and prices on sugar basis.

In Figure 3.1, on the vertical axis (expected) prices for the three types of sugar, denoted by P_A, P_B, and P_C are given. The production value of the A-quota is then indicated by the yellow box and that of the B-quota by the green box. Everything beyond these boxes belongs to C-sugar production (blue box). Five different marginal cost functions (MC_1-MC_5) that characterise five different producer types are also found in the figure. Following the general rule *marginal costs = product price*, producer type 1 is a high cost producer. His marginal costs of sugar beet production are so high that he will not completely fill his A-quota. For producer type 2 the A-quota is a binding restriction because his marginal costs are somewhere between P_A and P_B. Types 3 and 4 can be described similar to types 1 and 2 with the difference that the B-quota is referred to. The last type (5) is a low marginal cost producer because his marginal cost curve crosses P_C at a production quantity above total quotas.

Figure 3.1: Sugar beet producer types



Source: Author's illustration

The differences in the five producer types can also be expressed in terms of quota rents. Quota rents exist if marginal costs are lower than the price a farmer receives. Therefore type 1 has no quota rent at all because his marginal costs equal the relevant beet price (P_a). The contrary is true for the other producer types. Their total quota rent can be measured by the part of the yellow and green boxes that lie above the respective dotted line. The lower the marginal costs, the bigger the quota rents are. Clearly, the different producer types react differently to changes in quotas and prices. While type 5 only responds to changes in C-beet prices, the other types mainly react to changes in quota endowments and quota prices. The importance of farm heterogeneity with respect to the aggregated supply response is stressed in WITZKE and HECKELEI (2002).

As shown in Figure 3.1, the information of the individual farm quota endowment is essential information for the analysis of sugar beet production at farm level. As mentioned above, the FADN records include this information only for Belgium and the Netherlands. Consequently, we decided to estimate the missing quotas. How this is done is described in the next section.

3.2 Estimation of Single Farm Sugar Quotas and Beet Prices

VIERLING (1986) also analyses the FADN sample with respect to sugar beets. He solves the problem of missing data on farm quotas by using a pragmatic approach. He applies the national relation of A-, B- and C-sugar to every single farm. But this method is unsatisfactory due to a number of reasons: the national share of quota sugar is not constant for the observed years due to a varying sugar production. Applying the national shares would therefore trigger different levels of farm quotas in each year[18]. However, farm quotas are said to be constant in reality, except for a few cases of quota transfers. Applying instead the national average across years would yield relations of quotas to production that are inconsistent with national aggregates in single years. We would also probably observe a significant number of farms that do not fill their whole quota rights in some years due to yield variations, or other factors. Hence, it is advisable to allow for an under-delivery of quota rights by single farms in certain years. Our approach relies on farm level accounting identities, which serve as data constraints of a quota estimation exercise. Several assumptions are made and some prior information is used in the approach. The methodology is explained below.

[18] Note that it is possible that the farm quotas take the same value only if the relative changes in beet production are the same at farm and at national level.

3.2.1 Variables, Assumptions and Data

National Level

Q^A, Q^B	=	A- and B-sugar quota [tons of white sugar]
Y_t	=	national sugar production [tons of white sugar]
S_t	=	national average sugar content per beet [%] in year $t \in \{1990,\ldots,1999\}$
AP_t	=	average sugar beet price in year t [€/t]
P_t^A, P_t^B, P_t^C	=	national prices for the different beet types and years [€/t]

Farm Level

Y_{it}	=	sugar beet production of farm i = 1,...,N and year t [tons]
R_{it}	=	revenue from sugar beet production of farm i and year t [€]
W_{it}	=	Representative factor for farm i in year t
$AP_{it} = R_{it}/Y_{it}$	=	average sugar beet price of farm i and year t [€ per ton of sugar beet]

Unknown Quantities (Farm Level)

Q_i^A	=	A-quota of farm i [tons of white sugar]
Q_i^B	=	B-quota of farm i [tons of white sugar]
Y_{it}^C	=	C-sugar production of farm i in year t [tons of white sugar]
Y_{it}^{-B}	=	B-quota under delivery of farm i in year t [tons of white sugar]
Y_{it}^{-A}	=	A-quota under delivery of farm i in year t [tons of white sugar]
$P_{it}^A, P_{it}^B, P_{it}^C$	=	farm specific prices for A-, B- and C-sugar production in year t [€ per ton white sugar]

Assumptions

The relation between A- and B-quota is constant for all farms and equal to the national ratio q^{AB}:

$$\frac{Q_i^B}{Q_i^A} = \frac{Q^B}{Q^A} = q^{AB} \Leftrightarrow Q_i^B = q^{AB} Q_i^A$$

This assumption is in line with the regulations in the CMO Sugar. The most important assumption in our estimation approach is that individual farm sugar quotas are equal for one farm for years – a valid assumption for the vast majority of farms because the total quota endowment of a country did not change as well. We further need to assume that the individual farm sugar content per beet is constant across farms and equals the national averages found in the national statistics (S_t). This is an unrealistic but necessary assumption because more regionalized data has not been found nor does FADN provide this information.

3.2.2 Model Equations

The estimation model contains the following equations:

Sum of farm specific quotas, C-sugar production and B-quota under-utilisation should equal the observed farm production:

$$\begin{aligned} Y_{it} &= \left[(Q_i^A - Y_{it}^{-A}) + (Q_i^B - Y_{it}^{-B}) + Y_{it}^C \right] / S_t \\ (1.1) \qquad &= \left[Q_i^A + q^{AB} Q_i^A - Y_{it}^{-A} - Y_{it}^{-B} + Y_{it}^C \right] / S_t \\ &= \left[\left(1 + q^{AB}\right) Q_i^A - Y_{it}^{-A} - Y_{it}^{-B} + Y_{it}^C \right] / S_t \quad \forall i, t \end{aligned}$$

Observed sugar beet revenue is equal to sum of farm prices times production quantities of sugar:

$$(3.2) \qquad R_{it} = S_t Y_{it} P_{it}^A - (q^{AB} Q_i^A - Y_{it}^{-B})(P_{it}^A - P_{it}^B) - Y_{it}^C (P_{it}^A - P_{it}^C) \;\; \forall i, t$$

There are additional restrictions necessary concerning the variables $Y_{it}^{-A}, Y_{it}^{-B}, Y_{it}^C$.

I. A farm cannot produce C-sugar and does not simultaneously fulfil the quota

$$(3.3) \qquad Y_{it}^{-B} Y_{it}^C = 0 \;\; \forall i, t$$

II. If a farm does not fully use its A-quota, the B-quota has to be completely under-delivered.

$$(3.4) \qquad (q^{AB} Q_i^A - Y_{it}^{-B}) Y_{it}^{-A} = 0 \;\; \forall i, t$$

III. The A-quota under delivery cannot exceed the A-quota

$$(3.5) \qquad Y_{it}^{-A} \le Q_i^A \;\; \forall i, t$$

IV. The B-quota under delivery cannot exceed the B-quota

$$(3.6) \qquad Y_{it}^{-B} \le q^{AB} Q_i^A \;\; \forall i, t$$

Additionally Y_{it}^{-A}, Y_{it}^{-B} and Y_{it}^C are lower bounded by zero.

Farm specific prices are related to national prices by adding farm- and year-specific correction terms that are common for prices for A-, B-, C-beets:

$$(3.7) \qquad P_{it}^A = P_t^A / S_t + c_{it} \,;\; P_{it}^B = P_t^B / S_t + c_{it} \,;\; P_{it}^C = P_t^C / S_t + c_{it}$$

Alternatively, we test a version where farm specific prices are related to national-prices by multiplying farm- and year-specific correction terms that are common for prices for A-, B-and C-production:

$$(3.8) \qquad P_{it}^{A} = P_{t}^{A} c_{it} / S_{t} ;\; P_{it}^{B} = P_{t}^{B} c_{it} / S_{t} ;\; P_{it}^{C} = P_{t}^{C} c_{it} / S_{t}$$

The weighted sum over farms of single farm quotas divided by the weighted sum over farms of single farm sugar production quantities equals the national relation quota sugar /sugar production in each year[19]

$$(3.9) \qquad \frac{\sum_{i=1}^{N} \left(1+q^{AB}\right) Q_{i}^{A} W_{it}}{\sum_{i=1}^{N} Y_{it} W_{it}} = \frac{Q^{A}+Q^{B}}{Y_{t}}$$

Since this system of equations is not designed to use classical estimation procedures, we originally solved this set of equations using a cross entropy (CE) estimator[20] (GOLAN et al., 1996). A disadvantage of cross entropy estimation is the often arbitrary and non-transparent choice of support points and their prior probabilities. HECKELEI et al. (2005b) provide an alternative estimation procedure with the advantage of more transparent prior information. The so-called highest posterior density (hpd) estimator is a Bayesian approach where a prior probability density function, its mean and its standard deviation for each variable are chosen rather than using more arbitrary support points in a CE approach. As we do not know the pdf in our case, we make the most likely decision, namely to choose a normal. The choice of means and variance will be explained later on. It can easily be shown that the choice of a normal distribution boils the estimation problem down to a minimisation of squared differences of the chosen mean of the pdf and the estimates weighted by the assumed variance. This leads to

$$(3.10) \qquad \text{MIN} \sum_{i=1}^{N} \sum_{t=1990}^{1999} \left[\frac{\left(Q_{i}^{A} - \mu_{it}^{Q}\right)^{2}}{\left(\sigma_{it}^{Q}\right)^{2} k_{i}} + \frac{\left(c_{it} - \mu_{it}^{c}\right)^{2}}{\left(\sigma_{it}^{C}\right)^{2} k_{i}} \right]$$

μ_{it}^{Q} and μ_{it}^{c} are the assumed means for the farm quotas and the price correction factor respectively and σ_{it}^{Q} and σ_{it}^{Q} their assumed standard deviations. The number of observations per farm k_i ensures that all farms get the same weight in the objective function.

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[19] The experiences of HENRICHSMEYER et al. (2003b) had shown that equation (3.9) caused several problems. Consequently, it had not been imposed. Mainly due to the new estimation approach instead of using cross entropy, those problems no longer appeared in our estimation for most EU Member States. The implications of imposing this restriction are analysed in section 3.2.4.

[20] See HENRICHSMEYER et al. (2003b).

3.2.3 Implications of the Approach and Model Set Up

Estimation properties

The introduced estimation procedure finds those single farm quotas and price correction factors that are, given the restrictions introduced by the other equations, as close as possible to the assumed means. The prior standard deviation weights those deviations from the prior mean so that for a pdf function with a smaller variance deviations from the mean are punished more than the same absolute deviation in a pdf with a larger variance. Similar to the approach in HENRICHSMEYER et al. (2003b) we choose different prior distributions for the quota estimate in each year of the observed period, although this is somewhat at odds with the assumption of constant farm quotas and the idea that there is only one prior distribution per variable.. But our prior information is the national relation of quotas over production and this is not constant across years. We want the relation at farm level to be as close as possible to the national one in each year and in order to reflect that, we define the mean of those prior pdfs for each farm in each year to be at the national relation of quota/production multiplied by the individual farm sugar production in the respective year.

In case of the price correction factor, we want farm prices to be as close as possible to the national averages. Consequently, their means are equal to zero when equation (3.7) is imposed and equal to one if equation (3.8) is chosen alternatively. In the objective function the squared differences of estimated quotas and price corrections and their prior means are weighted with some standard deviations. Those are assumed at 20% of the respective mean. This relative definition of the standard deviation has the advantage that it corrects the heteroscedasticity, i.e., the objective function punishes a deviation of one ton from the prior mean less if the farm produces a lot of sugar as compared to a farm that produces only a few tons.[21] To summarise, this model set-up leads to an estimate of farm quotas which best fit the available data restrictions, model assumptions and prior information as expressed by the chosen prior pdf.

[21] For the price correction factor all farms have the same prior distribution. In cases where the correction factor is additive, the standard deviation was assumed at 5€.

Data

The national producer price for the three beet types plays a major role with respect to estimation results. During estimation, prices for all estimation years (1990-1999) are required. We use EU guarantee prices minus the levy on A-beets for the A-sugar beet prices, the EU guarantee price minus the levy on B-beets for the B-sugar beet prices. In the case of C-sugar beet prices[22], we use world market prices for sugar multiplied by 60% of the national average sugar content per beet. The C-sugar prices and producer levies were taken from LINDE et al. (2000).[23] Hereafter the prices are scaled by a constant factor for each country to the national average prices as available in the CoCo database[24] using the national shares of A-, B- and C-sugar. This guarantees that national supports of sugar beet production, common in Italy or Finland (BLUME et al, 2000), are included as long as they are part of the national production value of sugar beets. National quotas are taken from the respective regulations. The French quotas do not include the overseas territories, as they are not part of the FADN sample. National sugar production and sugar content per beet stem from the CoCo database as well. Farm individual data stems from FADN. While in section 2.5 all farms in the FADN sample are included in our investigation, we eliminate a number of observations for the estimation if either data errors are obvious or critical assumptions of our estimation approach seem to be flawed.

First, we delete all observations in cases where a farm is part of the sample for less than two years because the estimation process boils down to a simple calculation if a farm is only one year in the sample. For each farm, we further need data on sugar beet production quantities and values and their weighting factors. We only accept farms where the data on these three variables is complete. Hereafter, we check all farms where the observations are not found in a continuous timeline. This is done because if a farm is removed from the sample, the same farm identification number could be allocated to a completely different farm some years later. Two different farms could therefore be found under the same farm ID. The assumption of a constant sugar quota is consequently flawed by definition. In such cases, only

[22] The underlying assumption is that 60% of the companies' sugar revenues are given to producers.

[23] Their source is mainly FO Licht, a commodity expert of sugar markets.

[24] The CoCo (Complete & Consistent) database combines times series on areas, herd sizes, production, yields, market balances, price and the Economic Accounts for Agriculture at national level for all current EU Member States. System estimations under consistency constraints ensure that gaps in the underlying raw data from EUROSTAT are closed and inconsistencies are removed. The database is used and maintained by the CAPRI modelling network (BRITZ et al., 2004).

the most recent observations that are in the time line remain in the sample. Further, some consistency checks delete farms with implausible values on sugar beet yields or revenues.

Table 3.1 shows the implications of this reduction of observations. The highest reductions are found in Greece, Spain and Italy, mainly due to the problem of two different farms listed under the same farm ID. In Italy, Spain and even Germany, the samples are large enough compensate a high reduction in observations.

Table 3.1: Number of observations for 13 Member State before and after corrections

	BAS	change	NEW
SE	476	-21%	377
FI	507	-13%	439
IR	807	-26%	595
AT	1825	-6%	1711
UK	2379	-37%	1491
DK	2998	-24%	2267
NL	3751	-11%	3356
BL	4511	-18%	3714
EL	4558	-56%	2014
ES	8142	-39%	4930
FR	8513	-11%	7620
DE	12868	-35%	8361
IT	15786	-41%	9400

Source: FADN and author's calculations

This reduction of observations leads now to the problem that the new sample does not represent the sector anymore. However, this is a prerequisite for equation (3.9) and the subsequent presentation of aggregated results. Therefore, we decided to scale the farm specific representation factors so that the weighted sum over farms (of the new sample) of sugar beet production corresponds to regional and national production quantities for each year in the estimation. This scaling does not change the relations of representativeness among farms within a region (NUTS 2), but it can change those relations among farms of different regions.

3.2.4 Estimation Accuracy

For such an unconventional estimation, it is not easy to make conclusions about estimation accuracy. Fortunately, we can test this approach for the Netherlands and Belgium because these countries provide data on farm quotas for most of the farms in some years. We compare four versions of our model that differ in whether the national relation (equation (3.9)) is imposed and the price correction factor is additive or multiplicative. The idea behind an additive price correction factor is that it can be interpreted as constant mark ups or reductions due to quality, transportation cost or dirt content of delivered beets that are equal for each beet type. A correction factor defined relative to the prices implies larger changes for quota sugar prices than for C-sugar. In reality, both types of payments exist (compare SCHMIDT, 2003), so that a combination of both types is probably more realistic. Introducing two correction factors without further restrictions, however, is not recommended for an estimation system with few degrees of freedom. Therefore, we will decide below which of the two versions we will use. Table 3.2 gives the definition of those four versions.

Table 3.2: Four versions of the estimation model

	Equation (3.9)	Equation (3.8)	Equation (3.7)
MOD1	NO	YES	NO
MOD2	YES	YES	NO
MOD3	NO	NO	YES
MOD4	YES	NO	YES

Source: Author's illustration

We choose a number of indicators that help to assess these versions. Those are:

- Correlation between observed quotas and estimated ones calculated as

$$cc = \frac{\sum_{s=1}^{m}\left(Q_s - \bar{Q}\right)\left(FQ_s - \bar{FQ}_s\right)}{\sqrt{\sum_{s=1}^{m}\left(Q_s - \bar{Q}\right)^2 \sum_{s=1}^{m}\left(FQ_s - \bar{FQ}_s\right)^2}} \quad \forall s \in S \tag{1.11}$$

$$S = \left\{(i,t) : FQ_{i,t} \neq 0\right\}$$

The set S contains all (m) combinations of farms and years, where data on quotas was available in FADN (FQ_s). Q_s denotes the estimated quotas for each observation s. The means are denoted by a bar above each variable. Finally, cc – the correlation coefficient – measures the correlation between estimates and data and can take values between zero and one, where a higher value indicates a stronger correlation.

- The estimation bias calculated as the difference between the means over all observations of estimated quotas and original ones.
- The standard deviation of quotas in the data and the estimates, calculated as:

$$(1.12) \qquad stdd = \frac{\sum_{s=1}^{m}\left(Q_s - FQ_s\right)^2}{m-1} \quad \forall s \in S$$

- Finally, we calculate how many times the 'quota fill status' (is the quota filled or not) is identified correctly. The indicator, given in Table 3.3 as congruencies, is the share of correctly identified quota fill states of estimated quotas.

Table 3.3: Indicators of estimation accuracy

		cc	bias	stdd	congruencies
BL	MOD1	0.934	15.268	29.156	59%
	MOD2	0.747	-1.59	40.804	77%
	MOD3	0.932	14.879	28.807	59%
	MOD4	0.748	-1.597	40.758	77%
NL	MOD1	0.973	17.206	30.505	52%
	MOD2	0.797	-12.033	52.674	75%
	MOD3	0.974	16.442	28.124	53%
	MOD4	0.797	-12.02	52.693	75%

Source: FADN and author's calculations

As demonstrated in Table 3.3, the correlation between the estimated quota and the quota specified in the data is very high for models one and three in both countries. Models two and four show noticeably lower correlations. Obviously, imposing equation (3.9) influences the correlation coefficient and the standard deviation between estimated and original quotas negatively, while it enhances the estimation in terms of bias and congruencies. A comparison of models one and three shows that the differences that occur when the price correction factor is defined relative or additive to the beet prices, change the presented indicators only very slightly. Inspection shows that the estimated quotas in model one and three (model two and four respectively) only differ very little. A difference, however, is found in the estimated farm prices, whereby a great disadvantage of the additive versions is the occurrence of negative C-sugar prices which can be prevented by using the relative definition. Therefore and although HENRICHSMEYER et al. (2003b) argue in favour of the additive price correction factor, we decided to use relative ones as we use the estimated farm prices later on and would like to avoid implausible results caused by negative C-sugar prices. But is model one or two the better one? A not yet mentioned advantage of model two is – due to its design – that the aggregated results correspond to national statistics. This is greatly desired as we will include the results of this estimation in the regionalised agricultural sector model CAPRI in section 5. An econometrician would always choose the version that provides the highest correlations but for our analysis it is probably more important to ensure that the estimated quotas correspond to the observed aggregates as much as possible. The advantages and disadvantages of both models lead us to investigate an additional version of our estimation model (model five). We use the estimation system of model one. The resulting quotas are then scaled by a constant factor, so that national quotas are met. With these quotas, A-, B- and C-sugar prices are then recalculated. The results presented in Table 3.4 are promising. We preserve the high correlations from model one and gain in terms of all other indicators. We obtain congruencies of the fill status of original and estimated quotas of 93% in Belgium and 82% in the Netherlands. The bias, compared to model one, is noticeably reduced and the standard deviation between estimated and original quotas is greatly enhanced.

Model five is therefore superior to the other ones. But this improvement has its price. By applying constant scaling factors in each year to correspond to national quotas, we break with the most important assumption in the estimation, namely constant farm quotas over time. The reason why we still favour model five is that both samples show variance in quotas over time: Belgium (95% of all farms) and the Netherlands (83% of farms). The average standard deviation of original farm quotas over time amounts to 3 tons of white sugar in both countries. The respective standard deviations of estimated farm quotas of model five, however, only amounts to about 1 ton. Consequently, model five does not overestimate the variance in farm quotas over time and seems to be a further improvement compared to models one to four.

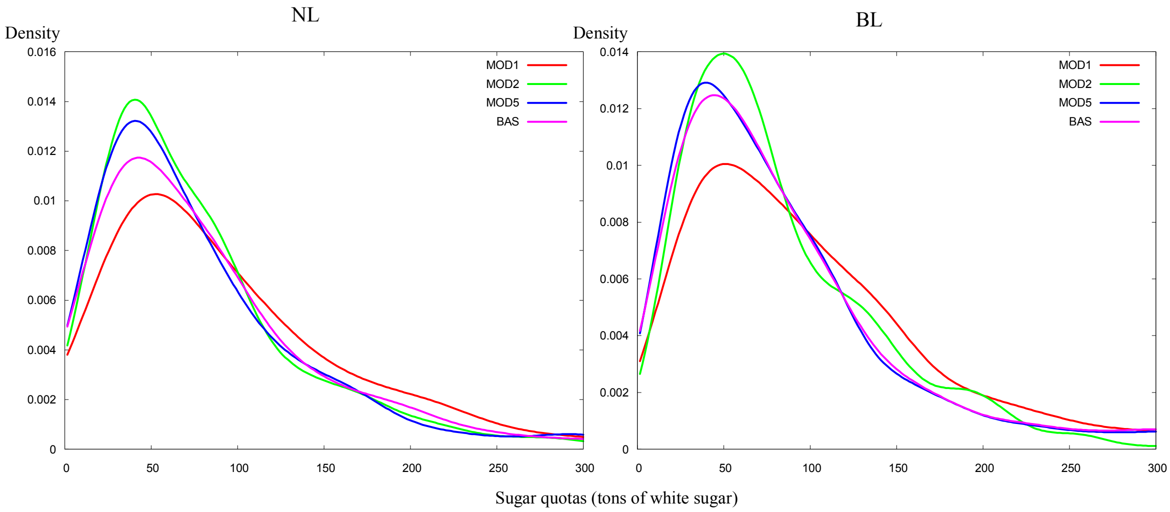
Table 3.4: Indicators of estimation accuracy (2)

		cc	bias	stdd	congruencies
BL	MOD1	0.934	15.268	29.156	59%
	MOD2	0.747	-1.59	40.804	77%
	MOD5	0.935	-2.76	22.13	93%
NL	MOD1	0.973	17.206	30.505	52%
	MOD2	0.797	-12.033	52.674	75%
	MOD5	0.973	-6.081	20.819	82%

Source: FADN and author's calculations

Of course, it can be considered inconsistent to make a model assumption and then break with it after estimating the model, but both steps – the estimation and the recalibration of resulting quotas and prices – could be done within one step. Farm quotas would then be different across years with the restrictions that they can be calculated as a farm specific constant multiplied by a constant across all farms of a country and that they sum up to national quotas. This leads exactly to the same results but increases computation time.

Figure 3.2: Aggregated results of farm quota estimation in term of pdf functions



Source: FADN and author's calculations

The favourite status of model five is also evident in Figure 3.2 which shows the probability density functions[25] of estimated farm quotas with models one, two and five and those for the original quotas (BAS). Especially in Belgium we see a high degree of congruence between model five and the original data, while models one and two show noticeable differences. In terms of distance between the original data graph and those of the estimations, model five is also the optimal choice.

3.2.5 Estimation Results

We apply model five to all EU Member States considered in this analysis. As mentioned before, we are not able to test the estimation results for the other countries in the same way as is done above due to missing data on farm quotas. But the principal functionality of our approach has been pointed out and should be transferable to other countries as well.[26] Table 3.5 summarises the results of the quota estimation.

Table 3.5: Key results of quota estimation

	Sugar production/Quota (%)			A beet price (€/t)		B beet price (€/t)		C beet price(€/t)	
	Mean	Standard deviation	< 100%	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
BL	117.6	24.2	11.8	43.30	3.66	43.30	3.68	20.93	4.56
DK	117.2	22.5	14.5	52.78	6.34	33.52	4.28	23.53	5.66
DE	118.2	23.3	10.3	54.88	7.39	34.93	4.90	24.98	5.85
EL	88.4	52.3	60.2	59.75	11.63	63.21	12.46	33.35	8.99
ES	105.4	41.0	40.0	56.36	12.53	58.50	14.95	30.07	6.63
FR	137.1	28.6	1.6	43.22	6.68	27.44	4.21	19.72	4.86
IR	107.3	18.9	27.8	45.58	4.20	45.60	4.45	22.67	4.92
IT	99.6	38.5	53.0	57.29	9.78	58.33	10.32	30.65	8.19
NL	112.0	22.1	22.5	49.93	5.66	49.57	5.37	24.53	5.16
AT	123.3	21.6	6.7	49.23	5.18	31.06	3.42	22.45	5.86
SE	104.7	15.1	36.7	45.87	7.32	28.77	4.11	22.22	4.78
FI	103.2	30.0	42.1	61.55	8.21	39.45	5.71	31.31	7.16
UK	121.6	21.9	8.4	49.26	5.66	49.24	5.64	22.59	4.95

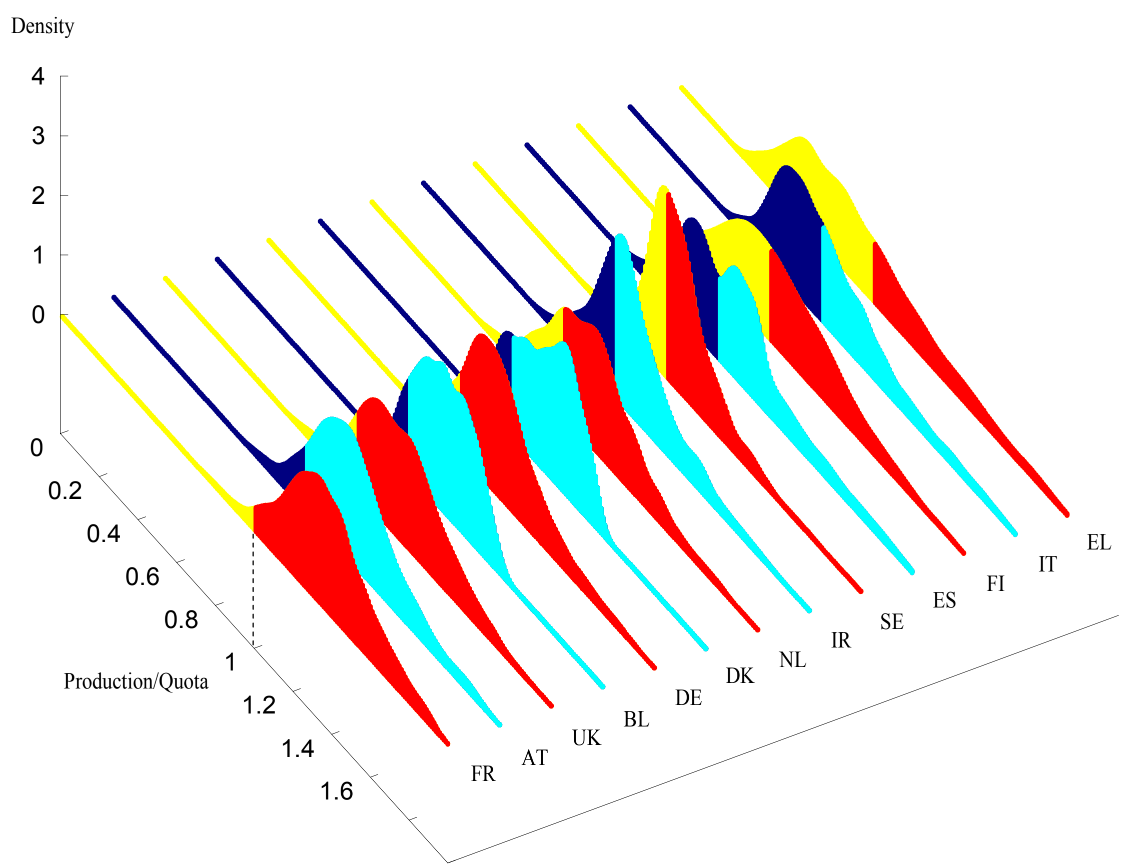
Source: FADN and author's calculations

[25] Kernel density estimates (see section 8.2) were used again.

[26] Note that Belgium and the Netherlands both apply the mixed price system. In the estimation, we deal therefore only with one quota and two prices. It cannot be precluded that the estimation behaviour is somewhat different for countries that apply the classical ABC system. Note that a price differentiation of C-beets (compare Schmidt, 2003) is not considered here either. .

The first block presents the distribution of the quota fill rate in the different countries. The first column shows the average quota fill rate for all farms and observation years and the second one their standard deviations. French farmers mainly seem to belong to the group of C-sugar producers as even the standard deviation subtracted from the mean production is more than 100% of quota production. Column 3 underlines this because a quota under-delivery appears in only 1.6% of all observations in France, Belgium, Denmark, Germany, Austria and the United Kingdom are C-sugar producers as well but the share of observations where quotas are not filled ranges from 6.7% to 14% so that we cannot exclude quota under-filling in those countries.

Figure 3.3: Kernel density estimates: Relation production/quota in the EU



Source: FADN and author's calculations

A country group consisting of the Netherlands, Ireland and Sweden is also still producing above their quota endowments on average, but shows a larger number of cases where quotas are not filled. The last group, Spain, Finland, Italy and especially Greece is characterised by an average production around or below the quota endowment and a lot of incidences were quotas are not filled. The density distributions in those countries vary greatly which means that even in those countries a number of farms produce C-sugar. These results are underlined by Figure 3.3 where we plot Kernel density estimates of the regional distributions of the production/quota relation. The density functions have different colours for production below and above the quota and are sorted by the share of observations where quotas are filled.

The remaining blocks in Table 3.5 give us the means and standard deviations of estimated prices. All three beet prices vary among Member States in terms of mean and variance, indicating different payment schemes. Remember that these prices are meant to include all mark ups and discharges that may be paid for quality, transportation, etc. They refer to an average sugar content of 16% per ton of beets in order to make the prices more comparable among countries. Differences between A- and B-prices in countries where the pool price system is applied can occur since the presented prices are weighted averages across farms and years, where the sample size can differ for the different prices. In the average of B-beet prices, only those farms are included that produce B-beets. The differences occur mainly in those countries, where a high share of A-quota under-delivery is found like Greece, Spain and Italy, while in Belgium A- and B-prices are almost equal. The highest average A-beet price is found in Finland due to an additional national aid paid for sugar beet production. The means of C-beet prices are all well above 20€/t except for France. They show reasonable magnitudes compared to the calculated figures in LINDE et al. (2000) on page 161. Prices in Italy, Spain and Greece are at a higher level compared to other countries. In particular, C-beet prices may be overestimated in those countries.

3.3 Sugar Beet Production Costs

Key indicators for the production of sugar beets are naturally the production costs. It has already been noted several times above that the FADN dataset does not include information on costs allocated to the different production activities. Only total expenditures on some inputs are available. Crop specific inputs include seeds, plant protection, fertilisers and a category called other crop specific inputs. Additionally, total expenditures on energy, repairs, water and services, which are not only associated with the cropping activities, are available. Originally, a major objective of this study was to estimate marginal costs of sugar beet production according to a parametric econometric estimation approach, as carried out by

WIECK (2005)[27] for example, but all efforts did not lead to usable results. Literature, on the other hand, provides some estimates of marginal production costs. Four different sources are described below:

- FRANDSEN et al. (2003)

  In this article, the authors analyse reform options of the CMO Sugar using a global general equilibrium model at European Member State level. Each country is associated with a certain producer type similar to the definition in Figure 3.1. This association is done according to the observed sugar production. Countries with high observed C-sugar quantities are therefore estimated to be low cost producers while countries that do not entirely fill their production quotas are assumed to have higher marginal production costs. They further assume that farmers consequently overshoot their quotas in their planning by an amount of two times the standard deviation of total production of the respective country to compensate for yield uncertainty. Under the definitions in Figure 3.1 they allocate Portugal, Finland, Italy and Greece to type MC_1, Sweden, the Netherlands and Ireland to type MC_2, Denmark, Belgium and Spain to MC_4 and France, Germany, Austria and the United Kingdom to the low-cost producer group MC_5. This approach has several disadvantages. First, it neglects farm heterogeneity. As shown in the previous chapter, we find in every country different fill rates of single farm quotas, which means in terms of the definition of FRANDSEN et al. (2003), that we also find different types of marginal costs curves. This is a general problem of aggregated models, but in the system of production quotas, it is an even greater one. The authors assume the low cost countries to be competitive at C-beet prices; consequently, the only relevant variable at the margin would be the C-beet price. In other words, France, Germany, the United Kingdom and Austria are assumed to be completely independent of the quota system and their production will not change if quotas or quota beet prices are reduced. Consequently, these four countries hardly react in the analysed scenarios – a not very plausible result.

[27] This study estimates marginal production costs of milk production. The framework relies on a cost minimisation problem, which is the likely choice, because in the milk sector the production output is quite limited by the quota. An adoption of this approach to the sugar sector is problematic due to the possibility to produce C-sugar beets.

- BUREAU et al. (1997)

  The analysis of an introduction of quota mobility is the main topic of this article. The authors develop regional quota supply and demand curves for twenty-five European regions (NUTS 2 or Member State level). This is done with the help of regional marginal cost curves. The analysis is based on single farm data. They also discuss the lack of detailed cost information in the data, which is, however, available for the French regions. They stack single farm Linear Programming Models where each farm maximises gross margins in order to obtain opportunity costs[28] of sugar beet production for each farm. Afterwards, they estimate a parametric function relating these opportunity costs to the total production and calibrate this function to the regions where cost data is incomplete. In those regions, farm data stems from FADN and other national data sources. Compared to FRANDSEN et al. (2003), this method allows for farm heterogeneity. The resulting opportunity costs of sugar beet production are, in terms of the ranking of individual Member States, comparable to FRANDSEN et al. (2003), but generally show a higher cost level.

- HENRICHSMEYER et al. (2003a) / VIERLING (1996)

  HENRICHSMEYER et al. (2003a) apply a method developed by VIERLING (1996). Both studies use the FADN data set but at different time periods. The problem of missing data on production costs of specific activities is solved here by using the ARACOST program, developed by DG AGRI, to obtain estimates. This program is based on simple algorithms that use the share of monetary outputs of one crop in the total crop, arable land or total farm output and multiplies this by the total expenditures of the respective input. This method implies that variable costs are high for those products that attain higher monetary outputs. In other words, the relation of total monetary output of an activity to its variable costs is constant for all activities that use the same factors, which is likely to be an unrealistic assumption. Furthermore, this calculation translates all fluctuations of the unit value of an activity into its costs. In the case of a bad harvest, the resulting variable costs are lower than in years with a good harvest. The same occurs for high and

[28] Opportunity costs equal the dual value of the quota constraints in the LP models

low prices, although the variable costs in reality are not correlated with these stochastic variables. One might argue that high prices are often correlated with low yields and vice versa, that a bad harvest in one production activity goes with bad harvest in the other ones so that the relations of monetary outputs are rather constant over time, but this only slightly diminishes the weakness of the approach. Both studies address this problem by using three-year average data so that stochastic fluctuations are smoothed. Once the variable costs of sugar beet production are established for each sugar beet producing farm, opportunity costs are added. VIERLING (1996) defines them as the gross margin of a predefined competing crop. We cannot predict which crop a farmer would switch to if sugar beet became more or less attractive, therefore, any attempt to predefine that crop is questionable. HENRICHSMEYER et al. (2003a) do not use a predefined competing crop. They say that a farmer will enhance all products which are part of his production program by the same share so they use the average gross margin of the farm specific crop mix excluding sugar beets as opportunity costs. Potatoes and perennials are excluded here. This method is still a simplification but an improvement on VIERLING (1996) since it reflects the crop rotation of a certain farm.

To summarise, the three different approaches lead to different estimates of marginal costs and all methods have their disadvantages. The most convincing approach seems to be that of BUREAU et al. (1997) since it uses data on variable costs available in France. Since such data is not available to us, we use the method of HENRICHSMEYER et al. (2003) here with small modifications. Variable costs per activity are calculated in the same way as in HENRICHSMEYER et al. (2003a). Opportunity costs are defined as the average gross margin of competing crops on each farm, but we do not categorically exclude potatoes since they are, in terms of production requirements, comparable to sugar beets. We only exclude potatoes if their share in the crop rotation is higher than 25% since an extension of potatoes above this share may not be considered advisable. This modification is especially relevant in the Netherlands where many farmers produce potatoes at the maximal level with respect to soil requirements.[29]

[29] All estimates have in common that they refer to the short term.. Costs for long-term decisions, such as investments in new buildings or machinery, are not included.

In Table 3.6 we compare the estimates for marginal costs of sugar beet production from the different sources mentioned above with our own estimates. Not very surprisingly, our estimates are comparable to those from HENRICHSMEYER et al. (2003a), since we use the same dataset. Both estimates are based on three-year average data of the years 1997-1999. Differences stem from the different treatment of competing crops explained above and from slightly different sample sizes.[30]

Table 3.6: Marginal costs of sugar beet production from different sources (€/t , 16% sugar content)[31]

	Bureau	Frandsen	Vierling	Henrichsmeyer	Adenäuer
AT	%	20.7	%	27.1	25.0
FR	29.6	21.9	34.0	29.7	26.9
DK	24.8	32.1	35.4	29.8	28.8
BL	31.0	33.5	33.1	28.8	29.2
DE	24.8	20.4	32.6	35.2	32.2
SE	%	41.1	%	34.3	32.7
IR	%	49.8	39.3	35.1	34.2
UK	32.0	19.9	35.9	34.9	34.3
ES	49.0	44.8	%	27.7	37.3
NL	34.8	49.2	36.2	36.3	37.8
FI	%	58.1	%	40.0	40.8
IT	65.7	65.1	44.5	40.4	41.7
EL	46.0	67.2	%	41.4	50.9

Source: BUREAU et al. (1997), FRANDSEN et al. (2003), VIERLING (1996), HENRICHSMEYER et al. (2003a) and author's calculations

The estimates of VIERLING (1996), compared to those from HENRICHSMEYER et al. (2003) and our own calculations, are generally at a higher level. This might either be a matter of different handling of competing crops or – as an economic explanation – due to technical

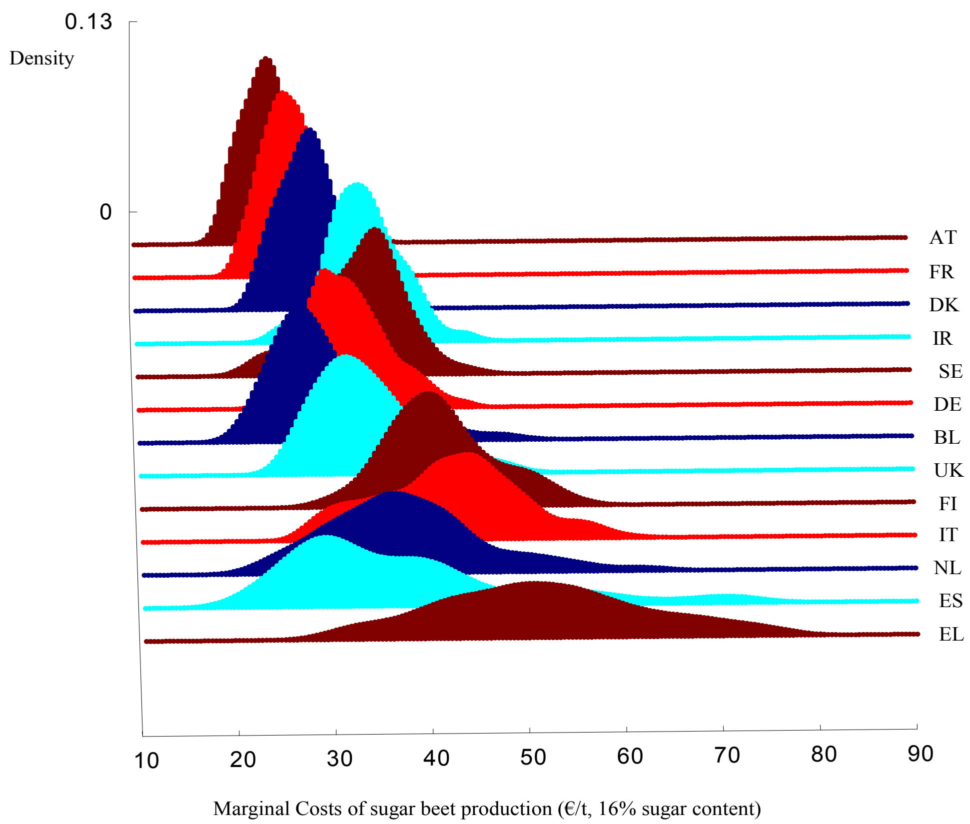
[30] We only use the smaller sample derived in section 3.1 which includes only those farms for which quotas were estimated. HENRICHSMEYER et al. (2003), in contrast, use all sugar beet producing farms during the period in question.

[31] Marginal costs of sugar beet production for all studies are translated into standard costs for sugar beets that contain 16% of sugar in order to obtain a better comparison among different countries with different average sugar contents. This is done by dividing the marginal costs of sugar beet production by the national average sugar content and multiplying it by 16%. Furthermore, BUREAU et al. (1997) and VIERLING (1996) do not present national values if more regionalised information is available. We calculate those values by averages across regions of a country weighted by regional three-year average sugar beet production.

progress, since the estimates of Vierling are based on 1988-1992 data. The estimates of FRANDSEN et al. (2003) are mainly influenced by their allocation of Members States to different producer types. You find countries with marginal costs around 20 €/t for the low-cost producing countries. Compared to the other estimates for those countries, one might conclude that the competitiveness of France, Germany, Austria and the United Kingdom is over-estimated. The estimates from BUREAU et al. (1997), which are based on 1990 data, are apart from some exceptions in a comparable range to our own estimates. The most obvious differences appear in Germany and Denmark, which according to our evaluation are less competitive, and Italy and Spain where the opposite is true.

All estimates confirm that Austria and France are among the most competitive countries in sugar beet production, while Italy and Greece are the least. The results of our own calculation of marginal costs are further illustrated in Figure 3.4. There it becomes obvious that in the countries where we find high average marginal costs, like Greece and Spain, the variance over farms is high as well.

Figure 3.4: Kernel density estimates: Marginal costs of sugar beet production for 13 EU Member States



Source: FADN and author's calculations

A recent study carried out by ISERMEYER et al. (2005) presents estimates of the price floor of sugar beet production in regions of the EU-25 below which sugar beet production is said to be abandoned in the respective region. Their approach shows similarities to ours, but rather than defining marginal cost at farm level and aggregating them to regional averages, they start with regional standard gross margins[32] of sugar beet production, reflecting the decoupled payment scheme as laid down in the CAP reform from 2003. Consequently, their marginal production costs are not differentiated within a region. They assume that sugar beet production leaves a certain region if marginal revenues are below marginal costs. Using horizontal aggregation of their regional estimates and quota endowments, they derive a price floor curve for the EU-25 as given in Figure 3.5. We now compare this curve to a curve that ranks our marginal cost estimates among European regions for which an estimation was carried out. The absolute levels of that price floor and our marginal costs are not comparable because our estimates do not include the effects of the decoupled payment scheme. It is the ranking between regions that should be comparable. Of course, we can only compare regions which are reflected in both studies. Both studies allocate Greek, Italian, British and Dutch regions to the right hand side, meaning that they are among the less competitive regions in Europe, but ISERMEYER et al. (2005) consider the Spanish regions much less competitive than we do. The *Rioja* region is especially eye catching in this respect. We identify this region as one of the most competitive across the selected regions while it is found at the other end of the scale in Figure 3.5. The same accounts for the eastern region *Alsace* in France. For Finnish regions the opposite occurs. Germany is generally considered more competitive by ISERMEYER et al. (2005) and our estimation shows lower variance of costs within a country. But, all in all, there are considerable differences in the results of both studies.[33]

In conclusion, our estimates of marginal costs of sugar beet production show reasonable magnitudes and are in line with some other studies, but they contradict the findings of ISERMEYER et al. (2005) in some ways. Nonetheless, the estimates are considered good enough to serve as inputs for the following analyses.

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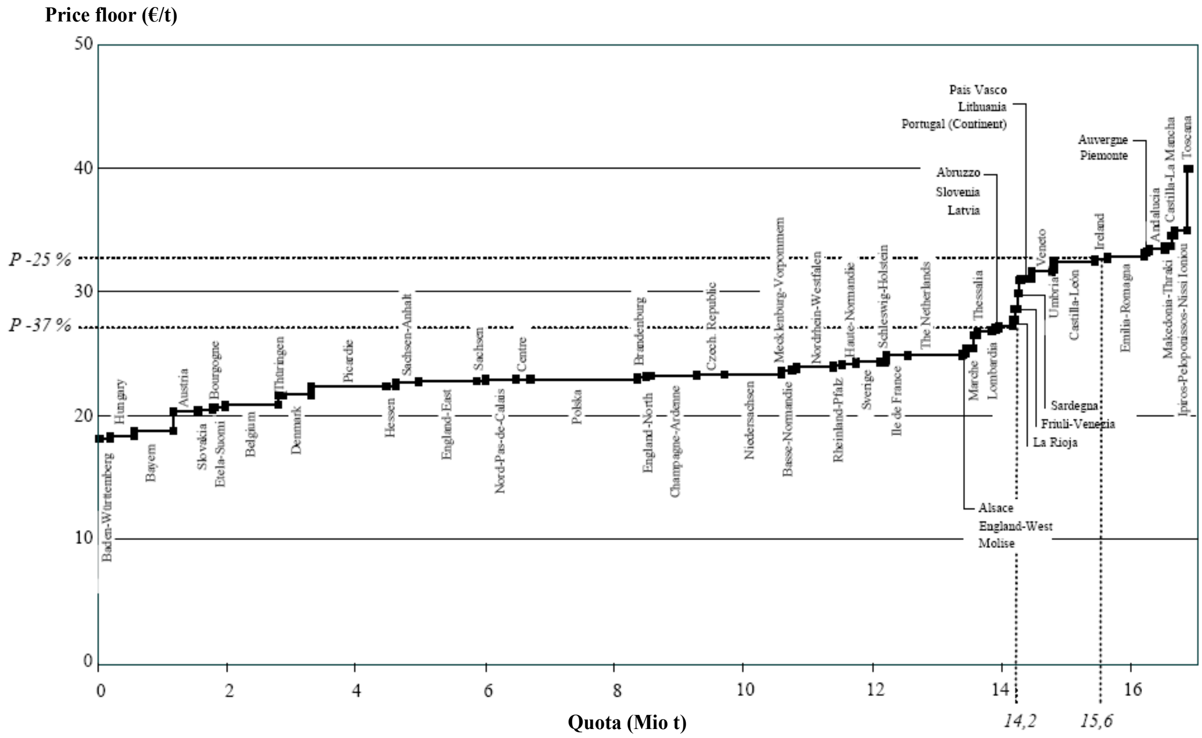
[32] They use EUROSTAT data from 1996.

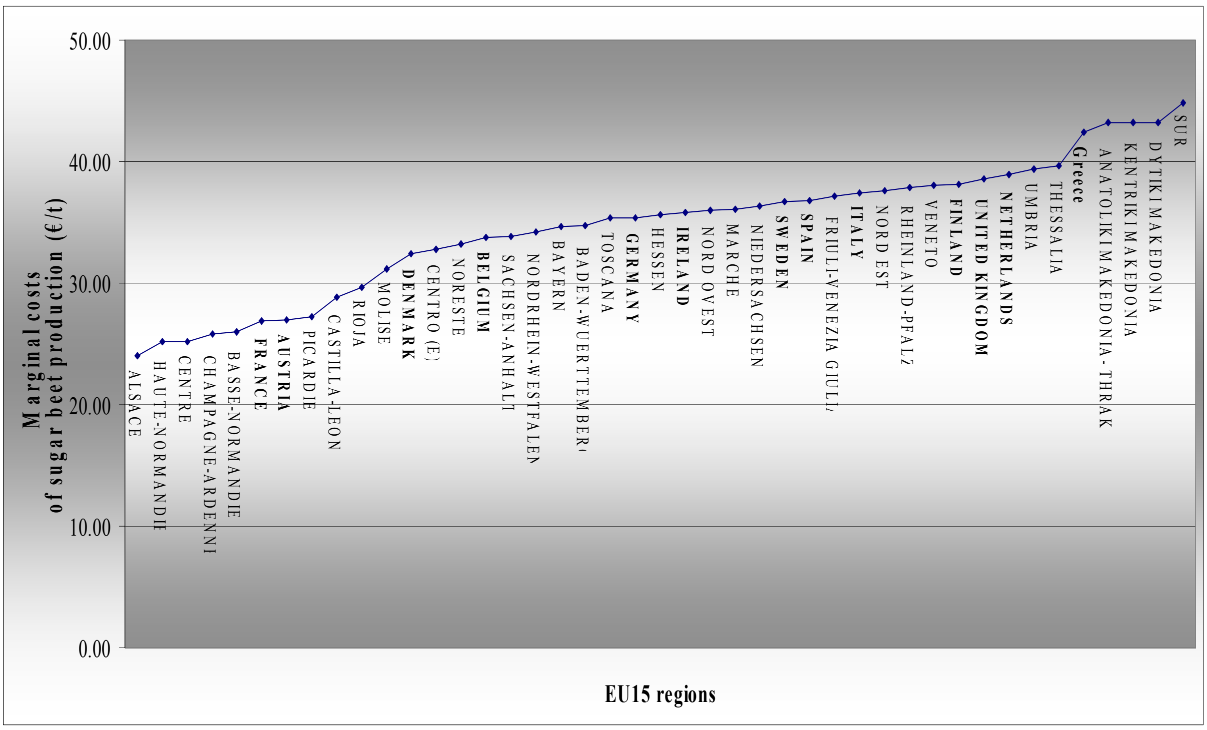
[33] Differences in the ranking of regions can technically be a result of different decoupled premiums. Although ISERMEYER et al. (2005) do not explain how regional marginal costs are corrected by the decoupled premiums, it is likely that regions where a high premium volume is distributed are more corrected than those with lower premium volumes.

Figure 3.5: Price floor of sugar beet production (ISERMEYER et al., 2005)



Source: ISERMEYER et al. (2005)

Figure 3.6: Ranking of marginal cost estimates among EU-15 regions



Source: Author's calculations

3.4 Summary

Section 3.1 gives an overview of what the quota and price support system currently in use implies for a farmer in a framework of profit maximisation, while section 3.2 deals with estimation of single farm quotas and beet prices for farms in the FADN sample. It becomes apparent that many European farmers produce considerable amounts of C-sugar beets. Section 3.3 deals with costs of sugar beet production. The estimated marginal costs of beet production are generally above the estimated C-beet prices given in Table 3.5.[34] In a framework of profit maximisation that would mean that producer type five (explained in Figure 3.1) should not exist at all. But that would be inconsistent with the observed large amounts of C-sugar beet production all across the 13 selected EU Member States. We conclude that profit maximisation is not an appropriate behavioural model for sugar beet farmers.

In the next chapter, we therefore consider and test behavioural hypotheses that go beyond the simple profit maximisation hypothesis. Hereby, we make use of the FADN sample and the results on prices and quotas and marginal production costs found in the current chapter.

[34] Note that the presented prices are based on the period 1990-1999 while marginal costs are based on the period 1997-1999.

4. Incentives to Supply Sugar Beets

It can be concluded from the previous section that many European farmers are producing C-sugar beets. Hence, if we compare total costs and total income of C-beets to soft wheat as other studies have done (e.g. LINDE et al. 2000, SCHMIDT, 2003), it becomes apparent that the gross margin of a hectare of C-beets is lower in nearly in all countries than that of competing crops. According to LINDE et al. (2000), the (EU) average marginal costs amount to 16 € per ton of beets and a gross margin of 12€ per ton is necessary in order to compete with soft wheat. Consequently, C-beet prices should be above 28€. This price has not been reached in the last decade according to our estimates presented in Table 2.1. SCHMIDT (2003) points out that marginal costs for C-beet production are considerably higher than the price which can be received for them. He also analyses the effects of possible price differentiation for C-beets. According to him, most sugar enterprises pay a higher price for a certain amount of C-beets[35] in Germany. But he points out that even this higher price is not sufficient to generate positive gross margins. In contrast to his study, our estimated average C-beet prices for Germany are somewhat higher. They fall in the range of those calculated by LINDE et al. (2000). Hence, the question is still unanswered why we observe large C-sugar amounts in the EU although gross margins tend to be negative.

This chapter provides an analysis of possible incentives for farmers to produce C-sugar beets part of which has already been published by ADENÄUER and HECKELEI (2005) and ADENÄUER (2005). Several hypotheses are made and their implications are presented.

4.1 Expected Profit Maximisation

4.1.1 Sugar Beet Production and Yield Uncertainty

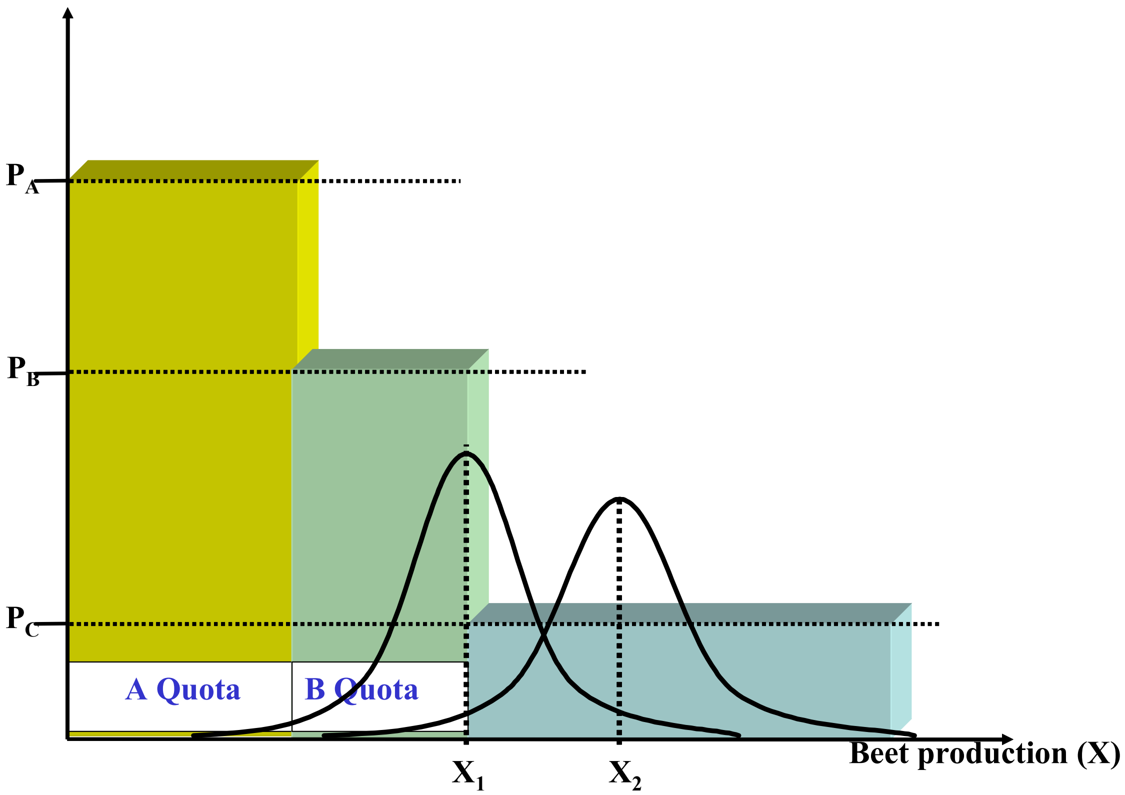
Yield uncertainty is a general phenomenon in agriculture. A farmer cannot perfectly predict the yields of his production activities, because they are influenced by weather and other environmental factors. In a quota system, this becomes even more relevant as there are typically additional economic incentives to fill the quota even in the case of a bad harvest. FRANDSEN et al. (2003) and LINDE et al. (2000) use a common assumption on the impact of

[35] Here, C-beets are distinguished into C1- and C2-beets. C1-beets receive slightly higher prices. Their quantity is again limited.

yield variance. They simply distinguish 'unintended' and 'planned' C-sugar production. The first one is only caused by yield variance and the latter is planned by farmers. The magnitude of unintentional C-sugar is predefined as a certain percentage of quota production (LINDE et al.) or according to the national yield variance (FRANDSEN et al.). This assumption is an extreme simplification of the decision situation of European farmers. In fact, what they call unintentional C-sugar production is likely to depend on production cost, perceived yield variance, individual quota endowments, and expected prices.

Similar to SCHMIDT (2003) [36], let us assume normally distributed sugar beet yields with a certain variance as in Figure 4.1. Suppose a farmer plans to produce – on average – the amount of sugar beets that is exactly equal to the quotas (X_1). In this case, the quota is under-filled with 50% probability implying loss of high quota revenue. Maximising *expected* profits may therefore require a higher planned production level (e.g. X_2).

Figure 4.1: Yield variance and quotas



Source: Author's illustration

Since both sugar beet delivery rights and sugar beet prices (see Table 3.5) are based on average sugar contents, they consequently adapt if those contents deviate from that average.

[36] Schmidt (2003) analyses the impacts of stochastic yields on sugar beet production within Monte Carlo simulations. We want to generalise his assumptions by deriving an analytical framework of this problem.

To eliminate these intermediate calculations, we now define sugar beet production as the process of cultivating beets but the harvested product is sugar. Consequently, we define prices and quotas as well as yields on a sugar basis.

4.1.2 Mathematical Framework[37]

Stochastic sugar yields imply stochastic revenues. Consequently, we start with the mathematical definition of revenues of sugar beet production. In order to make the following derivations more transparent, let us for now assume that there is only one quota quantity Q and two prices for sugar produced within the quota and sugar produced above it. After deriving the mathematical framework for this case, it is straightforward to extend it to the slightly more complex actual quota regulation. The definition of revenue (R_S) of selling sugar to the processing firm is defined as

(4.1) $$R_S = p^Q y_S - \left(p^Q - p^C\right) y_S^C .$$

y_S denotes sugar production quantity and y_S^C sugar quantity exceeding the quota. The respective prices are given by p^Q and p^C. We have chosen this specific formulation because it implies only one censored stochastic variable y_S^C resulting in less cumbersome derivations compared to alternative formulations. Assuming prices to be non-stochastic[38], the expected value of the sugar beet revenue is a function of expected total and expected C-sugar production written as

(4.2) $$ER_S = p^Q Ey_S - \left(p^Q - p^C\right) Ey_S^C ,$$

where E denotes the expectation operator. Assume now that the production y_S is an outcome of a normally distributed random process with the pdf

(4.3) $$f\left(y_S\right) = N\left(Ey_S, \sigma^S\right)$$

and the cumulated density function (cdf)

(4.4) $$F\left(c\right) = \int_{-\infty}^{c} f\left(y_S\right) dy_S$$

where σ^S is the standard deviation of sugar beet production y_S. The density functions of y_S and y_S^C for a given land allocation may appear as in Figure 4.2. Compared to the normally distributed variable y_S, the density function of the C-sugar quantity y_S^C is first mean-shifted by

[37] Parts of the mathematical framework were carried out by Thomas Heckelei.

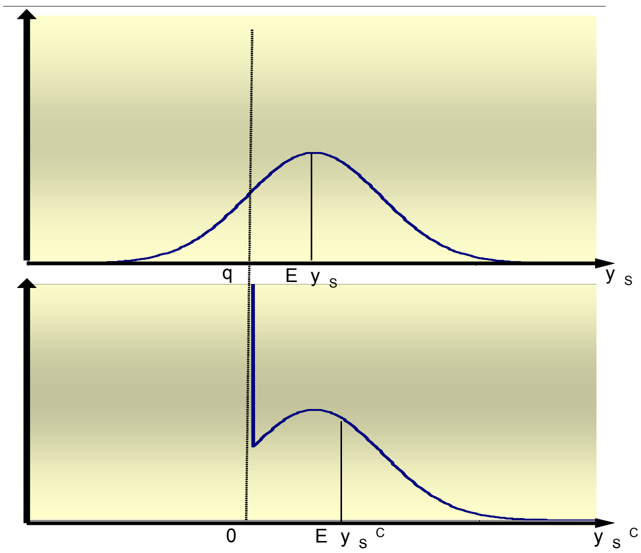
[38] We follow the approach of SCHMIDT (2003) who neglects price uncertainty. Hence, at least C-beets prices – are depending on world market prices and thus uncertain. We will focus on this problem later on.

$-Ey_S$ and then censored at zero. In contrast to a truncation point, the censoring point receives all the probability mass of outcomes of y_S below the quota limit Q, i.e. all cases where the C-sugar quantity is equal to zero. The censoring always moves the mean of the variable away from the censoring point. Using properties of censored random variables (see, for example, GREENE 1990, chapter 21) we can write equation (4.2) as

$$
\begin{aligned}
ER_S &= p^Q Ey_S - \left(p^Q - p^C\right) Ey_S^C \\
&= p^Q Ey_S \\
&\quad - \left(p^Q - p^C\right)\left(1 - F^C(0)\right)\left[(Ey_S - q) + \left(\sigma^S\right)^2 \frac{f^C(0)}{1 - F^C(0)}\right] \\
&= p^Q Ey_S \\
&\quad - \left(p^Q - p^C\right)\left(1 - F(q)\right)\left[(Ey_S - q) + \left(\sigma^S\right)^2 \frac{f(q)}{1 - F(q)}\right] \\
&= p^Q Ey_S \\
&\quad - \left(p^Q - p^C\right)\left[\left(1 - F(q)\right)(Ey_S - q) + \left(\sigma^S\right)^2 f(q)\right]
\end{aligned} \tag{4.5}
$$

where f^C and F^C are the pdf and cdf of the censored variable y_S^C, respectively. The second equal sign follows from the standard formula for a mean of a random variable censored from below and using the fact that the censoring point of the variable y_S^C is zero**.** The third equal sign reveals that all probability and density values can be expressed in terms of the distribution of the total sugar quantity and the fourth follows from algebraic manipulations.

Figure 4.2: Density functions of total and C-sugar beet production for given land allocation



Source: Author's illustration

We now further assume that the standard deviation of sugar beet production is proportional to the planned sugar beet production, i.e. $\sigma^S = Ey_S \cdot \sigma^0$, where σ^0 is the standard deviation of one unit of expected sugar beet production. Under expected profit maximization, optimal expected sugar production is given where marginal costs equal expected marginal revenues. Therefore, we need a formula for the expected marginal revenues (EMR), i.e. the derivative of (4.5) with respect to Ey_S:

$$\frac{dER_S}{dEy_S} = EMR = p^Q - \left(p^Q - p^C\right)\left[\left(-\frac{dF(q)}{dEy_S}\right)\left(Ey_S - q\right) + \left(1 - F(q)\right) + 2\sigma^s\sigma^o f(q) + \left(\sigma^s\right)^2 \frac{df(q)}{dEy_S}\right] \tag{4.6}$$

The expression involves several derivatives of density values and cumulative density values with respect to the mean of the distribution. Let's first look at the derivative of the density value, for example:

$$\begin{aligned}
\frac{df(q)}{dEy_S} &= \frac{d\left(\frac{1}{\sqrt{2\pi}\sigma^S}\exp\left\{-\left(q - Ey_S\right)^2 / 2\sigma^{S2}\right\}\right)}{dEy_S} \\
&= \frac{1}{\sqrt{2\pi}}\left[\begin{array}{l}\frac{-1}{\sigma^0\left(Ey_S\right)^2}\exp\left\{-\left(q - Ey_S\right)^2 / 2\sigma^{S2}\right\} \\ +\frac{1}{\sigma^0 Ey^S}\left(\frac{2\left(q - Ey_S\right)}{2\left(Ey_S\right)^2\left(\sigma^0\right)^2} + \frac{\left(q - Ey_S\right)^2 4Ey_S\left(\sigma^0\right)^2}{4\left(Ey_S\right)^4\left(\sigma^0\right)^4}\right) \\ \exp\left\{-\left(q - Ey_S\right)^2 / 2\sigma^{S2}\right\}\end{array}\right] \\
&= f(q)\left[\frac{-1}{Ey^S} + \frac{\left(q - Ey_S\right)}{\left(Ey_S\right)^2\left(\sigma^0\right)^2} + \frac{\left(q - Ey_S\right)^2}{\left(Ey_S\right)^3\left(\sigma^0\right)^2}\right] \\
&= f(q)\left[\frac{-\left(\sigma^S\right)^2 + Ey_S q - \left(Ey_S\right)^2 + (q)^2 - 2Ey_S q + \left(Ey_S\right)^2}{Ey_S\left(\sigma^S\right)^2}\right] \\
&= f(q)\left[\frac{(q)^2 - Ey_S q - \left(\sigma^S\right)^2}{Ey_S\left(\sigma^S\right)^2}\right]
\end{aligned} \tag{4.7}$$

.

Noting that the $F(q^A)$ is

$$F\left(q^A\right)=\int_{-\infty}^{q^A}\frac{1}{\sqrt{2\pi}\sigma^S}\exp\left\{-\left(x-Ey_S\right)^2/2\sigma^{S2}\right\}dx$$

and that the derivative of an integral is equal to the integral of the derivative (if bounds of integral do not depend on the variable of integration), we can write

$$\begin{aligned}\frac{dF(q)}{dEy_S}&=\int_{-\infty}^{q}\frac{1}{\sqrt{2\pi}\sigma^S}\left[\frac{x^2-Ey_Sx-\left(\sigma^S\right)^2}{Ey_S\left(\sigma^S\right)^2}\right]\exp\left\{-\left(x-Ey_S\right)^2/2\sigma^{S2}\right\}dx\\&=\left(-\frac{x}{Ey_S}\right)\frac{1}{\sqrt{2\pi}\sigma^S}\exp\left\{-\left(x-Ey_S\right)^2/2\sigma^{S2}\right\}\Big|_{-\infty}^{q}\\&=\left(-\frac{q}{Ey_S}\right)\frac{1}{\sqrt{2\pi}\sigma^S}\exp\left\{-\left(q-Ey_S\right)^2/2\sigma^{S2}\right\}-0\\&=\left(-\frac{q}{Ey_S}\right)f(q)\end{aligned}\qquad(4.8)\;.$$

Substituting equations (4.7) and (4.8) into (4.6) we obtain an analytical expression of marginal expected revenue as

$$\begin{aligned}\frac{dE\left[R_S\right]}{dEy_S}&=EMR=p^Q\\&-\left(p^Q-p^C\right)\left[\begin{array}{l}\frac{q}{Ey_S}f(q)\left(Ey_S-q\right)+\left(1-F(q)\right)\\+2\sigma^s\sigma^o f(q)+\left(\sigma^s\right)^2f(q)\left[\frac{(q)^2-Ey_Sq-\left(\sigma^S\right)^2}{Ey_S\left(\sigma^S\right)^2}\right]\end{array}\right],\end{aligned}\qquad(4.9)$$

which can be simplified to

$$EMR=p^Q-\left(p^Q-p^C\right)\left[\left(1-F(q)\right)+f(q)\sigma^S\sigma^0\right]\qquad(4.10)$$ [39]

[39] Note that in case of stochastic prices the result for EMR would be exactly the same as long as prices and yields are independent. In this case, prices only need to be replaced by the mean of the expected prices. Stochastic prices therefore play no role for the analysis of expected marginal revenues.

4.1.3 Sensitivity Analysis of Expected Marginal Revenues

Equation (4.10) gives the expected marginal revenue of sugar production for our 'one quota assumption'. It can easily be extended to a 'more' quota system. In this section, we will analyse the properties of the EMR with respect to the variables on which it depends. Our model is therefore extended to a system with A-, B- and even C1-quotas. EMR is then given as:

$$\begin{aligned} EMR = {} & p^A \\ & -\left(p^A - p^B\right)\left[\left(1-F\left(q^A\right)\right)+f\left(q^A\right)\sigma^S\sigma^0\right] \\ & -\left(p^B - p^{C1}\right)\left[\left(1-F\left(q^{AB}\right)\right)+f\left(q^{AB}\right)\sigma^S\sigma^0\right] \\ & -\left(p^{C1} - p^{C2}\right)\left[\left(1-F\left(q^{ABC}\right)\right)+f\left(q^{ABC}\right)\sigma^S\sigma^0\right] \end{aligned} \tag{4.11}$$

P^A, P^B, P^{C1} and P^{C2} are the prices for the respective sugar type and q^A, q^{AB} and q^{ABC} the respective cumulated quotas. The EMR of sugar beet production depends on the following variables: sugar prices, yield variance, and finally the quota endowments. To analyse the impacts of these variables on the EMR, we generate a reference farm with the following settings. For better comparability, we take the reference settings from SCHMIDT (2003), but transfer beet prices into sugar prices by dividing them by 16% sugar content per beet.

Table 4.1: Reference data for EMR analysis

A sugar quota	B sugar quota	C1 sugar quota	coefficient of yield variation	A sugar price	B sugar price	C1 sugar price	C2 sugar price
50 t	10 t	5 t	0.15	363 €	231 €	106 €	69 €

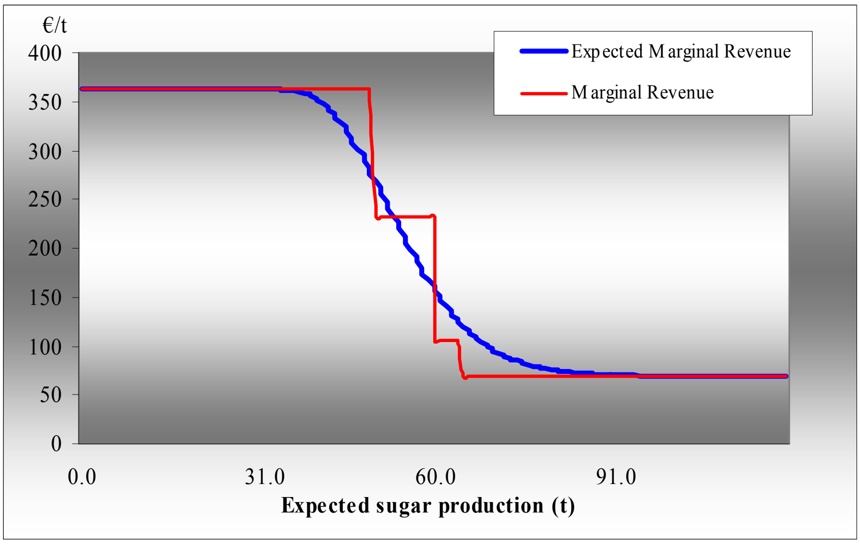
Source: SCHMIDT (2003)

The magnitude of these numbers is not important for now, since we are analysing only the general properties of the EMR function.[40] A comparison between expected marginal revenues and marginal revenues without stochastic yields is given in

[40] Note that both C-sugar prices seem to be generally lower than our own estimates for Germany given in Table 3.5. There are two main reasons for this: (1) Our estimates include discharges and mark ups not included here and (2) the prices used by SCHMIDT (2003) refer to another time period.

Figure 4.3. Both variables are evaluated at different relations of the expected production to the A+B quota endowment.

Figure 4.3: Expected marginal revenues of sugar production



Source: Author's calculations

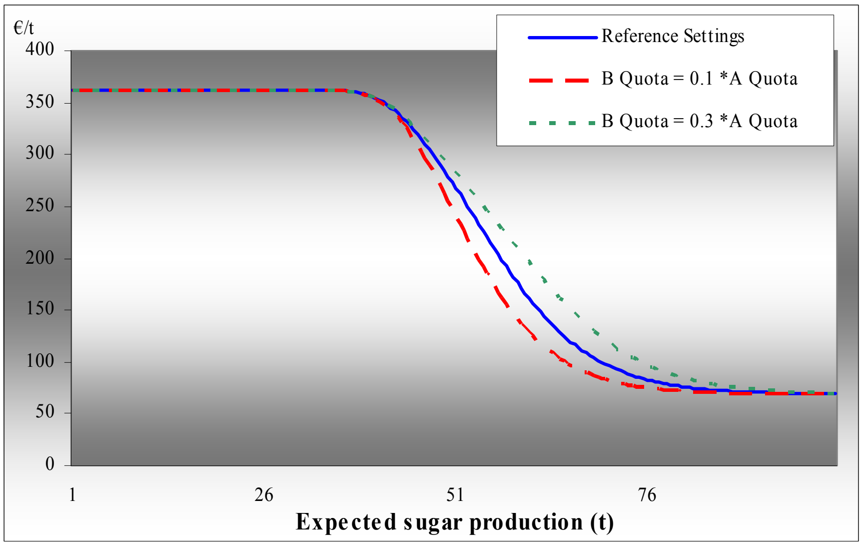
The marginal revenue of sugar production equals the respective price for the four different beet types. The expected marginal revenue (EMR), hence, smoothes out the characteristic kinks of the marginal revenue function, while both are congruent at both endings of the graphs. While a farmer producing sugar at marginal costs of about 300 €/t exactly fills his A-quota if he applies classical profit maximisation, he will not fulfil his A-quota under expected profit maximisation because getting less money for sugar produced beyond the A-quota is for him a greater loss than not completely filling his A-quota. On the other hand, a farmer with marginal costs of about 90 €/t supplies under EMR assumptions C2-beets, which he would not have done as a profit maximiser, because the expected loss of not filling his quota in case of a bad harvest is higher than that of producing C2-beets prices that are lower than his marginal costs.

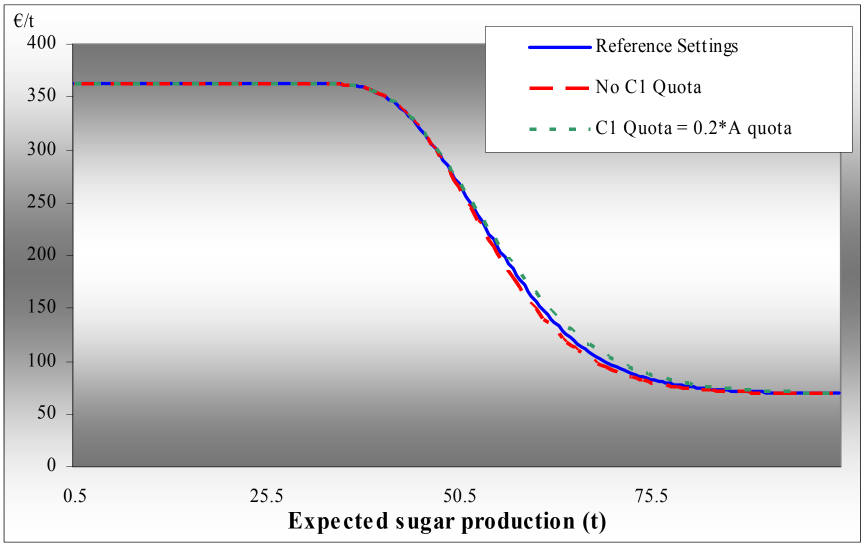
Now we examine how expected marginal revenues depend on the different variables that are part of its definition. The EMR in

Figure 4.3 is our starting point and will be repeated in all following figures. We start with:

Changes in the quota endowments

Figure 4.4: Expected marginal revenues and quota changes (1)

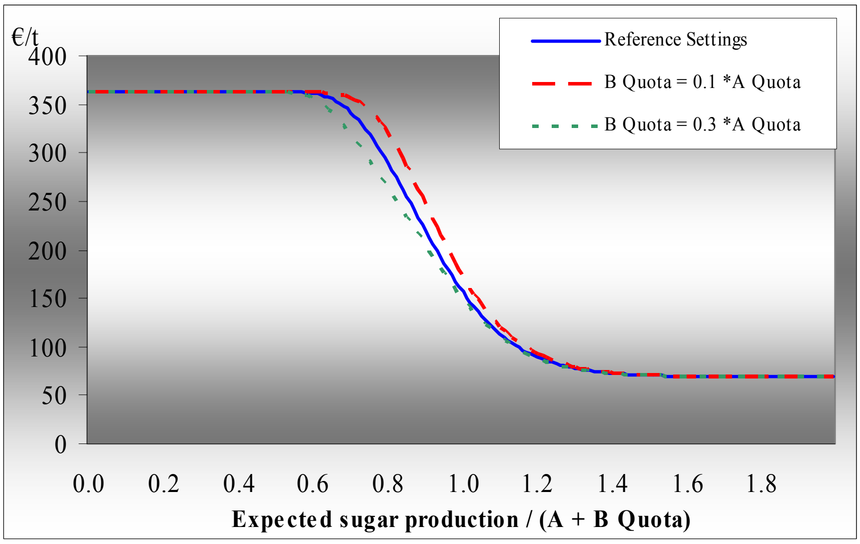




Source: Author's calculations

Figure 4.4 shows that a higher B-quota reduces the slope of the EMR function while it is made steeper by a reduction of the B-quota. A higher B-quota therefore triggers higher production as long as marginal costs are not so high or so low that B-quota changes do not matter. Changes in C1-quotas have principally the same effect, but of a lower magnitude because price differences and absolute quota changes are lower. It is very likely that rising quotas trigger rising production; it may be more interesting to graph the EMR against the expected sugar production relative to the A+B-quota. Then, the picture looks different:

Figure 4.5: Expected marginal revenues and quota changes (2)



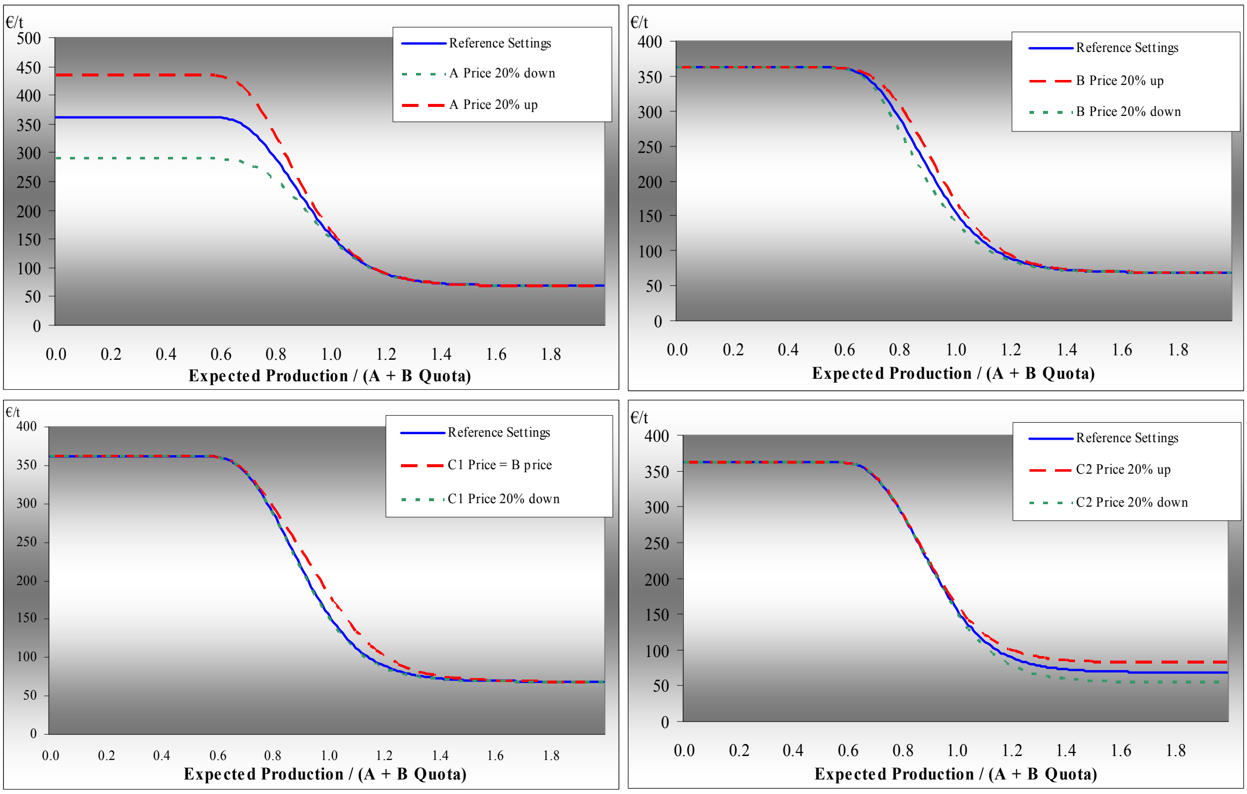
Source: Author's calculations

At first sight, it is somewhat surprising that a higher B-quota now reduces the slope of the EMR function because with the same marginal costs the corresponding supply quantities relative to the A+B-quota would be lower. But imagine a farmer planning to fill his A+B-quota in the reference and then the B-quota is reduced. The probability that the A-sugar price is relevant in case of a bad harvest is then higher than before. Consequently, the expected marginal revenue rises as well if the farmer still plans to fill his quota exactly. A reduction of B-quotas can therefore trigger higher shares of C-sugar.

Changes in sugar prices

The impacts of price changes on the EMR of sugar beet production are obvious. Only those parts of the EMR function where the respective price plays a role are affected. A farmer who produces at marginal costs of 200 €, for example, is only affected by changes in B-sugar prices. A high cost producer, who has marginal costs that amount to about 300 €/t, does not care about changes in C-sugar prices, while he is greatly affected by changes in A-sugar prices. The contrary is true for a low cost producer who will react to C-price changes but not at all to varying A-prices. The impacts of varying C1-prices are obviously small but only as long as the C1-prices are only slightly higher than those for C2-sugar. If C1-beets received the same price as B-beets, this would trigger higher shares of C-sugar as well.

Figure 4.6: EMR for different sugar prices

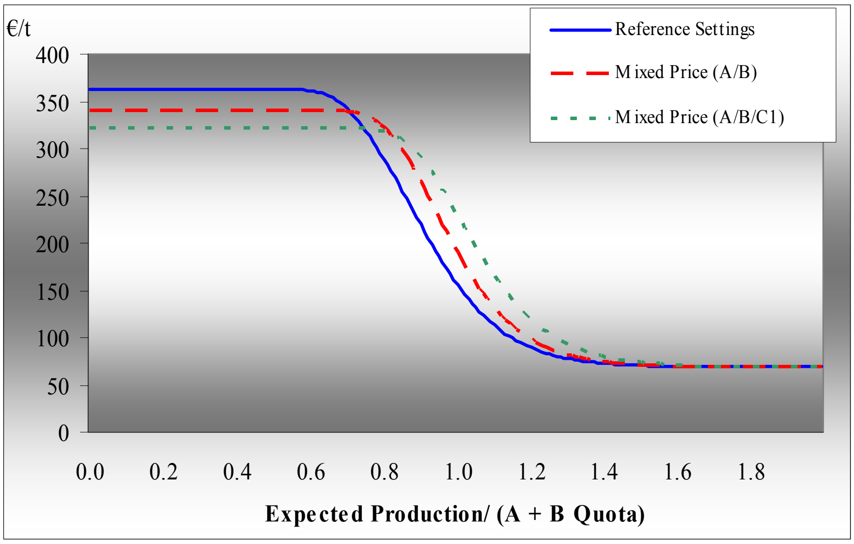


Source: Author's calculations

Mixed price system

A special feature of European sugar markets is that processing firms have the possibility to pay farmers based on mixed prices. That means farmers receive the same price, regardless of whether they produce within the A-quota or within the B-quota. This system is implemented in Spain, Portugal, Italy, Belgium, Ireland, Greece, and the United Kingdom. The effects of such a system are shown in Figure 4.7. Compared to the classical payment scheme, the maximum values of the EMR functions are lower. But the decreasing part of the functions is moved to the right. A farmer producing at marginal costs of 200 € would cultivate more beets under a mixed price system than in the reference because it is now more 'expensive' for him not to fill the B-quota. If there a mixed price system was implemented that also contained C1-beets, the effect would be even greater. Such a system is actually implemented in the Netherlands where farmers receive the mixed price for 106% of total quotas (LINDE et al. 2000). Generally speaking, mixed price payment schemes trigger higher C-sugar productions, as long as marginal costs of sugar production do not equal A- or C-beet prices.

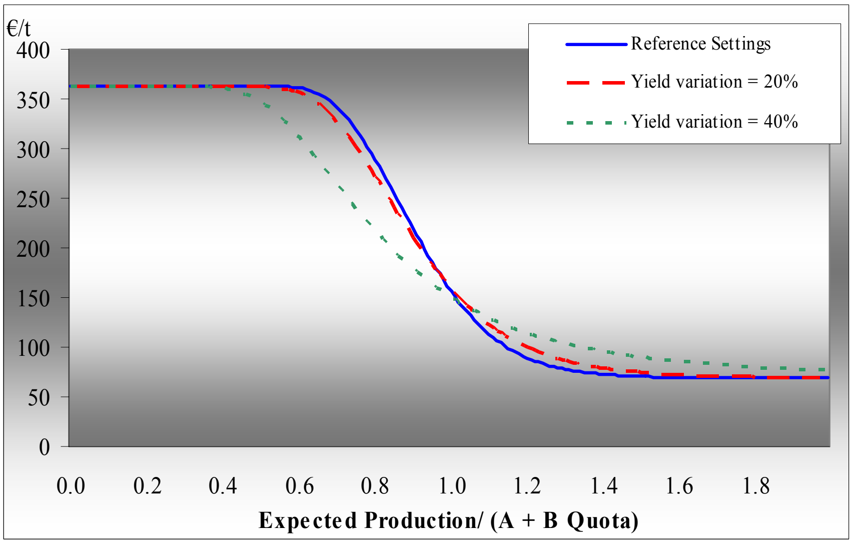
Figure 4.7: EMR and mixed price systems



Source: Author's calculations

Changes in yield variance

Figure 4.8: EMR for different yield variations



Source: Author's calculations

Higher yield variation means in this context nothing but higher uncertainty. A C-sugar producing farm has to cope with a higher probability that B- or even A-sugar prices are relevant, so that the EMR function takes a higher value. A high cost producer, who does not completely fill his quotas, however, is faced with a higher probability that C-prices will be relevant for him. Consequently, expected marginal revenues are lower. One can see that a certain point exists – in our example at marginal costs of about 150 €/t – where the EMR value does not react to changing expected yield variance. Here both effects, that of a higher probability of C-beet prices and that of A-beet prices, compensate each other.

This small sensitivity analysis gives us an idea of how the expected marginal revenues of sugar production depend on certain variables. It becomes apparent that changing different economic variables will affect sugar production in different ways. All reactions are strongly dependant on the marginal costs of sugar production. The distinction between C1- and C2-sugar seems to be of minor importance under the assumed conditions. Therefore, we further refrain from using a C1/C2 differentiation and return to the classical case of A-, B-, and C-sugar.

In the next section we will examine whether the framework of expected profit maximization can contribute to explain the observed C-sugar amounts in the EU.

4.1.4 Contribution to Explain European C-Sugar Production

We will now analyse observed sugar quantities in the EU Member States with respect to expected profit maximisation. In the first step, we treat each country as if it were one farm. This ignores all differences between farms, but in the second step, an analysis at farm level will be carried out.

Analysis at EU Member State level

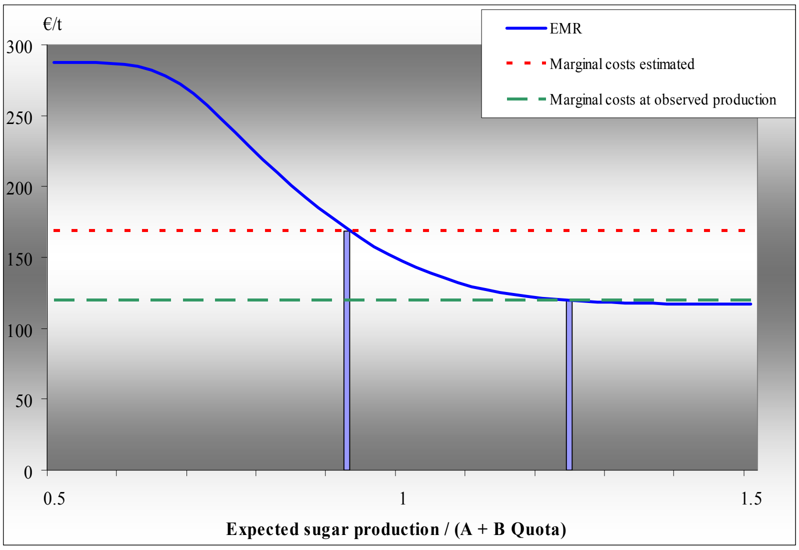
As in section 3 and for better comparability with HENRICHSMEYER et al. (2003a), we deal with average figures during the years 1997-1999. Each aggregated national farm for now is assumed to own the national quota endowment. We take the A-, B- and C-sugar prices from the farm quota estimation in section 3.1 and calculate their weighted averages during the three years. The national yield variation calculated based on FADN is explained in the farm level analysis in the subsequent section. Production quantities and yields are taken from the CoCo[41] data base. To compare the observed sugar productions with the optimal one under expected profit maximisation, it is necessary to know the marginal costs of sugar production. For our analysis, we use our estimates shown in Table 3.6. For simplification we assume the national marginal production costs of sugar to be independent of sugar beet acreage.

Figure 4.9 shows for France what the optimal sugar production would be under profit maximisation. On the x axis, sugar production quantities relative to the quota endowment are given. The red dotted line is the marginal cost curve of the French producer estimated at 168 €/t of sugar and assumed to be independent of the total production quantity.

[41] See section 5.1.1

At the point where the marginal cost curve crosses the EMR function (at about 93%) the optimal sugar production is found. The observed production, hence, is given at 124% of the quota endowment. If that were the planned production of a producer that maximises expected profits, it would mean that his marginal costs of sugar production only amount to about 120 €/t, which corresponds to only about 19 €/t of sugar beet.[42] Our own estimates and those of the three other sources analysed in section 3.3, suggest that this would be quite low.

Figure 4.9: Expected profit maximization of an average French sugar beet farmer



Source: author's calculations

The picture looks similar for most of the 13 EU Member States. But there are some countries where marginal costs at the observed production are closer to our estimates than in France. The optimal sugar production at estimated marginal costs under expected profit maximization, estimated marginal costs, and marginal cost at observed production quantities for the time period 1997 to 1999 are given in Table 4.2. Member States are sorted by the difference between estimated marginal costs and theoretical ones at observed sugar production under expected profit maximization. We find Greece at the top. According to their EMR function, they even produce at higher marginal costs than the estimated ones. Consequently, observed production is below the theoretical optimum. Greece is followed by two countries, where estimated marginal costs and those at the observed production are almost equal, Spain and the Netherlands. In the case of the average Dutch farmer, this is only because we enhanced the national quota endowment by 6% since LINDE et al. (2000) point out that in the Dutch payment scheme for sugar beets, the mixed price is paid for up to 106% of

[42] Sugar content of 16%

the quota endowment. At position four and five we find Italy and Finland where observed and optimal production are not far apart. Starting with Austria, the gap between estimated marginal costs and those at observed supply quantities increases notably. Especially in the main C-sugar producing countries, the United Kingdom, France and Germany, expected profit maximization seems to be insufficient to explain beet producer's behaviour.

Table 4.2: Optimal and observed sugar production and corresponding marginal costs of sugar production under expected profit maximization, averages for 1997-1999

	Sugar production in expected profit maximum / quota at estimated marginal costs	Observed sugar production / quota	Estimated marginal costs (€/t of sugar)	Marginal costs at the observed production (€/t of sugar)
EL	0.94	0.82	318.38	346.64
ES	1.03	1.04	233.02	224.73
NL	0.98	1.00	236.09	225.22
FI	0.96	1.02	254.72	237.32
IT	0.98	1.04	260.9	241.51
AT	1.02	1.24	156.48	126.6
DK	0.96	1.26	179.75	136.39
IR	0.94	1.06	213.58	167.2
FR	0.92	1.24	168.27	119.29
BL	1.00	1.16	182.61	130.93
SE	0.94	1.08	204.52	151.7
DE	0.92	1.20	201.03	141.35
UK	0.98	1.32	214.14	131.22

Source: Author's calculations

We should still keep in mind that the current analysis is based on average beet producers and disregards potential aggregation problems. That means in each country we find farmers with higher and lower marginal costs compared to the ones given in Table 2.1. Consequently, there might be farms where the optimal sugar production with respect to expected profit maximisation is closer to or farther away from the observed one. To test this theory, we will return to farm level analysis in the next section.

Analysis at farm level

In the previous sections we pointed out potential problems with aggregate or average analysis. In each country we will find a distribution of marginal costs across farms around the average. This implies the general inability of the aggregate model to represent producer behaviour: for example, the national quota might be over-filled even if average values would indicate differently. To get an overview of distributional implications we calculate optimal sugar production quantities for sugar producing farms in the FADN database and compare them to observed ones. We use the same sample as in the quota estimation in section 3.1. Production quantities, sugar yields[43] and the respective prices and marginal costs are calculated as three-year averages for each individual farm. Yield variation, however, is assumed to be constant (relative to the mean production) across farms within one region because an individual farm calculation of yield variance across maximal ten, but mostly about five years would result in a poor estimate. This is a simplification as well, because in reality, a farmer observes the yield fluctuation on his own farm and is less interested in that of his neighbours. The regional yield variance is calculated across all farms in one region that produce sugar beets in the years 1995-1999. Again, we use in each region only the 95 quantiles of the probability mass in order to eliminate outliers. The regional coefficient of yield variation is calculated as:

$$(4.12) \qquad V_r = \frac{\sqrt{\sum_{i,t}(y_{it} - \mu_r)}}{n_r \mu_r} \qquad \forall i \in r, t \in T_i$$

$$T_i = \{(i,t) : FQ_{i,t} \neq 0, MC_{it} \neq 0\}$$

T_i is a cross set that includes for all farms i the dates of the period 1995-1999 where they are part of the sample. V_r is the coefficient of variation in region r, n_r the number of observations in a region, $y_{i,t}$ the sugar yield of farm i in year t and μ_r the average regional sugar yield. FQ_{it} and MC_{it} denote farm quotas and marginal costs.[44]

As a result of this calculation, the yield variation amounts about 16% of the respective mean yield on EU average. It varies among the different countries and regions. Higher yield variances are found in Greece, Finland, Italy and Spain while they are lower in Belgium, the

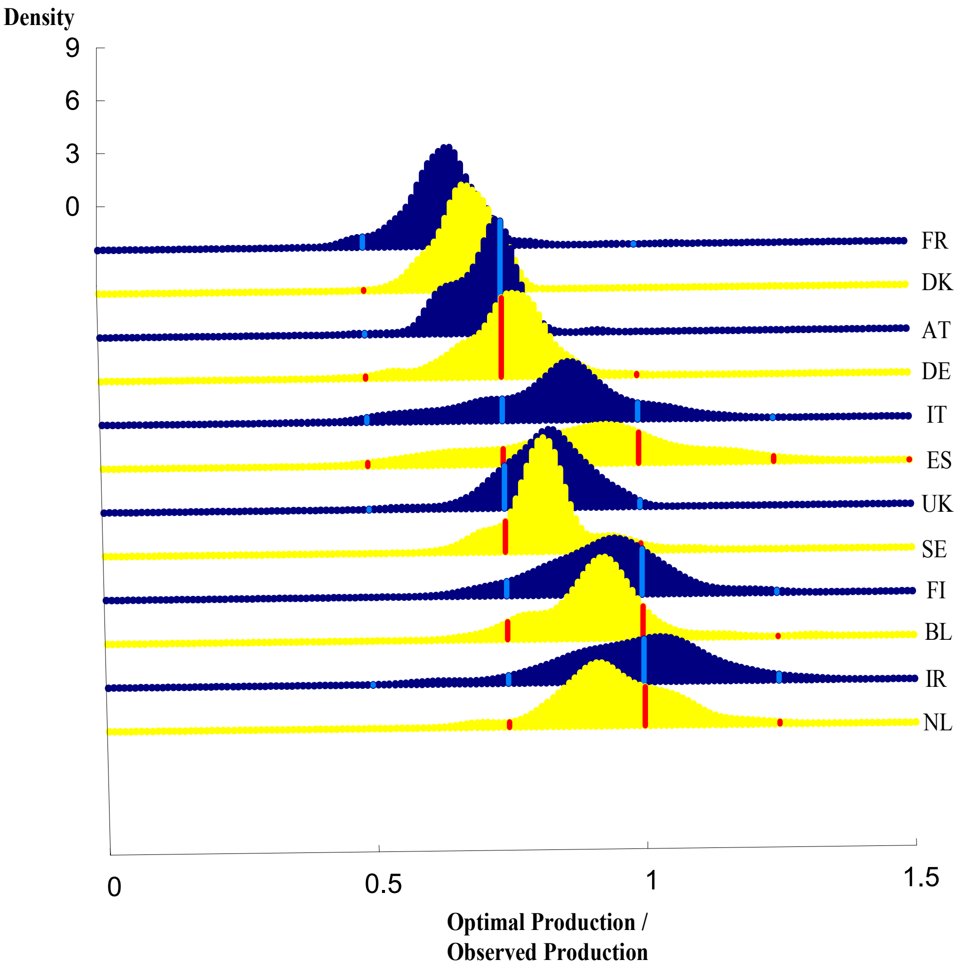
[43] Sugar beet yields are calculated by dividing production quantities by the respective acreages. Those are then multiplied by the average national sugar content derived from the CoCo data base. Thereby we disregard heterogeneity across farms in terms of sugar contents.

[44] We should add that yield variation is only estimated in those regions where at least 20 observations are remaining. If the number of observations is lower, as in some regions in south Italy, the national average yield variation is used.

Netherlands and Denmark. The highest variance in sugar yields is found in *Pais Vasco* in Spain with 29%, while the northern German regions (11%) and *Champagne-Ardenne* in France (10%) show the lowest yield variations. As apparent in Figure 8.2 in the Annex, there seems to be a south-north decline in relative yield variation.

Having defined all necessary variables to calculate the profit maximising production quantities for each individual farm and our base year, we can compare the results to the observed supply quantities. The ratio of expected profit maximising production over observed production is the indicator presented in Figure 4.10 in terms of Kernel density estimates.

Figure 4.10: Kernel density estimates of optimal over observed production under expected profit maximization



Source: Author's calculations

For better orientation, the functions are marked every 0.25 step of the support. In France, Denmark, Austria, the United Kingdom, Sweden, and Germany we find hardly a single farm with an observed production quantity above the expected profit maximum. In the other countries, there may be farmers whose expected profit could be the maximised objective function as a number of farms actually produce around the derived quantity (ratio takes an value is unity).[45]

Under the given assumptions, we conclude that expected profit maximisation seems to be insufficient to explain observed sugar productions for most farmers across the 13 Member States considered. In order to rescue the hypothesis, one would have to refer to particularly high yield variability at particular locations which is neglected in our use of the average standard deviation or speculate that highly efficient farmers have not been included in the FADN sample. Both are unrealistic assumptions.

The next chapter analyses whether the observed C-sugar quantities in the EU Member States are possibly the outcome of utility maximisation with risk averse behaviour.

4.2 Utility Maximisation under Risk Aversion

Expected profit maximization implies risk neutral behaviour of farmers. Risk averse behaviour can be modelled with a utility maximization framework where expected profit and variance of profits enter the utility function as arguments. To some extent, risk averse farmers are willing to accept lower expected profits as long as the profit variance decreases sufficiently. Which combination of profit mean and variance is optimal depends on the degree of risk aversion. We will now extend the analysis of the previous section to examine the additional importance of the variance of profits.

4.2.1 Mathematical Framework

The first required element, the definition of expected revenues, has already been derived in section 4.1.2 (equation (4.10)). It depends on planned production, the quota endowment, variance of yields, and prices. The variance of expected sugar beet revenues can be computed based on the definition of revenue given in equation (4.2). When we apply the formula for linear combination of two random variables[46] we obtain the following result:

$$\begin{aligned}(4.13)\qquad VAR(R_S) &= \left(p^Q\right)^2 VAR\left(y_S\right) + \left(p^C - p^Q\right)^2 VAR\left(y_S^C\right) \\ &+2\left(p^Q\right)\left(p^C - p^Q\right) COV\left(y_S, y_S^C\right)\end{aligned}.$$

[45] Greece was excluded from this analysis due to data errors.

[46] See for example GREENE (1990), chapter 3.6.2.

Let us look at the different terms of the sum. The first contains the already used yield variance:

$$\text{(4.14)} \qquad \mathrm{VAR}(y_S) = \left(\sigma^S\right)^2$$

Using the previously introduced notations, one can apply a formula for the variance of censored variables[47] for the second term:

$$\text{(4.15)} \qquad \mathrm{VAR}\left(y_S^C\right) = \left(\sigma^S\right)^2 \begin{pmatrix} 1 - \dfrac{f(q)}{1-F(q)}\left(\left(\sigma^S\right)^2 \dfrac{f(q)}{1-F(q)} - \left(q - Ey_S\right)\right) \\ + \left(\dfrac{q - Ey_S}{\sigma^S} - \sigma^S \dfrac{f(q)}{1-F(q)}\right)^2 F(q) \end{pmatrix} (1 - F(q)).$$

And finally we need the covariance of the two variables. Starting with the definition of the covariance one can write:

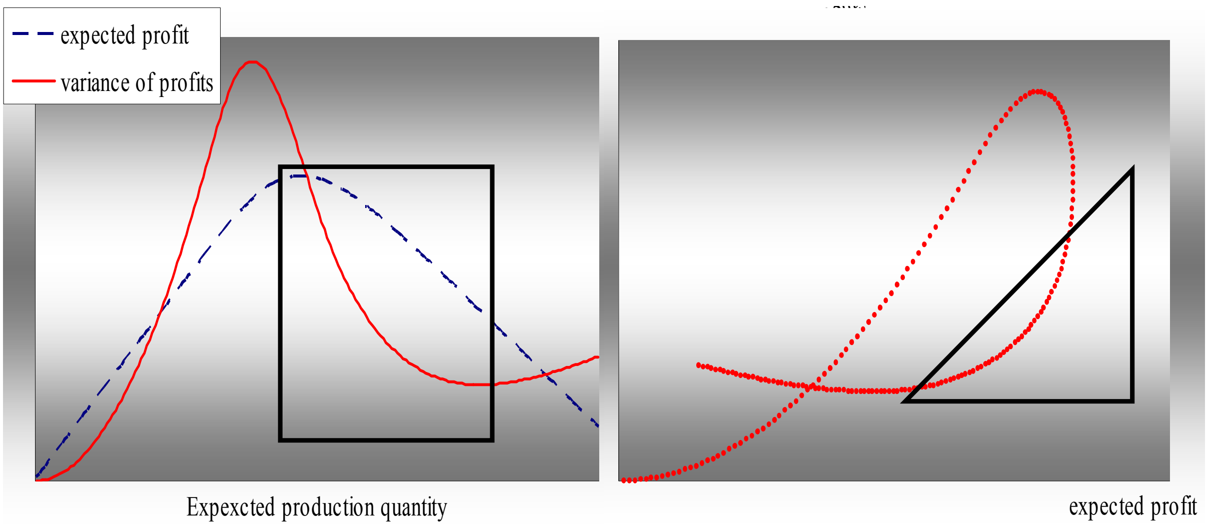
$$\text{(4.16)} \qquad \begin{aligned} \mathrm{COV}\left(y_S, y_S^C\right) &= E\left[\left(y_S - E[y_S]\right)\left(y_S^C - E\left[y_S^C\right]\right)\right] \\ &= E_{y_S>q}\left[\left(y_S - E[y_S]\right)\left(y_S - q - E\left[y_S^C\right]\right)\right] P[y_S > q] \\ &\quad + E_{y_S \le q}\left[\left(y_S - E[y_S]\right)\left(0 - E\left[y_S^C\right]\right)\right] P[y_S \le q] \\ &= \begin{pmatrix} E_{y_S>q}\left[y_S^2\right] - E_{y_S>q}[y_S]q - E_{y_S>q}[y_S]E\left[y_S^C\right] \\ -E[y_S]E_{y_S>q}[y_S] + E[y_S]q + E[y_S]E\left[y_S^C\right] \end{pmatrix} P[y_S > q] \\ &\quad + \left(E\left[y_S^C\right]\left(E\left[y_S\right] - E_{y_S \le q}\left[y_S\right]\right)\right) P[y_S \le q] \end{aligned}$$

The second equal sign follows from the possibility to divide expectations into conditional expectations. We distinguish between two probability distributions conditional on y_s being above and below q. Consequently, both distributions are truncated normal distributions, the first one being truncated from below, the second from above. Note that $E_{ys>q}[y_s]$ is different from $E[y_S^C]$ since the former is a truncated and the latter a censored variable. We can now substitute the relevant formulas for means of truncated, censored, and squared variables into (4.16) (GREENE 1990, chapter 21). The weighting factors (P[y<q] and P[y>q] are given by the value of the cumulated normal distribution at q and its complement value, respectively.

[47] See for example GREENE (1990), p. 726. In our case, it makes no difference whether we use the distribution of the variable y_S^C that is censored at zero, or that of the variable y_S, censored at the quota endowment. The variance of both distributions is the same.

The final formula derived by substituting (4.14), (4.15) and (4.16) into (4.13) is considerably more complex than the expected marginal revenue in the previous section. We will therefore refrain from writing it out here.[48] Instead, we show the general shape of this variance function in Figure 4.11. Note that the variance of expected profits equals that of expected revenues as long as yield fluctuations do not affect the production costs.[49] We keep this assumption in order show the interdependencies of expected profits and their variance.

Figure 4.11: Expected sugar beet profits and the variance of profits



Source: Author's calculations

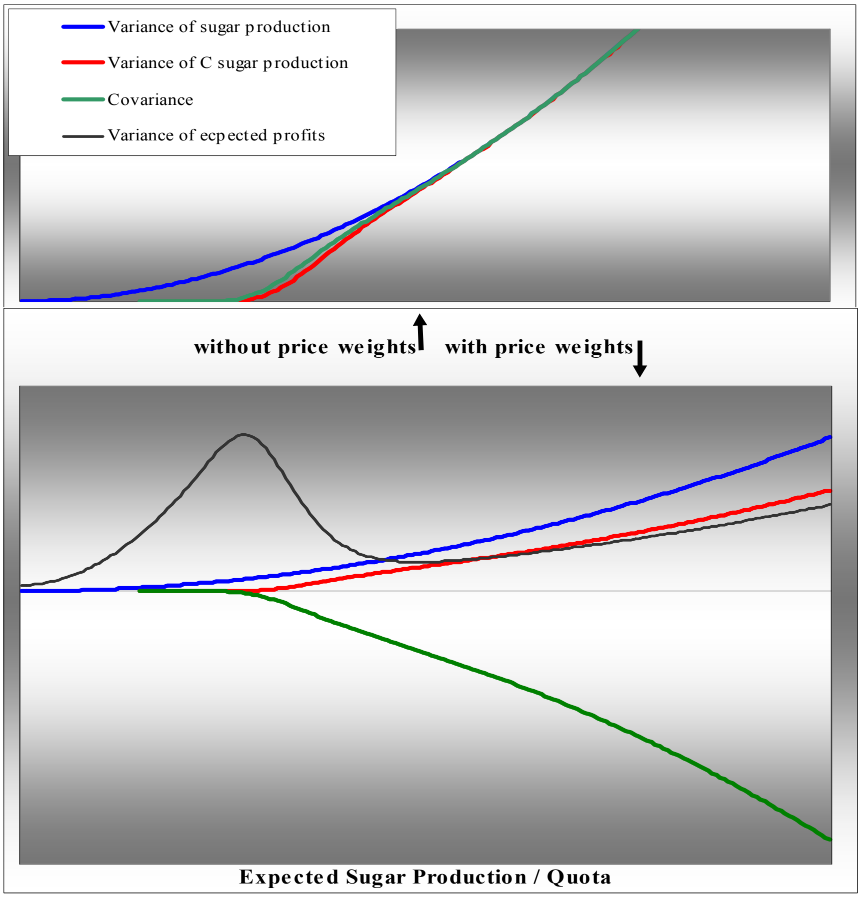
To understand this shape it is helpful to look at equation (4.13). Disregarding the price weights for now, there are three variance and covariance functions added up, all depending on the expectations of sugar production. It turns out that all of them are monotone increasing in expected sugar production as visible in the upper part of Figure 4.12. It is further apparent that all three functions are asymptotically identical, because increasing planned sugar production moves the censoring point of the C-sugar production to the left tail of the pdf so that both distributions become identical. Consequently, the variance of sugar production equals that of C-sugar production. Also, the covariance of two identical stochastic variables equals their variance, so that the functions are identical for high planned sugar production. The slope of all three functions depends on the assumed yield variation. The higher it is the steeper they are.

[48] The mathematical derivation of the final formula is given in section 8.2.

[49] Some positions of total marginal costs, hence, might be considered stochastic. For example, transportation costs of sugar beets to the processing firms will be lower in the case of a bad harvest. The same accounts for opportunity costs. A farmer cannot predict his marginal income from competing crops, because yields and prices are likely to be uncertain as well. We disregard these points in our analysis.

The characteristic shape of the variance of expected profits, however, strongly depends on those three functions and on the prices that serve as weights. In the lower part of Figure 4.12, we find the three elements of equation (4.13) including the weighting factors. The two variances are added while the covariance part is negative because p^C is generally lower than p^Q. Obviously there is a certain scope where the covariance component is absolutely greater than the sum of the two variances. This is a necessary condition for the variance of profits to have local minima and maxima. One can imagine two cases were this condition is violated. Either the variance is extremely high so that the variance of sugar production dominates over the whole domain, or the weight of the covariance part is too small to compensate the other components. The product $2p^Q(p^C-p^Q)$ must be of a certain magnitude or, in other words, if the difference between quota- and C-sugar prices becomes very small, the variance of expected profits might have no local minimum at all. Given the current price differences between quota- and C-sugar, the latter is likely to be irrelevant.

Figure 4.12: Components of the variance of profits



Source: Author's calculations

It should be pointed out that it would be complicated to extend the system to include more quotas, because the variance and covariance of all variables have to be considered. In the case of the classical two-quota system, we deal with three normal distributions of which two are censored. Their variance will always be a positive part in the expected profit variance function. The covariance between the uncensored variable and each of the censored ones always accounts negative, but the covariance between the two censored variables accounts positive because they are both pre-multiplied by negative price differences. Nonetheless, the general conclusions remain the same.

On the left side of Figure 4.11, we also plot an expected profit function. Where its maximum is located naturally depends on the assumed production costs. As long as the maximum lies to the left of the variance minimum, there is a certain range where both expected profits and their variance decrease. This range is marked with the black frame. Risk averse producers will operate within this range because they might forego higher expected profits if they gain in turn less profit variance. On the right side of the same figure, expected profits and variance are plotted on different axes in a mean-variance diagram. Here, the triangle marks again the range, where risk averse cannot be excluded.

The question is now whether risk averse behaviour is sufficient to explain the observed C-sugar quantities in the EU. But before answering this question, we will provide a short sensitivity analysis of the variance function with respect to the variables it depends on.

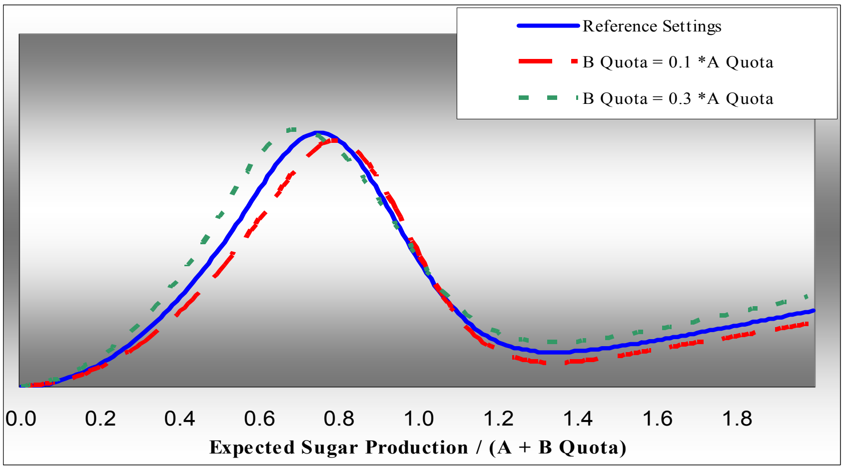
4.2.2 Sensitivity Analysis of the Variance Function

The following sensitivity analysis, similar to that of the EMR, is based on the reference settings given in Table 4.1 on page 56. We systematically vary the variables of interest ceteris paribus and start with:

Changes in the B-quota endowment

In Figure 4.13, the B-quota is once reduced and once enhanced by 10% of the A-quota. Higher B-quotas shift the variance function to the left. This somewhat counterintuitive result depends on the unit of the x axis. If this was expected sugar production instead of the given ratio, higher B-quotas would shift the function to the right. But here we face two effects: (1) the values of the components of the variance function change and (2) the scaling of the x axis as well, because the denominator of the ratio is changed. The most interesting point of this analysis is to find out how the variance minimum is affected, because it characterises the point of maximum risk aversion. In this case, the location of the variance minimum is nearly the same for the three B-quota endowments. Let us take the example of two producers who only differ in terms of their B-quota endowment and who are both so risk averse that they plan their sugar production at the minimum of the expected profit variance. The producer with the lower B-quota will supply less sugar while the C-sugar share relative to his total quota amount will stay almost constant.[50]

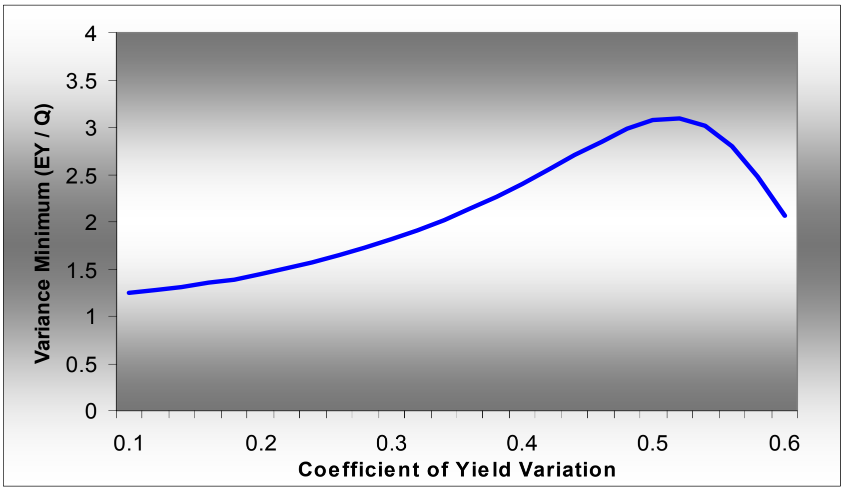
Figure 4.13: Variance of sugar revenues – changing B-quota



Source: Author's calculations

Changes in yield variance

Figure 4.14: Variance minimum of sugar revenues – changing yield variance



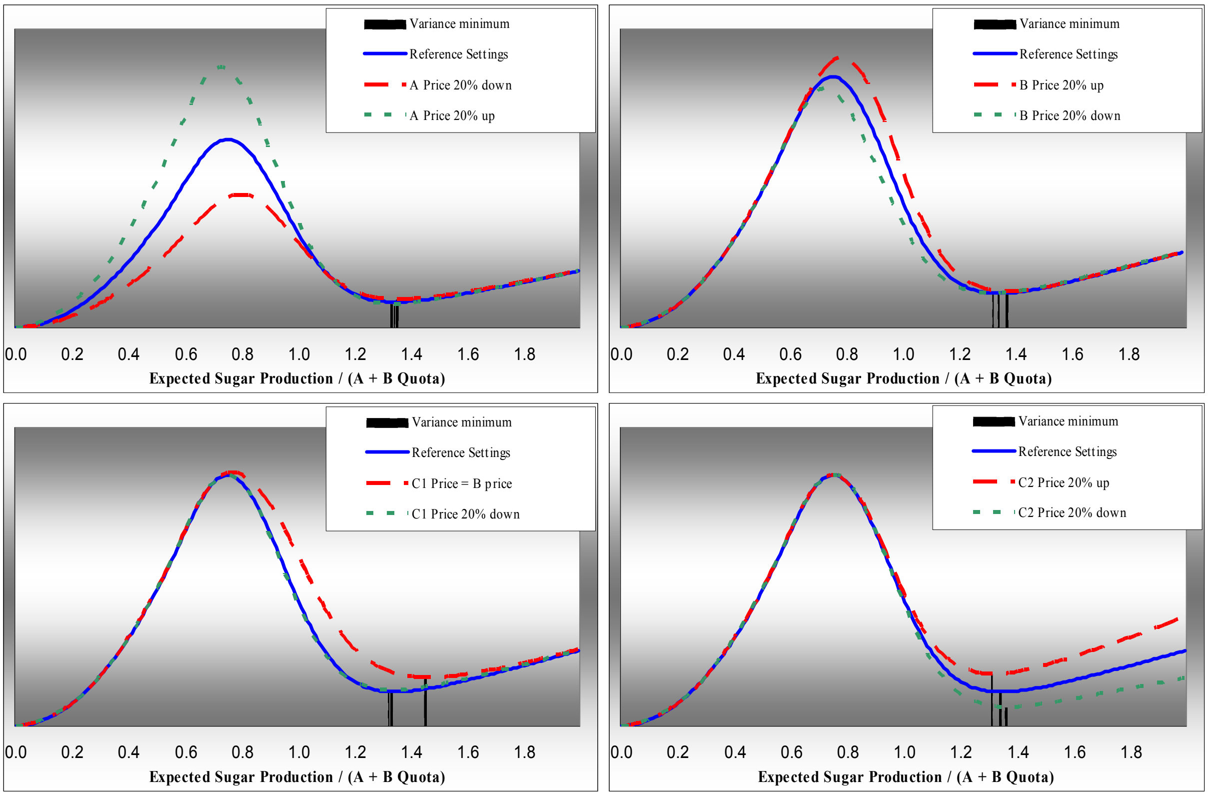
Source: Author's illustration

[50] It should be added that increasing B-quotas are also likely to change the characteristics of the variance function. It appears that an additional local minimum occurs if B-quotas become large enough because the covariance between sugar production and sugar production above the A-quota is not able to dominate the

Changes in yield variance show an interesting result because increasing yield variance moves the variance minimum upwards but beyond a certain value downwards again as shown in Figure 4.14. Beyond a certain yield variance, no minimum exists at all because the function becomes monotone increasing. At this point the positive elements of the variance function dominate the negative ones across the entire domain.

Changing sugar prices

Figure 4.15: Variance of sugar revenues – changing prices



Source: Author's calculations

From Figure 4.15 it becomes apparent that the location of the variance minimum depends on all sugar prices. Changing A-prices has the lowest influence on the location of the local minimum. There is a tendency that higher A-prices shift the minimum to the right. The same accounts for higher B-prices, higher C1-prices and lower C2-prices. Generally one can say that the lower the price differences, the closer are the variance minimum and its maximum. As in the EMR analysis, paying the same price for B- and C1-sugar tends to result in higher

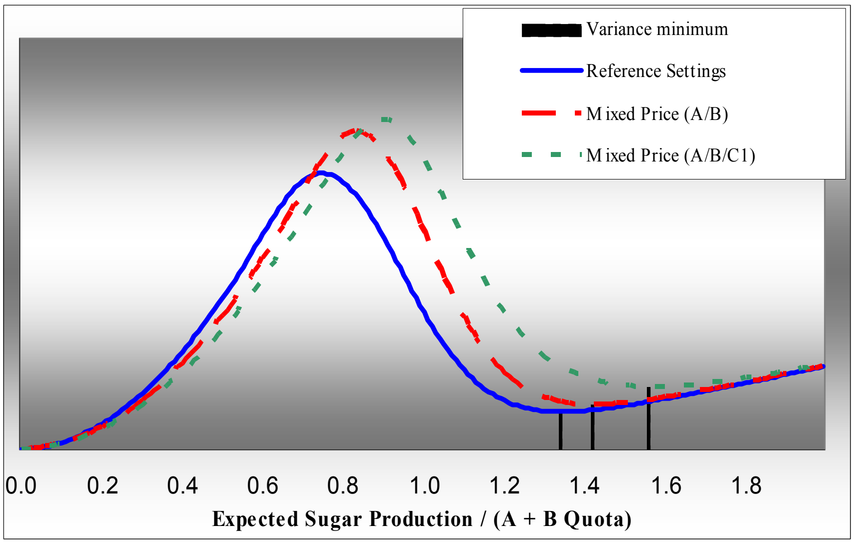
increasing variance effects. Nonetheless, this appears only for B-quota shares above 40% of the A-quota which is not reached by any EU Member State. Consequently, we will disregard that possibility.

C-sugar amounts, whereas the distinction between C1- and C2-sugar is of minor importance if C1-sugar receives only a slight mark up compared to C2.

Mixed price system

The location of the expected profit variance minimum strongly depends on the payment scheme. Figure 4.16 clearly shows that effect. The minimum is considerably shifted to the right the more prices are mixed. This is because the price differences between quota- and non quota-sugar become larger and it is apparent from the previous Figure that greater price differences lead to a variance minimum that is associated with larger C-sugar supply. Consequently, one would assume that in those EU Member States where mixed prices are applied, risk averse behaviour can explain more of the observed C-sugar quantities. This will be investigated in section 4.2.3.

Figure 4.16: Variance of sugar revenues – Mixed price system



Source: Author's calculations

Stochastic C2 prices

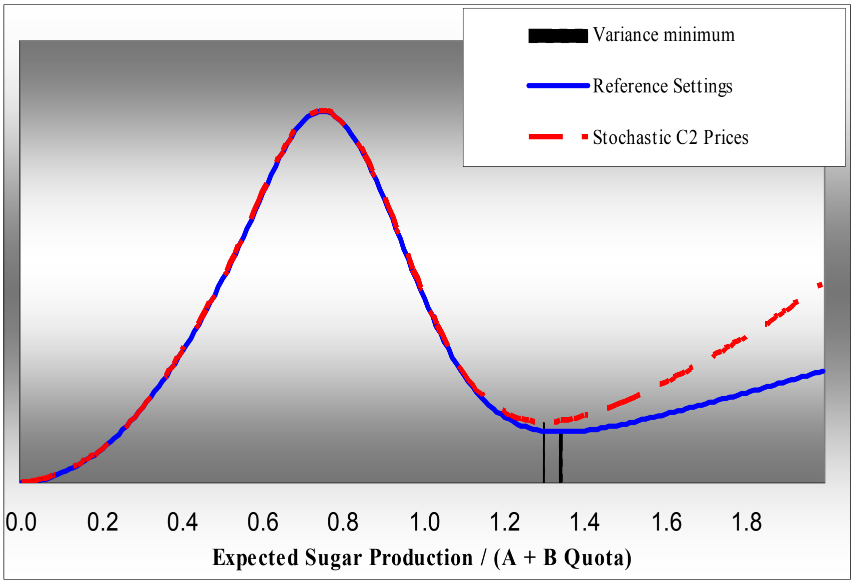
As we actually deal with uncertainty, one might ask why we examine yield uncertainty but not the more common variable in risk analysis – prices. We already mentioned that stochastic prices have no influence at all on expected sugar revenues. Their variance, however, depends on whether prices are uncertain or not. But are prices really that uncertain for sugar beet producers? At least prices for quota beets are laid down in inter-trade agreements between farmers and sugar processing firms before sugar beets are seeded. Consequently, it doesn't make much sense to assume them to be uncertain. In contrast, C2-beet prices are derived from the world market price of sugar which is a free market price with considerable fluctuations. It is therefore reasonable to evaluate the effect of stochastic C2-beet prices on the variance of expected profits.

Under the condition that C2-prices are uncorrelated with sugar yields and using the properties of uncorrelated joint distributions, the variance of expected profits can be written as:

$$\begin{aligned} VAR(R_S) = & \left(p^Q\right)^2 VAR\left(y_S\right) + \left(E\left[p^C\right] - p^Q\right)^2 VAR\left(y_S^C\right) \\ & +2\left(p^Q\right)\left(E\left[p^C\right] - p^Q\right) COV\left(y_S, y_S^C\right) \\ & +VAR\left(p^C\right) Ey_S^C + VAR\left(p^C\right) VAR\left(y_S^C\right) \end{aligned} \tag{4.17}$$

This equation is the same as (4.13), except for the additional last line. An extension to a multiple quota system is very simple because it does not affect that new component. We assume that C2 prices will vary at 30% around the expected value given in Table 4.1. The impacts on the variance of expected profits are given in Figure 4.17.

Figure 4.17: Variance of sugar revenues – stochastic C2-prices



Source: Author's calculations

Obviously, stochastic C2-prices shift the variance minimum to the left. Consequently, the scope where risk aversion is a possible objective becomes smaller. In other words, if we take uncertain world sugar market prices into consideration, it tends to lower C-sugar production of risk averse producers.

To summarise, we can see that the shape of the expected profit variance function depends on price differences, quota endowments, yield variation and whether prices are stochastic or not. The most interesting question is where the variance minimum is located because it gives the point of maximum risk aversion. We will now analyse whether this framework of utility maximisation under risk aversion may help explain the observed sugar supply.

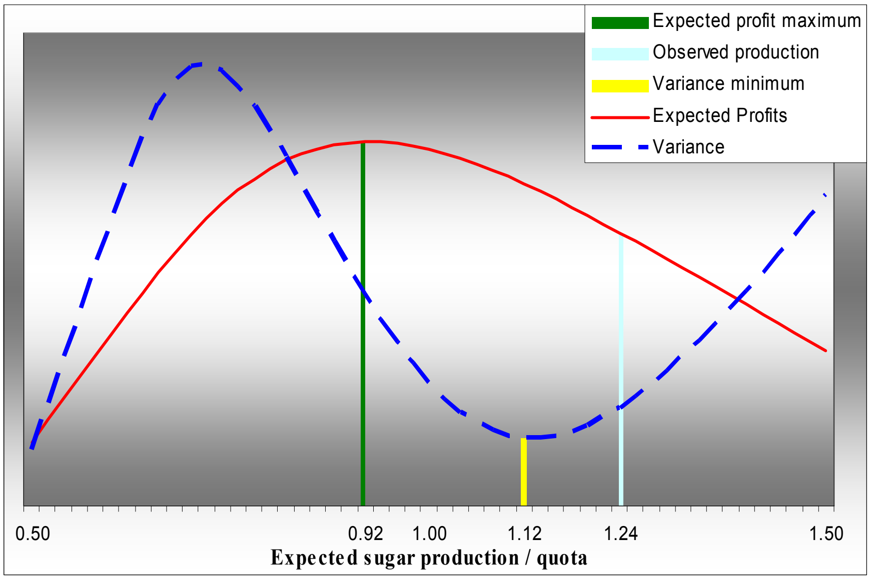
4.2.3 Contribution to Explain European C-Sugar Production

This section investigates whether the theoretical framework derived in the previous section can help to understand why observed sugar quantities are well above the expected profit maximum in most EU Member States. The analysis is again carried out for an aggregated Member State model and at farm level.

Analysis at EU Member State level

The assumptions on prices and marginal costs are the same as in the EMR section. Consequently, we identify in Figure 4.18 the same maximum of expected profits at a production-quota relation of 92% in France. The calculated variance minimum is found at a ratio of 112%.

Figure 4.18: Expected profits and variance of profits of an average French beet farmer

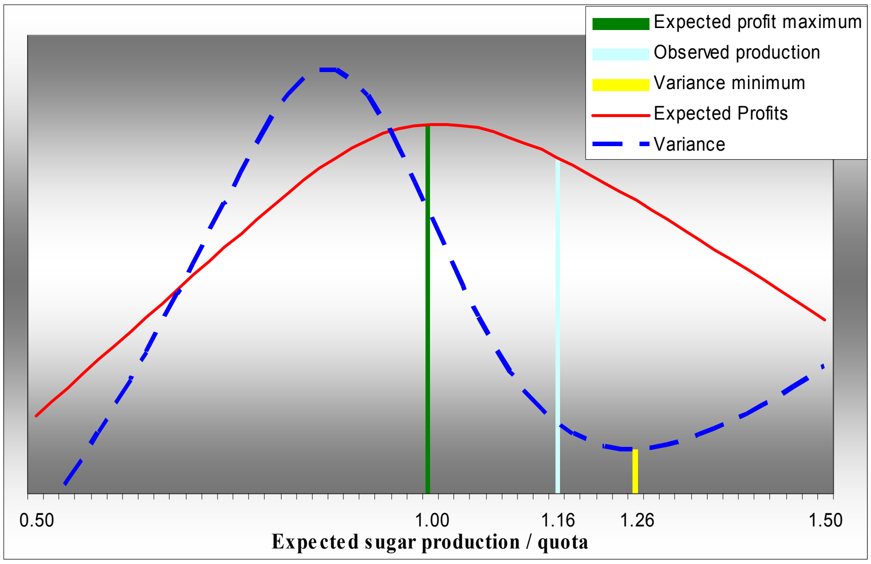


Source: Author's calculations

We observe, hence, production at 124% of the quota endowment in a range where expected profits are decreasing and the variance increasing. Regardless of how the actual utility function of a risk-averse producer weights profits and variances, all combinations that are right of the variance minimum lead to a lower utility than those within the range between profit maximum and variance minimum. We must therefore conclude that utility maximization with risk aversion cannot explain the observed sugar production in France in this average producer model.

The picture looks different in Belgium as is apparent from Figure 4.19. The observed production lies well within the range where risk-averse behaviour is possible. Although the picture implies a high degree of risk aversion because the observed production is closer to the variance minimum than to the expected profit maximum, risk aversion might explain the observed sugar quantities in Belgium.

Figure 4.19: Expected profits and variance of profits of an average Belgian beet farmer



Source: Author's calculations

But why do we find the variance minimum in France at 112% and in Belgium at 126% of the production over quota ratio? The answer can be derived from the sensitivity analysis in the previous section. In terms of yield variance, both countries do not differ much from each other. The B-quota shares, however, are different. In Belgium it amounts to about 22% of the A-quota and in France to about 27%. We already have shown that higher B-quota shares move the variance minimum slightly to the left. In terms of prices, a major difference between the two countries is that in Belgium a mixed price for A- and B-sugar is paid. Applying mixed prices ceteris paribus, leads to a variance minimum lying at a higher production quantity to quota ratio compared to the classical payment scheme (see page 74).

The influence of the price system on the variance minimum is further stressed in Table 4.3. The lowest production quantities over quota ratios at the variance minimum are found in countries applying the classical payment scheme, while they are generally higher in mixed price countries.[51]

Table 4.3: Measures for average risk aversion for 12 EU Member States

	Observed production/quota	Sugar production/quota at variance minimum	Percent of maximum risk aversion
AT	1.24	1.14	>100
DK	1.26	1.14	>100
FR	1.24	1.12	>100
DE	1.20	1.14	>100
UK	1.32	1.28	>100
SE	1.08	1.16	64
BL	1.16	1.26	62
IR	1.06	1.28	35
IT	1.04	1.18	30
FI	1.02	1.20	25
NL	1.00	1.24	8
ES	1.04	1.22	5

Source: Author's calculations

The last column in Table 4.3 is called "percent of maximum risk aversion". This measurement of risk aversion is simply calculated as the difference between observed production and profit maximum divided by the difference between variance minimum and profit maximum. Therefore, a value of 0% means risk neutrality and 100% implies production at the variance minimum as the maximal possible production that can be explained by risk-averse behaviour.[52] In Austria, Denmark, France, Germany and the United Kingdom, risk aversion obviously cannot fully explain the observed production, since it is above the variance minimum. In Spain, Sweden, Belgium, Ireland, Italy, Finland and the Netherlands, risk aversion would be a satisfactory model.

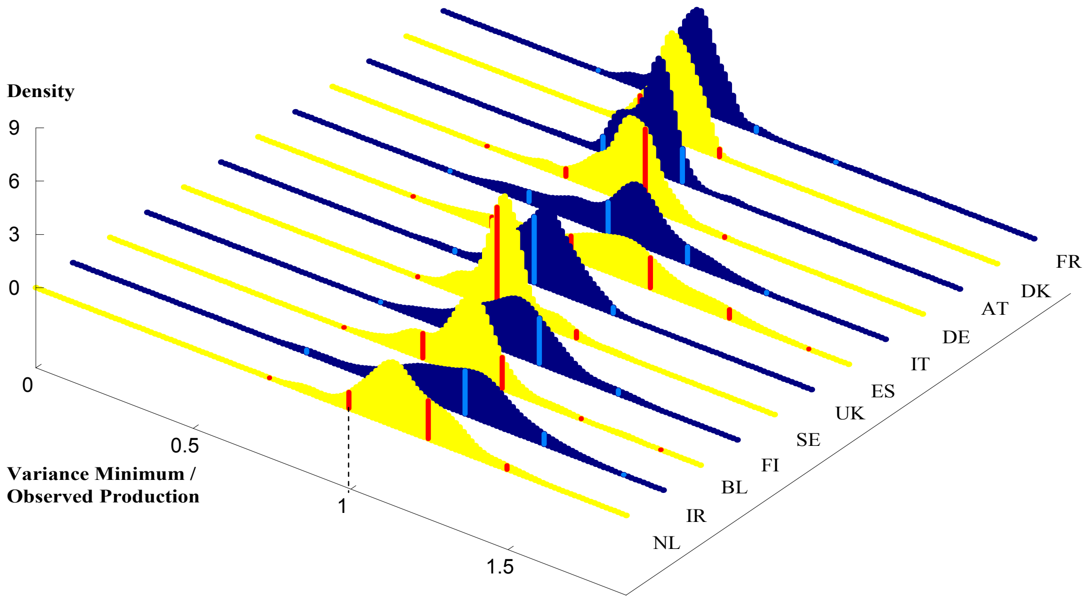
[51] Greece is excluded from this analysis because a very high relative yield variance and relative small price differences lead to a variance function without a local minimum.

[52] Admittedly, it would be desirable to use measures of risk aversion that are well known from literature (e.g. HIRSCHLEIFER AND RILEY, 1992). Unfortunately, such an analysis would require the definition of utility functions that classically depend on income or the share of agricultural income in the total family income as well as personal preferences which are all unknown to us. Nonetheless, our approach is sufficient to show how risk-averse behaviour may possibly contribute to observed C-sugar quantities.

Analysis at farm level

This variance analysis is also carried out at the farm level. We calculate kernel densities of the pdfs of the ratio variance minimum over observed production for twelve EU Member States. This fraction indicates if risk aversion might explain observed production quantities, because this is only possible for values above one.

Figure 4.20: Kernel density estimates of variance minimum over observed production



Source: Author's calculation

Figure 4.20 shows that in France, Denmark, Germany and Austria there is hardly a farm that supplies sugar below the minimum of profit variance. We can therefore confirm that risk aversion is insufficient to explain observed sugar quantities in these countries under the estimated quotas, prices and yield variations. From Table 4.3 the same conclusion might be drawn for the United Kingdom, but Figure 4.20 shows that about half of all farms in this country are producing below the variance minimum so that risk averse behaviour would be a valid model to explain observed behaviour for those farms. Whereas in Sweden or Italy we find a larger part of the probability mass to have a value below one of the selected ratios which we did not see in the aggregated view. It is clear that farm heterogeneity should not be neglected.

It should be pointed out that, in contrast to the farm analysis of the EMR, these results are independent of marginal cost estimates, because we assume them to be non-stochastic and consequently, they do not affect the location of the variance minimum.

4.2.4 Downward Risk and Upward Potential

Risk-averse behaviour, as discussed above, implies that farmers plan their sugar beet allocation not only based on expected profits, but on their variance as well. One might argue that the total variance of expected profits is a weak measurement to quantify the risk associated with a certain planned production, because it does not distinguish between the downward risk that the final profits might fall short of expected profits and the upward potential that they might be exceeded. It might therefore be possible that risk-averse farmers do not include the upward "risk" in their planning situation and only concentrate on the downward risk side.

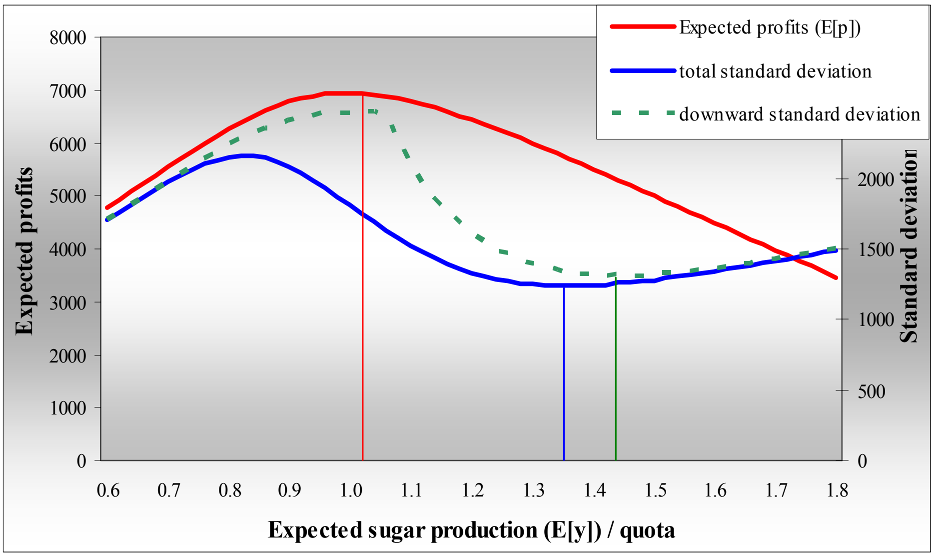
With respect to the analysis carried out in the previous section, such a distinction is unnecessary as long as the distribution of profits at a certain planned production is symmetric to its expectation value. 'The variance of outcomes that lie above the expectation value were the same as that of those below it and the minimum of total variance, hence, would be found at the same planned production as that of the downward component. However, profits from sugar beet production are not necessarily distributed symmetrically due to the interplay of several normally distributed and censored variables. We will therefore now analyse whether the conditional variance of profits below the expectation value has a different shape than that of total variance. For this purpose, we will consider again the reference farm given in Table 4.1 but use only the one-quota case for simplicity. For a number of planned production quantities (E[y]) we draw the final production (y) 200.000 times from a normal distribution and calculate the expected profits and the total standard deviation function similar as in the previous sections.[53] Additionally, we now calculate the average downward standard deviation of profits conditional on the actual profit being below their expected value.[54] Results are given in Figure 4.21. Obviously, the downward standard deviation of profits below their expected value is higher or equal to the total one. If it is higher, it means in other words that

[53] We do not calculate variances but standard deviations in order to fit all curves into one graphic. The general shape of the variance function is the same as that of standard deviations which are their square roots.

[54] We calculate the average squared differences of profits that fall below expected profits and take the square root of that value.

expected profits are distributed such that the density function is flatter and wider for profits below the expectation value while it is steeper and narrower for higher ones.

Figure 4.21: Expected profits, total and downward standard deviation



Source: Author's calculations

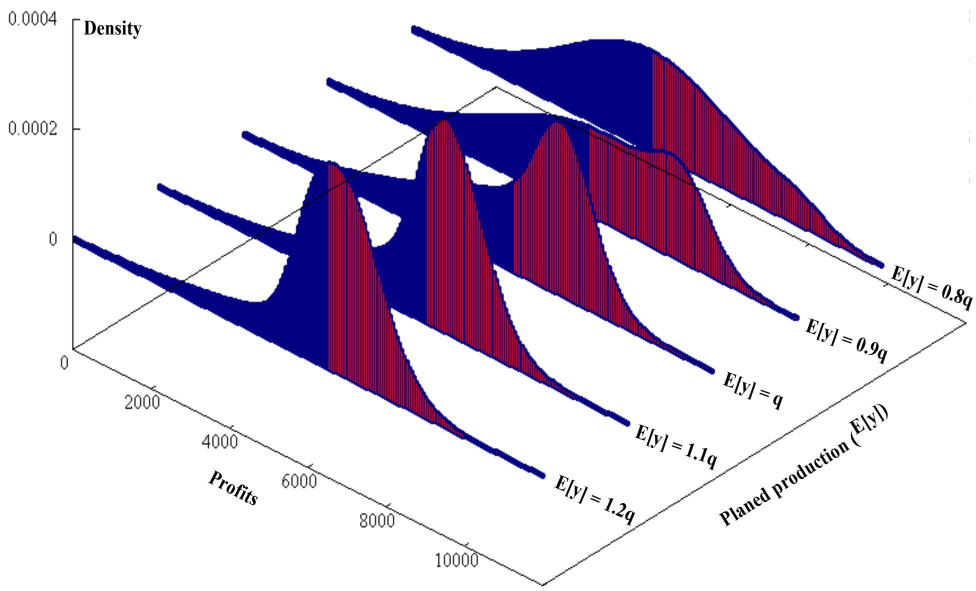
This coherence is shown in Figure 4.22. Here we graph the density functions of profits at different planned productions. The part of the probability mass where profits lie above the expectation is marked with red stripes. It becomes obvious that the density functions are not symmetric around their means in a range where the probability to over- or to undershoot the quota is relevant, while they are symmetric if planned production moves away from the sugar quota. We further see that the probability to overshoot the planned profits seems to increase in this range while the spread of observations is higher for observations below the mean.

Given the shape of the standard deviation function in Figure 4.21, we recognise that its minimum is found at a higher production level than that of the total standard deviation. We conclude therefore that concentration on the downward risk side provides further potential to explain observed C-sugar quantities. For two main reasons, we refrain from analysing this potential as detailed as in the previous sections:

- The mathematical framework to derive the downward standard deviation function goes beyond the scope of this study.
- Even if the concentration on downward risk might be able to explain more parts of the observed sugar supply in those regions where we were not able to explain it up to this point, we would have to refer to the assumption of extreme high-risk

aversion there. From our point of view, it is not likely that the most risk-averse farmers would be found in the main C-sugar producing countries, which are said to be the most competitive in Europe. Nonetheless, this cannot be ruled out.

Figure 4.22: Distribution of profits at different planned production quantities



Source: Author's calculations

4.3 Further Explanations for Observed C-Sugar Quantities

The results of the previous sections suggest that there are further reasons that might trigger additional sugar supply on European markets. In this section, we will analyse a number of specialities of sugar- and sugar beet production that might help explain the observed C-sugar quantities. We will start with a theory closely connected to the previous risk analysis.

4.3.1 Risk Management

It is appropriate to discuss the concept of risk management in a framework of sugar beet production and yield uncertainty. HARDAKER et al. (1997) define the process of risk management by simplifying it into three basic steps:

- Identify the sources of risk or the uncertain consequences that may impact an outcome of interest pertaining to the operation.
- Measure the effects of risk sources by determining the probability of their occurrence and the severity of their consequences.

- Manage the risk by understanding where current risk management strategies do not address the sources of risk adequately and then implement more effective strategies.

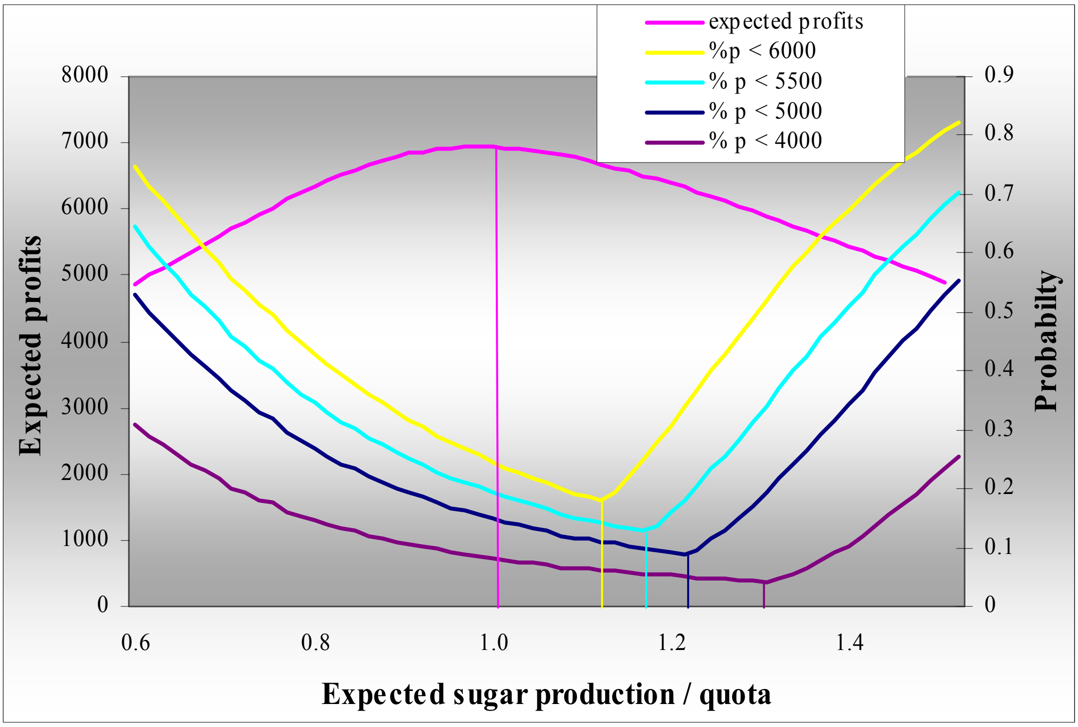
Since we are concentrating on yield uncertainty, the first step has already been taken. Of course, there may be a number of other risks (price uncertainty for in- and outputs, quota uncertainty[55], etc.), but we will not include them for now. The second step is the search for a tool with which this risk can be measured. In section 4.2.4, we chose expected profits and the variance of profits as an indicator to maximise the utility of the sugar beet production operation. JORION (2001) defines a risk management tool that focuses specifically on the downside risk facing an operation, and measures these risks in financial terms by using a single monetary value that is easy to interpret: The Value at Risk (VaR). How one can apply the concept of VaR in agriculture is described by HOTZ et al. (2004) with the example of uncertainty in pig production and marketing. They calculate the 20% VaR for different risk management strategies. In their example, 20% VaR means the cash flow losses that occur with a 20% chance in the selected period. He shows that taking into account different risk sources affects the cash flow losses considerably. The choice of the 20% VAR, however, is just an example because it is up to the farmer to choose it. One can further think of a situation where the farmer is not interested in the cash flow loss at a certain probability, but – the other way around – in the probability to meet a certain cash flow loss. A farmer chooses from different strategies the specific one with the lowest probability at which the trigger cash flow loss might occur (last step of risk management – choose the strategy).

We can easily construct a VaR example for the sugar beet case. Let us assume that the farmer of our example farm (Table 4.1) wants to minimise the risk that his profits from sugar beet production fall short of a certain trigger level. As the expected profit maximum is found at about 7000 € in our example, we choose 4 trigger levels at 6000€, 5500€, 5000€ and 4000€. Then we take the Monte Carlo simulations from section 4.2.4 and calculate for each planned production the share of observations where profits are below the different trigger levels.[56] Results are given in Figure 4.23.

[55] See section 4.3.2.

[56] The share of observations below a trigger level equals the probability to undercut that level because we compute enough observations for a convenient approximation of the real distributions.

Figure 4.23: Probability for profits being below a certain trigger value



Source: Author's calculations

Obviously, the lowest probability that the final sugar beet profits are below the different trigger levels is found in the C-sugar producing range. The lower the level of profit that we do not want to undercut, the more C-sugar production is found at the minimum of those probability functions. It is therefore possible that such risk management behaviour potentially leads to C-sugar production even if we keep in mind that other risks might be included in a VaR analysis. But again there are reasons why we deem their contribution to the observed C-sugar supply to be marginal:

- If we compare the probability to undercut the trigger levels at the expected profit maximum with its minimum, we see that the probability reduction is only marginal. For the 6000€ border, it is reduced from 25% to 18%. The farmer only gains a 7% reduction in the probability that his profits are lower than 6000€ at the costs of a loss in expected revenues of about 400€. For the lower trigger levels, his gains are even less and the costs even higher.

- The VaR focuses only on the downward risk side which often limits the upward potential of financial performance as well. Like most risk management tools, it does not deal with maximising financial performance and choosing the most profitable risk management strategy.

Nonetheless, European farmers might apply risk management strategies rendering an additional piece in the puzzle of possible C-sugar explanations.

4.3.2 The Role of Expected Quota Changes

The theory presented in this sub-section assumes that producers expect future changes in their quota endowment to be based on current production. The higher current production is, the higher is the expected quota increase or the lower the expected quota loss. Farmers pay, so to speak, an insurance premium in the form of a higher beet production. Two hypotheses can be distinguished:

Farmers expect to gain additional quotas.

Suppose that farmers expect that a small amount of sugar beet quota will be reallocated every year. This happens when quotas return to the sugar processors from farmers abandoning their production or from quota cuts to farmers who do not fill their quotas. In such cases, sugar processors can redistribute this amount of quota among other producers. Further assume that the sugar companies distribute those quotas among the farmers of a region using a certain key that reflects a smaller quota package for a farm with a lower production (relative to its quota endowment) and vice versa. Consequently, each unit of beet production delivers an additional value in terms of raising the expected additional quota allocation to farmers. This additional value is the discounted stream of expected profit gains for the time after quota reallocation.

Farmers expect (or fear) that their quota will be cut.

This hypothesis is probably more relevant than the first one, because the probability of a quota cut seems higher than that of a quota increase to farmers through reallocation, especially in the context of the recent CMO reform proposals including quota reductions. Modelling the impact of expected quota cuts on the preferability of C-sugar production today is very similar to the case of expected additional quotas. The higher the production, the higher the probability of a lower quota cut which means a higher future value from the point of view of a beet producer.

HENRICHSMEYER et al. (2003a) base their analysis on both hypotheses by adding an insurance mark up on C-beet prices. This mark up depends on quotas and quota beet prices so that even regions supplying a large amount of C-sugar respond to changes in these two variables. They point out that the additional value that is added to C-sugar beet prices depends strongly on three variables:

- Expected quantities of distributed and reduced quota amounts
- The differences between A-, B-, and C-sugar beet prices
- The production of each producer in the base period

The most uncertain variable is the first one, because there is only little information on the handling of quota cuts and redistribution of quotas. One incident occurred in 2003 in Ireland where 132 beet growers under-supplied their beet delivery rights by over 10%. Their quotas were reduced by the amount of the shortfall (IRISH FARMER'S JOURNALINTERACTIVE 2003). In regulation 90/45/EEC the European Commission lays down the rules for the Belgian sugar markets. There it says "*….(29) Following the 1986/87 marketing year, the delivery rights thus allocated to the various growers (or suppliers) concerned can be readjusted according to the following basic rule governing the adjustment of rights: each winter in which an undertaking's average production for the last three marketing years is below its maximum quota, half of the delivery shortfalls of the growers (calculated by the difference between the supply right allocated during the last marketing year and the average of the supplies carried out during the last three marketing years) are allocated to the traditional growers (or suppliers) in proportion to the average of their deliveries during the last three marketing years. The factory committee (1), in agreement with the coordinating committee (2), can allocate a portion of such available quantities to solve special cases. ….*"

Nonetheless, the amount of actual quota redistributions in the last decade in the EU Member States has been very minor. But from the farmer's point of view, it is not that relevant how often it occurs as long as the processing firm can make them believe that they practice quota cuts and redistributions. Processing firms might have an interest to do this in order to fully use their capacities (comp. SCHMIDT, 2003).

In their analysis, HENRICHSMEYER et al. (2003) assume that farmers expect every year a quota reduction of 2% and speculate that they might gain 0.5% additional quota.[57] Based on a time horizon of 13 years and a redistribution key that reflects a higher quota package or a smaller quota reduction for regions with high C-sugar supply in the base period, they calculate the additional C-sugar beet value per ton of beets at about 26% of the respective quota rent on average across the European NUTS 2 regions. It varies between 20% and 30%.

[57] The assumption of 2% yearly quota reductions is based on their expected quota reductions due to the EBA agreement. An expected reduction of 25% is distributed among 13 years. Lacking an empirical basis about the amount of expected yearly quota distribution, they choose a relatively small value for redistributed quantities.

Unfortunately, an empirically based calculation of the additional expected income coming from these speculative motives is hardly feasible. Nonetheless, this theory can contribute towards explaining observed C-sugar supply.

4.3.3 Discontinuity in Land Allocation

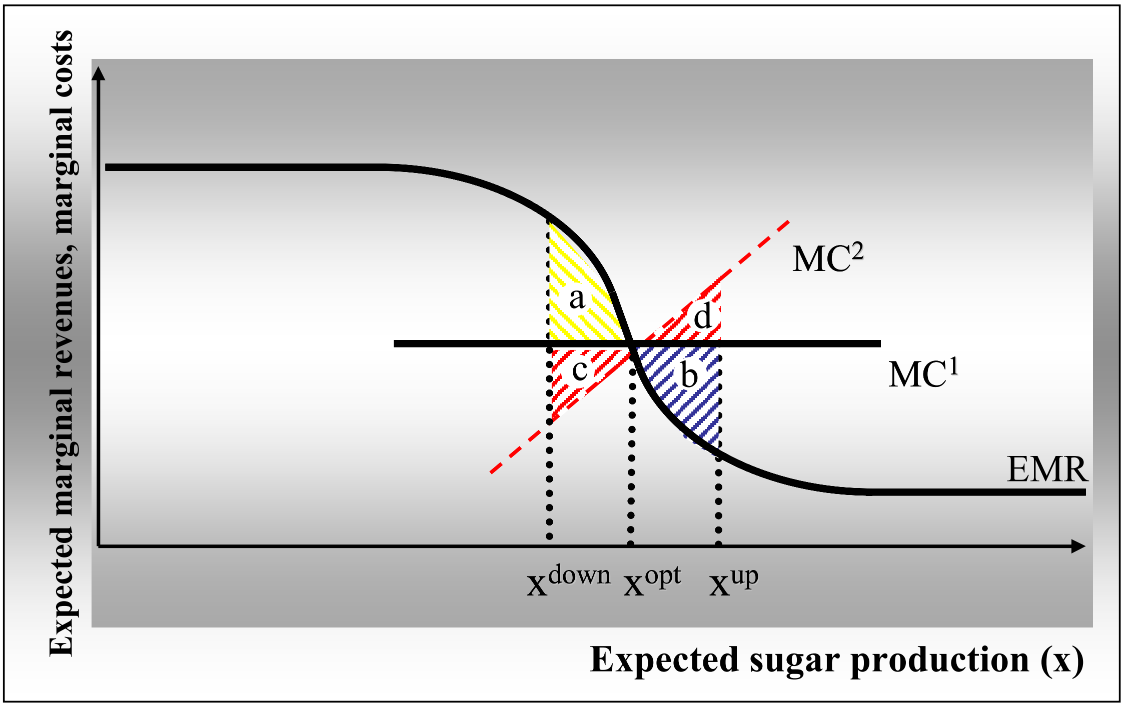
Discontinuity in land allocation at farm level might possibly be relevant. It is understandable that farmers prefer to avoid cultivating more than one crop per plot, because such divisions trigger additional costs.[58] In that case, they face a finite number of possible field combinations. So far, our economic analysis of sugar land use assumes that land allocation is continuous. In this section we assume that sugar beet farmers are expected profit maximisers and calculate their optimal sugar beet land allocation according to the theory derived in section 4.1. The resulting optimal land allocation has to be approximated by any possible combination of plots. The farmer has then to decide whether he will supply above the theoretical optimum or below it given that he is not able to meet the continuous optimum exactly.

We will now examine if there is any reason why farmers would prefer to round up the optimal land allocation according to the next larger field combination. In Figure 4.24 we show which variables are important to decide whether rounding up or down is the more profitable strategy. Let us assume a farmer knows his expected marginal revenue function. We further assume that he has constant marginal production costs given by MC^1. The theoretical optimal production x^{opt} is then given at the intersection of marginal costs and expected marginal revenues. For now we assume that this optimum is located exactly in the middle of the smallest final plot the farmer decides to cultivate with beets. If he does not want to divide that plot, he has to decide whether to grow sugar beets on the entire plot (round up to x^{up}) or not to cultivate beets on it (round down to x^{down}). The answer to the question which decision is more profitable is found in the two shaded areas (a) and (b) in Figure 4.24. They represent the loss of expected profits compared to the optimal situation. We have chosen MC^1 so that both areas amount to the same size. In this case, the farmer loses the same amount of money, independent of the direction he takes. It can easily be shown that shifting the marginal cost function to higher levels leads to a lower size of the shaded area (a). Consequently, rounding down is the better decision if marginal costs are higher than MC^1. Inversely, lower marginal

[58] The larger the plot, the lower the average costs because some cost components (make-ready time, headland cultivation) decrease with increasing plot sizes. If the harvest is done by a company, they often charge a certain fix amount per plot additionally to the hectare payment.

costs make area (b) increase relative to (a) so that rounding up is the more profitable decision. In Figure 4.24 we further define a linear increasing marginal cost function MC^2 in order to show that the conclusions from this examination are independent of the assumption whether marginal costs are constant or linear increasing. It can be seen that the areas (c) and (d) have the same size so that they compensate each other. The decision remains a matter of (a) and (b).[59]

Figure 4.24: Discontinuities in land allocation in a framework of expected profit maximisation



Source: Author's illustration

The relevance of this effect, however, cannot be very easily quantified. Nonetheless, we might obtain further insights from farm data. We use again our estimates on quotas, prices and marginal costs for sugar producing farms in the FADN sample. It is possible to analyse if the marginal cost estimates generally lie below or above the marginal costs indicated by MC^1. The definition of MC^1 in a one-quota case is given by the inflexion point of the EMR function. This can be derived by setting the second derivative of the EMR equation (4.10) to zero. The inflexion point is then found at an expected production of

[59] For non linear marginal cost functions this rule does not hold. However, given that the range between x^{up} and x^{down} is limited, the assumption of linear increasing marginal costs might render this a satisfactory approximation.

(4.18) $$Ey_S{}^i = \frac{\sqrt{1+12(\sigma^0)^2}-1}{6(\sigma^0)^2} q.$$ [60]

$Ey_S{}^i$ is generally lower than q because the factor in front of n of σ^0 and asymptotically reaches 1 when σ^0 goes to 0 and approaches 0 if σ^0 becomes infinite.[61] Substituting equation (4.18) into (4.10) gives us the corresponding expected marginal revenue at the inflexion point which we calculate for each FADN farm in our sample. We then calculate the share of farms, where the estimated marginal costs lie below the EMR at the inflexion point.[62] Results are given in Table 4.4.

Table 4.4: Shares of farms with marginal costs below the inflexion point of EMRs

	Share of farms with marginal costs below inflexion point (%)
Austria	96.9
France	96.4
Denmark	94.0
Germany	92.7
Finland	85.4
Belgium	84.2
Spain	83.7
Italy	76.0
United Kingdom	73.0
The Netherlands	70.5
Ireland	54.7
Greece	48.9
Sweden	37.0

Source: Author's calculations

Obviously, in most EU Member States, the share of farms where marginal production costs are below the EMR at the inflexion point is above 50%. In Denmark, Austria, France

[60] The derivation of equation (4.18) is available from the author upon request.

[61] The denominator of the pre-factor is always greater than the numerator if σ^0 greater than zero, which can easily be shown mathematically. The differences between both becomes smaller, the smaller σ^0 is and vice versa.

[62] The simplification to a one-quota system creates imprecision in cases where no mixed prices are applied, but we only intend to show general tendencies.

and Germany, the C-sugar supplying States, these farms amount to above 90%. Given these results, we can conclude that in these countries there is a clear tendency to fill the last plot entirely with sugar beets rather than to abandon it.

We are aware that this analysis is based on the assumption that the decision on the final plot is symmetric to the continuous expected profit maximum. Of course, it is unlikely that this optimum is located exactly where the "last plot" is cultivated half way. A more empirical analysis would require information on the number of plots and the distribution of plot sizes within the FADN sample. This information is not available to the author; therefore we will adhere to the symmetry assumption because on average across farms it may render a good approximation. The results presented in Table 4.4 might therefore be biased if we face an actual distribution of plot sizes that trigger a situation where x^{down} is consequently closer to the continuous expected profit maximum than x^{up} or vice versa.

Although we are again not able to quantify the effect of discontinuities in land allocation on optimal land allocation, we conclude that this theory has the potential to trigger additional sugar supply and contribute to the possible explanations of observed C-sugar quantities.

4.3.4 Calculations Based on Average Sugar Contents

As mentioned before, farmers sign contracts with processing firms in which sugar beet delivery rights and prices are stipulated. These are based on an average sugar content of 16%. Normally a conversion table that shows how beet delivery rights and prices change with sugar contents that deviate from the average is included as well. But what if farmers simply plan with that average sugar content? As long as the effective sugar content lies above that average, which is valid for most of the EU-15 Member States, an underestimation of sugar contents will trigger additional sugar quantities as well. We will illustrate this effect by running the Member State model which was used in the sections 4.1 and 4.2 again based on the assumption that producers plan their supply based on average sugar contents. As expected, the resulting optimal supply quantities are observed at a higher production compared to section 4.1 for most countries as can be derived from Table 4.5. Compared to Table 4.2, only Italy, Spain, Finland and Greece show lower ratios of optimal production/quota because here the effective sugar content lies below 16%. We further see that the variance minimum moves in the same direction if we compare the table below with Table 4.3. Apart from the fact that theoretical optimum and observed production move closer together for those countries where large parts of observed production could not be entirely explained in the previous sections, we see that the observed production falls in the range between expected profit maximum and variance minimum for almost all C-sugar producing countries. Utility maximisation might therefore be able to explain more of the observed production than previously assumed. Only France shows still production quantities that cannot entirely be explained by risk averse behaviour combined with sugar yield under-estimation.

Table 4.5: Sugar production /quota – observed, expected profit maximum, variance minimum at 16% sugar content, averages for 1997-1999

	Sugar production / quota (%)		
	observed	expected profit maximum	variance minimum
FR	124	98	119
UK	132	113	148
DE	120	104	129
IT	104	90	109
DK	126	112	133
AT	124	114	127
ES	104	96	112
FI	102	95	119
SE	108	104	129
BL	116	112	141
IR	106	104	142
EL	82	80	-
NL	100	102	129

Source: Author's calculations

We can simply extend the model of underestimating the effective sugar content to a model of underestimating sugar beet yields additionally. It can be assumed that farmers have a yield expectation that underestimates technical progress. This would of course trigger additional sugar quantities. Generally, it is questionable to assume that a large share of farmers underestimate expected sugar yields per hectare. But we cannot rule out that a number of farmers might act overcautiously especially because the sugar yield breaks down into two uncertain components, namely, sugar beet yield and sugar content. Anecdotal evidence from some German farmers suggests that they consequently underestimate sugar yields. Unfortunately, this is only very poor empirical evidence on which to base a general behavioural model. We therefore conclude that underestimating expected sugar yields triggers higher production quantities and might be an additional piece in the puzzle of explaining observed sugar quantities.

4.3.5 C-Sugar from Quota Beets

Persistent rumours in some Member States (e.g. Germany) suggest that sugar refineries distribute delivery rights above quota quantities (SCHMIDT 2002, SCHMIDT 2003). In this case, the aggregate C-beet production as perceived by growers is smaller than the quantity inferred from national statistics. Unfortunately, the relevance of this practice in the different EU countries is difficult to assess.

Generally, processing firms are not allowed to distribute more delivery rights than their quota amounts, but the CMO Sugar shows some windows of opportunity. SCHMIDT (2003) points out that the CMO defines the average processing losses at 3%. This means that sugar beets with an average sugar content of 16% are processed to 13% sugar. Consequently, the sugar plants have to calculate the distributed delivery rights based on 13% effective sugar content. In reality, however, the processing losses have been reduced down to about 2% since the early days of the CMO, where those processing losses were defined. If beet delivery rights have not been adjusted since then, we would face today a certain percentage of C-sugar coming from quota beets.

The incentives for sugar processors to engage in these practices might be to fully use existing capacities. SCHMIDT (2003) stresses further that about 65% of the sugar production costs are fixed costs that are not allocated to the C-sugar production. From the sugar processors' point of view, C-sugar production can therefore be seen as profitable in terms of using existing capacities so that they might have the incentive to make the farmers deliver enough sugar beets. Distributing more quotas, hence, triggers additional costs, because the C-sugar from quota beets can only be sold at C-sugar prices, while the beets have to be bought at quota beet prices. But for the given example, the processing firm would pay the farmer only for an effective sugar content of 13% while they can derive 0.14 tons more of sugar from one ton of beets. 1% sugar per ton of beets would then enter the processing firm at zero costs.

Although this hypothesis is highly speculative, we can conclude that if this is practised in the C-sugar producing EU Member States, our farm quotas are consequently under-estimated. As a consequence, all hypotheses to explain the observed C-sugar supply in Europe that have been discussed so far become more relevant, because we now need to explain less C-sugar beet production quantities at farm level.

4.4 Summary

The purpose of this chapter is to find explanations for the observed sugar supply in the EU. This analysis is necessary because simple profit maximisation is insufficient to reflect the specialities of sugar beet production. Our first hypotheses include yield uncertainty in a mathematical framework of (1) expected profit maximisation and (2) utility maximisation under risk aversion.

Expected profit maximisation changes the characteristically kinked demand function, as it existed under simple profit maximisation, to a continuous function decreasing expected marginal revenue from A- to C-sugar. It could be shown that, dependant on the effective marginal costs, C-sugar production is likely to occur even if a farmer's marginal production costs of sugar are well above C-sugar prices. A sensitivity analysis of expected marginal revenues shows how it depends on sugar quotas, yield variation and sugar prices. Two simulation models, one at Member State level and one at farm level, are set up in order to answer the question whether expected profit maximisation is able to explain observed sugar supply. We have found out that under the given assumptions, only parts of the European sugar supply can be explained by this behavioural model whereas it seems to be insufficient especially for the major C-sugar producing countries.

SCHMIDT (2003) discovered that utility maximisation under risk aversion might trigger further C-sugar supply depending on the degree of risk aversion. We extended his work by analysing the variance of expected profits mathematically. A sensitivity analysis shows how the location of the variance minimum, identified as the point of maximal risk aversion, changes with respect to quota endowments, prices and yield variance. Again we compare how the observed production is related to the variance minimum of expected profits at EU Member State and at farm level. As a result, we find a number of European farmers, again especially in the major C-sugar producing countries, where the observed production in the selected period exceeds the variance minimum so that risk aversion is insufficient to explain observed C-sugar production for those farmers as well.

Four further theories that try to explain observed C-sugar quantities are discussed in depth. Those are (1) the fear of farmers of losing quota rights if quotas are not filled entirely, (2) discontinuities in land allocation, (3) the impacts of calculations based on average sugar contents and (4) the possibility that sugar refineries might distribute sugar beet delivery rights above sugar quota quantities. All these hypotheses have in common that their empirical relevance is difficult to assess, but potentially, additional C-sugar supply is triggered.

There may be additional explanations. To reconcile the low C-beet price with observed C-beet supply, it is frequently alleged that fixed costs are borne by quota beets alone while C-beet supply only covers the variable cost (SCHMIDT 2003). While this is a plausible explanation for the short run, beet growers should be inclined to reduce their capacity in the long run if the C-beet price permanently falls short of full cost coverage. We further know that supplying huge amounts of sugar beets is a matter of prestige or tradition for some farmers. Others claim that the assumption of rationalism of farmers is not valid. We chose not to include these theories in our analysis because it is even harder to assess their relevance, but they provide additional potential to explain observed C-sugar quantities.

We conclude that all the presented theories have a certain capability to explain parts of the observed sugar production across the EU but none of them is able to explain it entirely. The reality is likely to be a mixture of the presented theories but we do not know which combination is true for farmers. For modelling purposes this insight is somewhat frustrating because modelling means applying certain behavioural models that are able to explain observed economic variables. Nonetheless, based on the analysis in this section, we will modify the sugar (beet) supply part of the agricultural sector model CAPRI in the subsequent sections in order to obtain a realistic supply response on quota and price changes.

5. Quantitative Analysis of Relevant Policy Options

This chapter is designed to analyse the impacts of reforming the CMO Sugar with respect to several proposals that have been and currently are being discussed. We use a special version of the agricultural sector model CAPRI for modelling purposes. It differs from the standard versions because it is adjusted to reflect the economic incentives to supply sugar beets discussed in the previous section. Consequently, we provide in this section a small description of the standard CAPRI model, especially focussing on land allocation. This is followed by a discussion of the specialities of modelling sugar supply, processing and international trade. A sensitivity analysis is provided to show how the sugar beet allocation depends on certain assumptions before we finally define simulation scenarios and discuss model results.

5.1 The CAPRI Modelling System – General Layout

5.1.1 Overview

The regionalised agricultural sector modelling system "CAPRI" (**C**ommon **A**gricultural **P**olicy **R**egional **I**mpact) was developed in the context of the Fourth Framework Project (FAIR3-CT96-1849)[63] from 1997 until the end of 1999. It has been further developed under the “CAPSTRAT” (2001-2004) and in the current “CAPRI-DYNASPAT” project. Over the whole time period many applications of the modelling system have provided quantitative analysis of special agricultural policy reform proposals.[64] The final model version of the CAPSTRAT project serves as a basis for our analysis. The model is generally designed as a projection and simulation tool for the European agricultural sector based on the following:

- A *physical consistency framework*, including balances for agricultural area, young animals and feed requirements for animals as well as nutrient requirement for crops. Those are explicitly realised as constraints in the regional supply models.

[63] The final consolidated report with a detailed model description is available on the project web site: http://www.agp.uni-bonn.de/agpo/rsrch/capri/finrep.pdf .

[64] Find more details on http://www.agp.uni-bonn.de/agpo/rsrch/capri/capri_e.htm.

- *Economic accounting principles* according to the definition of the **E**conomic **A**ccounts for **A**griculture (EAA). The model covers all outputs and inputs included in the national EAAs for the Member States of the EU-15. Revenues and costs are broken down consistently to NUTS 2 regions and production activities.
- A *detailed policy description* that covers the relevant payment schemes with their respective ceilings on the supply side. Tariffs, intervention purchases and subsidised exports are included on the market side.
- *Behavioural functions and allocation steering strictly in line with micro-economic theory*. Functional forms are chosen to be globally well behaved, allowing for a consistent welfare analysis.

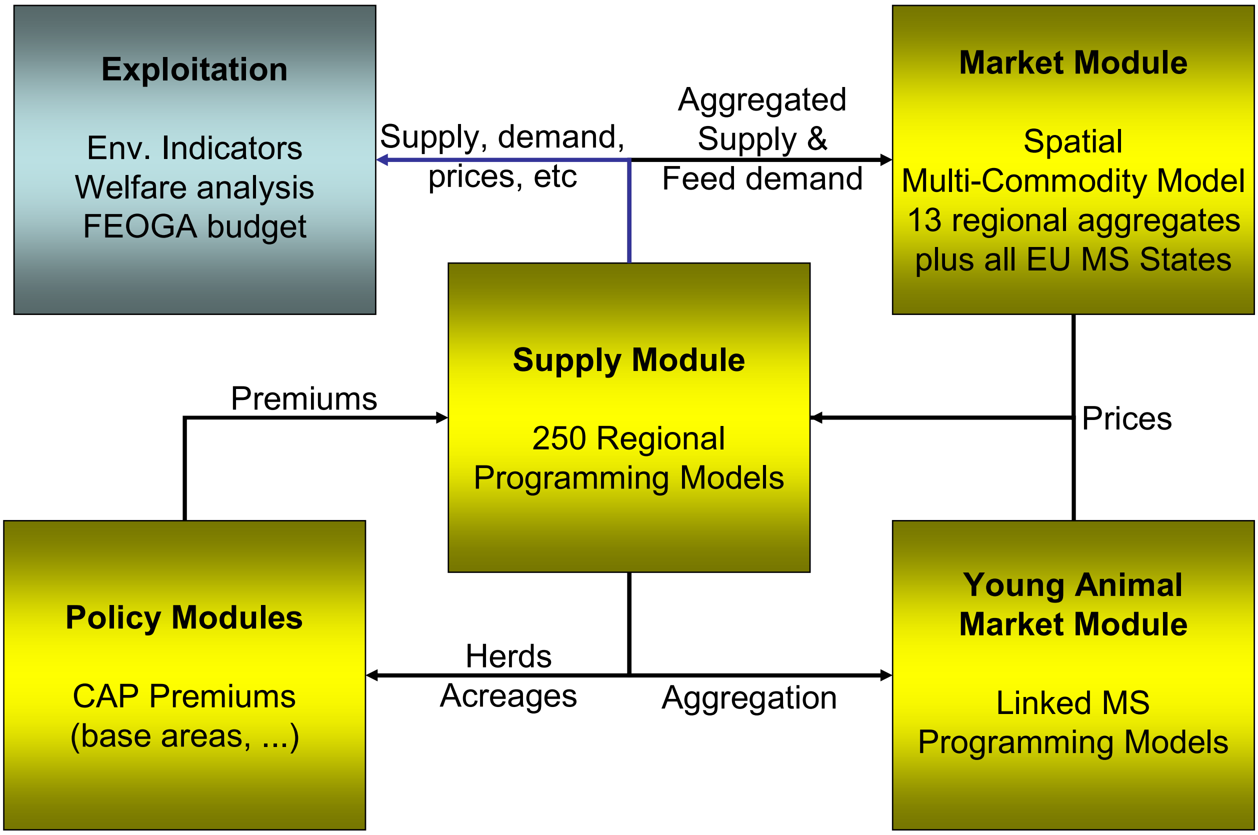
A model can only perform well if it is based on comprehensive data. As indicated by its name, CAPRI is a regionalised sector model, so that regionalised data is essential. At national level, the CAPRI modelling system makes use of the CoCo data base[65] which is consistent with the EAA and completed using simulation estimation techniques under data consistency constraints in order to fill gaps. The only uniform data sources at EU level for regionalised data are the REGIO database from EUROSTAT and the FADN data. Both sources are exploited in order to build the CAPRI regionalised database. Given the regional resolution of these sources, NUTS 2 is chosen as the minimum level of regionalisation. REGIO is used to define acreage, herd sizes and yields at NUTS 2 level. Data at national level (cropped hectares, slaughtered heads, herd sizes and production quantities) are taken over without changes from CoCo and data from REGIO are corrected to allow for a consistent aggregation. FADN data provide parameters for input demand functions to estimate the input allocation and income indicators for activities at a regional level. In total there are about 200 regions in the database and modelling system, covering the whole of EU-15.

The model distinguishes between a supply and market module, which are iteratively coupled. The interplay of the modules is shown in Figure 5.1. The supply module consists of aggregate programming models at NUTS 2 level, working with exogenous prices defined at Member State level in the market module. After being solved, the regional results of the NUTS 2 supply models – crop areas, herd sizes, input/output coefficients, etc. – are aggregated to Member State level. Member State models built with an identical structure as

[65] A detailed description can be found in: W.BRITZ, C.WIECK, T. JANSSON (2002): National Framework of the CAPRI Database: The CoCo-Module, CAPRI working paper 02-04, available on the project web site.

the NUTS 2 models are then calibrated to the aggregated results of the NUTS 2 models. Next, young animal prices are determined by linking these Member State models. Then, supply and feed demand functions of the market module are calibrated to prices of the current iteration and aggregated Member State results on feed use and supply. The market module is solved. Producer prices at Member State level, as calculated by the market module (a Multi-Commodity Model based on the Armington Approach in Armington, P., 1969) drive the next iteration with the supply module. Equally, in between iterations, premiums for the activities are adjusted if ceilings are overshot according to the results laid down in the Common Market Organisations. After a certain number of iterations, equilibrium is found, so that prices and supply quantities take the same values in the supply and market parts. Finally, all model results are passed to an exploitation module to aggregate them to different levels, carry out a welfare analysis or calculate other indicators of interest. More detailed information on the CAPRI system is available in BRITZ et al. (2004).

Figure 5.1: Schematic description of CAPRI



Source: Author's illustration

To provide a better understanding of the model adjustments made in order to model the European sugar sector that we will explain in section 5.2, a more detailed description of the two main CAPRI modules – the regional programming models in the supply part and the multi commodity model – is given in the subsequent sections.

5.1.2 Land Allocation in the Regional Programming Models of CAPRI

One of the general philosophies on which the CAPRI model is based is that such a model should be able to reproduce a certain base year. In other words, observed base year production patterns are the result of an optimisation process. Each NUTS 2 region acts here like one farm[66]. Several exogenous variables enter the non linear programming models that are formulated for each region. The most important ones are:

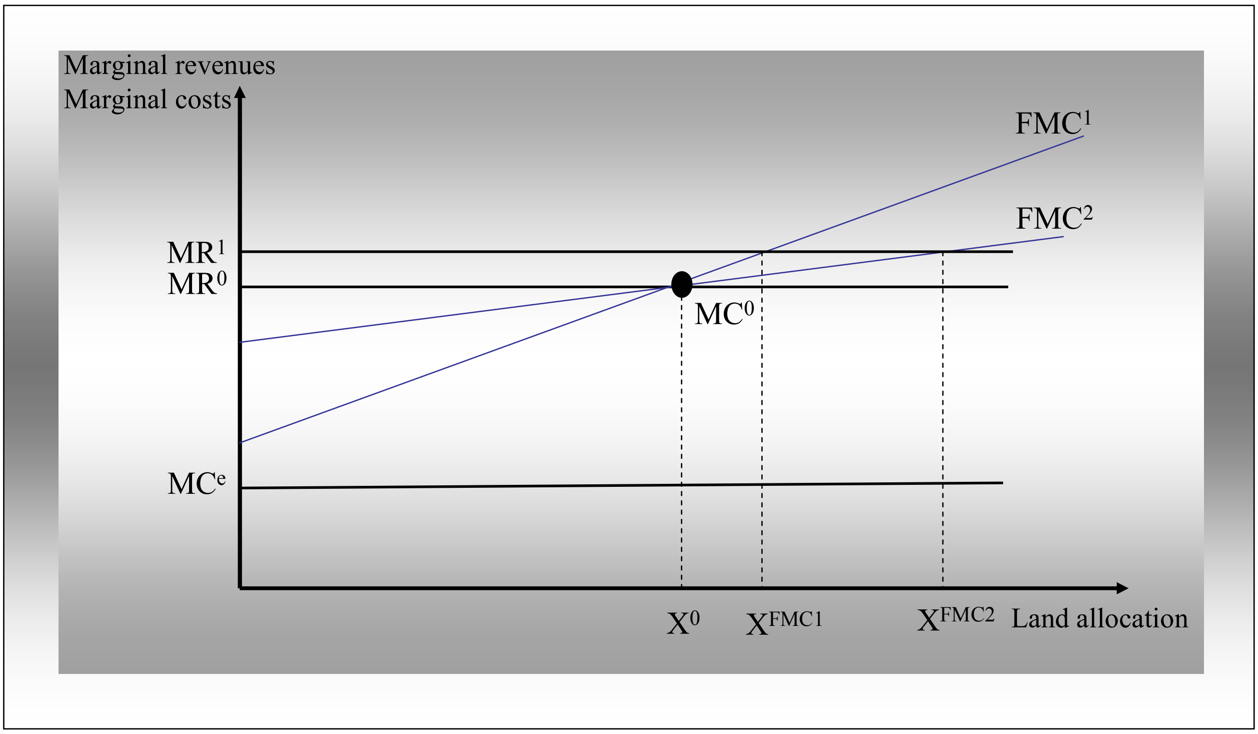
- The regional area endowment
- Yields per hectare for all production activities observed in the base year
- Per hectare variable production costs and input coefficients that were estimated from the FADN
- Quota endowments
- Product prices (as resulting from the market module)
- CAP premiums
- Set aside rates

Given those exogenous factors in the base year, an optimisation of regional profits using linear programming models will not reproduce observed quantities, because linear programming models characteristically choose the most profitable production activity as long as no bounds are reached. This general problem of overspecialisation is further stressed in HOWITT (1995a) where the author provides an alternative: Positive Mathematical Programming (PMP). The idea of PMP, which has become very common in the last decade, is to introduce a non linear cost function, quadratic in land allocation (or production) and define the parameters of that function so that marginal profit in the base year is equal to zero, characterising a profit maximum.

Unfortunately, the definition of such a cost function is not unique since there may exist an infinite number of possible choices. It is only known that marginal revenues equal marginal costs in the base year, but that is not enough to define the two parameters of a linear increasing marginal cost curve. HECKELEI (2002) explains how such cost functions could be estimated using first order conditions as restrictions from time series data, but the adoption of his approach to the CAPRI supply module has not yet been done. A comprehensive overview of the history of PMP is given in HECKELEI (2005a).

The importance of the parameters of the non linear cost functions is shown in Figure 5.2 – simplified to the one product case. The only hard information in the calibration is the point MC^0, defined by the marginal revenue (MR^0) at the observed land allocation (X^0). MC^e gives the explicit defined production costs per hectare which include the shadow costs of the explicit constraints in the model (land or set aside restriction). The figure shows that there is a gap between marginal costs and marginal revenues which we want to close using the PMP approach.

Figure 5.2: Implications of PMP calibration



Source: Author's illustration

Therefore, we define a marginal cost function through the point MC^0. FMC^1 and FMC^2 are two of infinite possible choices for it. It becomes apparent how important the choice of the

[66] In fact, we distinguish between two technologies, one intensive and one extensive production process. This distinction only complicates the explanation of the allocation steering mechanism at this point so we will disregard it here.

function's slope is with respect to the steering of land allocation. To illustrate this, we shift the marginal revenue – due to rising product prices or premiums – to MR^1, the resulting new land allocations X^{FMC1} and X^{FMC2} that refer to the two different marginal cost curves are quite different. HECKELEI (2002) e.g. points out the importance of the PMP slopes and shows how the original approach of HOWITT (1995b) arbitrarily chooses those parameters of the quadratic cost function.

The slope of the marginal cost function should be based on observed supply behaviour. Until empirical supply elasticities are estimated, CAPRI uses prior supply elasticities based on expert knowledge in the calibration process. Basically, the slope of the marginal cost function (β) is derived from the elasticity formula:

(5.1) $$\varepsilon = \frac{\Delta x}{\Delta p}\frac{p_0}{x_0} \Leftrightarrow \frac{\Delta p}{\Delta x} = \frac{1}{\varepsilon}\frac{p_0}{x_0} = \beta$$

p_0 and x_0 are the observed base year prices and supply quantities of a certain product in a certain region. Once the slope is defined, the intercept of the marginal cost curve is recalculated with respect to the base year observations taking into account the explicit cost parts as well as the shadow values of restrictions in the model.[67]

At this point, we need to address the difference between those prior supply elasticities that go into the calibration and those coming out of it because total costs are the sum of the quadratic cost function, explicitly modelled input costs and the shadow costs of binding restrictions of the non-linear programming models. The difference between the prior and the final elasticities in the model stems mainly from the latter cost component. Both elasticities would be equal if those shadow costs were constant. In fact, they are not, because if the price for one product increases while all other prices stay constant, the land price is likely to increase as well. Consequently, total cost, if production for that certain product is extended, increases at a higher rate than according to the quadratic cost function. As a result, the effective supply elasticities tend to be lower than the prior ones.

5.1.3 The Market Module

The CAPRI market module comprises 13 county blocks, trading among each other. Those blocks are the *EU-15*, *East European countries*, *Norway*, *Mediterranean countries*, *Canada*, the *USA*, *Australia & New Zealand*, *high tariff traders* (as Japan), *free trade developing countries*, *India*, *China*, *ACP* countries and the *rest of the world*. For each of them, except the

[67] Note that the cost function does not include cross effects between products.

EU-15, a system of well behaved behavioural functions for supply, demand, processing and feed use for all products is set up. The EU-15 itself is broken down into Member States and the behavioural functions are defined at that level and aggregated to EU-15 level. These behavioural functions generally define the four market positions depending on respective (producer and consumer) prices. They are elasticity based using elasticities that stem from other studies or models.

Trade between the country blocks relies on the Armington approach (Armington, P., 1969). The basic principle here is that consumers have different preferences for a particular product depending on its origin. For example, a French consumer might be willing to spend more money on cheese originating in France than for cheese coming from the US. The Armington approach allows such preferences to be reflected without separating cheese into two products. Compared to a classical net trade model where products are considered homogenous and a spot world market is present, the Armington approach considers products heterogeneous and import prices for the same product from different origins are different as well. A CES utility function is calibrated for each product in each trading block so that observed trade flows and price differences in the base year can be reproduced by Armington's optimality conditions.

CAPRI uses a two-stage Armington approach. In the first stage, consumers decide about the consumption quantities of domestic sales and imports, while in the second stage, they choose between different import-origins. Those decisions are no matter of absolute price levels, but of price relations. The price for imports of a certain product in the first stage is calculated as the average of the import prices from the different origins weighted with the import streams according to the second stage. The weighted averages of import prices and domestic prices from the first stage define consumer prices that drive the behavioural demand functions. The substitution elasticities in the first stage are generally set smaller than for the second one, assuming that consumers will be less responsive regarding substitution between domestic and imported goods compared to changes between imported goods. Due to the small amount of empirical information on such substitution elasticities, they are defined for most products at 6 in the first stage and at 8 in the second one.[68]

The market model represents a number of policy instruments that influence international trade. It reflects tariffs, tariff rate quotas, export subsidies and intervention taking into account

[68] Some exceptions, mainly for less tradable goods like milk or meat products, are made where substitution elasticities are assumed to be lower.

WTO commitments. A detailed description of the policy instruments in the CAPRI market module is given in JUNKER et al. (2003). For a better understanding of the subsequent sugar specific adjustment in the market part, it is necessary to explain the modelling of tariff rate quotas more precisely.

5.1.4 Modelling Tariff Rate Quotas in CAPRI

Tariff Rate Quotas (TRQs) establish a two-tier tariff regime: as long as import quantities do not exceed the import quota, the low in-quota tariff is applied. Quantities above the quota are charged with the higher Most-Favoured-Nation (MFN) tariff. CAPRI distinguishes between two types of TRQs: those that are open to all trading partners, and bi-lateral TRQs. With regard to model sugar trade with the EU, the latter are the more important ones. A market under a TRQ mechanism may be in one of the following regimes:

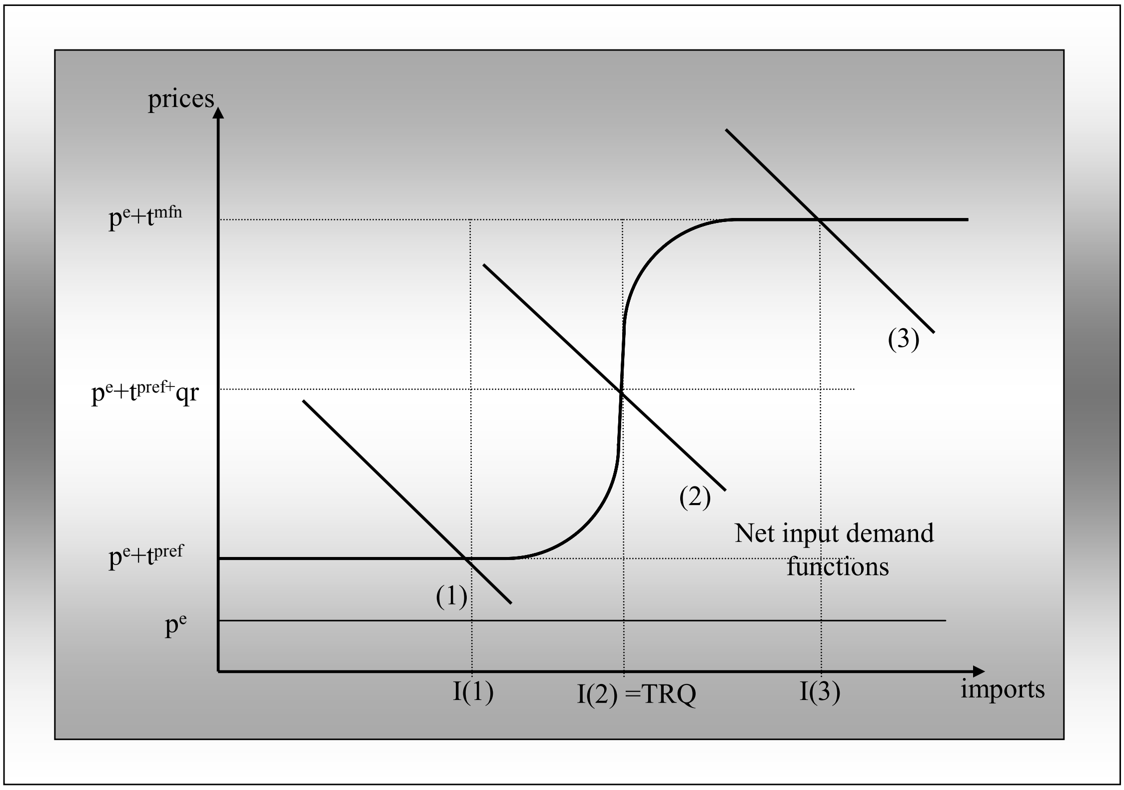
(1) Quota under-fill: the in-quota tariff is applied. The willingness of consumers to pay for imported goods is equal to the border price plus the in-quota tariff.

(2) Quota exactly filled: the in-quota tariff is applied. The willingness of consumers to pay and thus the actual price paid is somewhere between the border plus the in-quota tariff and the border price plus the MFN tariff. The difference between the price on the market and the border price plus the in-quota tariff establishes a quota rent. Depending on property rights on the quota and the allocation mechanism, the quota rent is shared in different portions by the producers, importing agencies, the domestic marketing chain or the administration. Typically, the quota rent cannot be observed nor is there any knowledge about distribution of the rent rendering distributional analysis rather difficult.

(3) Quota over-fill: the higher MFN-tariff is applied. Consumers pay, therefore, the border price plus the MFN-tariff. The quota rent is equal to the difference between the MFN and the in-quota tariff. Again, how the quota rent is distributed to agents is typically not known.

Those 3 regimes are visualised in Figure 5.3. The characteristic kinks of the TRQ system as shown in LIAPIS and BRITZ (2001) are smoothed out by the sigmoid function in order to achieve a differentiable function. The import price for a certain product in the three regimes is equal to the market price in the exporting country + the respective tariff which is in regime (1) the in quota tariff (t^{pref}), in (2) the in quota tariff + a certain quota rent (qr) and the out quota or MFN tariff (t^{mfn}) in the third case.

Figure 5.3: Bilateral TRQ representation in CAPRI



Source: Author's illustration based on LIAPIS, and BRITZ (2001)

A broader description of the actual version of the CAPRI model can be found in the model documentation (BRITZ et al. (2004)). We now proceed to a description of the model adjustments made in order to analyse reform options of the CMO Sugar.

5.2 Sugar Specific Adjustments in CAPRI

Originally the treatment of sugar beet production in CAPRI did not resemble the mechanisms of the CMO Sugar. Production quantities were bound to base year levels; there was no distinction between quotas and the corresponding prices. Impact analyses of changes in the economic and political environment of sugar beet production were consequently hardly possible. This section gives an overview of how we adjusted the CAPRI model based on the economic incentives to supply sugar beets analysed in section 1.

5.2.1 Quotas, Prices and Processing Industry

Sugar quotas are publicly available only at national level. Since CAPRI treats each NUTS 2 region as one farm we need at least an estimate of the sugar beet delivery rights that are located within one region. We are well aware that something like a regional sugar quota does not exist because administrative regional borders do not necessarily correspond to the acquisition area of processing firms. But since we do not intend to model the sugar industry and the impacts of transportation costs or possible mergers of processing firms, our assumption is that regional sugar beet delivery rights are the weighted sum over all farms within that region of the estimated sugar beet quotas derived in section 3.1, where the estimation procedure ensures that national quotas and sugar beet production quantities of the three-year average period 1997-1999 are perfectly met by the weighted sums of the respective farm values (equation (3.9)). Our simulation base year, however, is a three-year average around 2001. Consequently, we need to adjust regional quotas, because in 2001 and 2002 national sugar quotas were reduced. Regional quotas are consequently calculated as follows:

$$Q_r^{bas} = Q_r^{A398} \frac{Y_n^{bas}}{Q_n^{bas}} \frac{Q_n^{A398}}{Y_n^{A398}} \quad (5.2)$$

The regional sugar beet quota in the base year 2001 (Q_r^{bas}) is defined as the result of the weighted aggregation of farm beet quotas for the years 1997-1999 (Q_r^{A398}) multiplied by the relation of national sugar production (Y_n^{bas}) over national sugar quotas (Q_n^{bas}) in the base year, multiplied by the reciprocal relation of the three-year average national figures around 1998. The resulting sugar beet delivery rights enter the model and only change if national sugar quotas are adjusted during simulations.

Differentiations of sugar beet prices have not been included in the CAPRI model so far. Generally, the model works with equal prices within EU Member States, disregarding regional price heterogeneity. This might not be relevant for a crop like soft wheat were prices are not likely to differ much among regions within a country, but for sugar beets, greater differences between prices paid by different sugar companies might exist, which we do not take into consideration. In CAPRI the linkage between each sugar beet price and market sugar price – as it results from the market module – is based on a reduced form equation given in equation (5.3). We link the farm-gate price ($P^{beet}_{MS,x}$) of a type of sugar beets (x) to the relevant derived revenue from sugar and molasses (R^{mola}_{MS}), taking into account the applicable levy and the processing coefficient 'sugar per ton of beets' ($\Phi_{MS,suga}$). The parameter α is calculated so that consistency with an average beet price derived from the

EUROSTAT Economic Agricultural Accounts (EAA) is achieved, meaning that the sum over the product of the base year quantities of each sugar beet type multiplied by the respective price meets exactly the production value of sugar beets in the base year.

Data on market sugar prices per EU Member State ($P^{suga}{}_{x}$) are taken from BLUME et al. (2003). Sugar world market prices are already included in the CAPRI system. The revenue of molasses, hence, is fixed on the basis of the by product revenue defined in the official calculation of the basic beet price (LINDE et al. 2000, p 9). Export costs are calculated by the price differences between the average EU market price for sugar and the world market price multiplied by the difference between A- + B-sugar production and domestic demand. From them, the respective levies are calculated. [69]

(5.3)
$$P_{MS,x}^{beet} = \alpha_{MS}\left[\left(P_{MS,x}^{suga} - levy_x\right)\phi_{MS,suga} + R_{MS}^{mola}\right]$$

We are well aware that our representation of the sugar processing industry is extremely simplified and that introducing an optimisation framework that is empirically based on the economic conditions in the processing industry would probably improve their representation. However, as the processing industry is not our primary focus of interest, we choose this simple but convenient method. The base year estimates of the variables in equation (5.3) are given in Table 5.1. It becomes apparent that the parameter α ranges from 0.41 to 0.66 meaning that processing firms pass between 41% and 66% of their sugar revenues to the farmer. If we keep in mind that minimum beet prices are calculated with the rule of thumb ‘sugar revenue multiplied by 58 percent’ (EU Commission AGRI/63362/2004), we see that our estimates range around that value.

[69] HENRICHSMEYER et al. (2003) and ADENÄUER et al. (2004) use an additional coefficient in the price linkage function that reflects the variable processing costs of processing beets to sugar. We use a simpler version because it appeared to be easier to handle during the simulation runs. This method implies that sugar processing firms allocate less of their costs to C-sugar production than to quota sugar – a reasonable assumption.

Table 5.1: Sugar and sugar beet prices in the base year (2001)

	A-beet price (€/t)	B-beet price (€/t)	C-beet price (€/t)	MS sugar price (€/t)	α
BL	51.8	51.8	16.0	691.8	0.50
DK	50.3	43.4	15.7	672.5	0.48
DE	54.9	47.5	16.8	680.5	0.53
EL	53.5	46.5	17.2	682.7	0.66
ES	54.7	54.7	17.4	703.0	0.54
FR	44.7	38.8	13.2	706.1	0.46
IR	49.7	49.7	15.6	694.6	0.53
IT	39.8	39.8	13.1	685.2	0.48
NL	52.4	52.4	16.6	683.6	0.51
AT	51.2	44.3	15.8	685.6	0.48
PT	53.8	46.8	17.1	691.8	0.41
SE	52.4	45.4	15.9	687.8	0.48
FI	54.1	47.0	16.9	691.8	0.53
UK	52.2	52.2	15.5	725.4	0.50
	World market price sugar = 194 €/t				

Source: Author's calculations

5.2.2 Introducing Marginal Costs from FADN

As already noted, the regional nonlinear programming models represent one profit maximising farm, owning all regional production factors. In section 3, however, we found that profit maximisation may be inappropriate in the case of sugar beet production, because every region that supplies C-beets in the base year is assumed to be competitive at C-beet prices (see Figure 5.2). Therefore these regions will not react at all to changes in quotas or quota beet prices. Consequently, we replace it by expected profit maximisation under yield uncertainty which has proven to be a better solution compared to profit maximisation. Technically we substitute the regional sugar beet revenue definition by the definition of expected sugar beet revenues given in equation (4.5). This function requires regional quotas and prices, which are provided as described above, and information on the magnitude of regional sugar beet yield variances, which we calculated in section 4.1.4.

As the discussion in section 3 has shown, introducing expected profit maximisation in CAPRI alone would barely make the regional sugar beet supply react to quota or quota price changes as long as we observe very high C-beet productions in the base year because such a region would be calibrated to very low marginal costs. In order to exploit the results from section 3, we are now going to use our marginal cost estimates for sugar beet production. As mentioned before, those appear to lie above C-sugar beet prices in the base period. Farm costs are here aggregated to one regional marginal cost value as described below in section 5.2.3. Their magnitude is given in Table 5.2. One of the most relevant sugar specific adjustments of CAPRI is that we take those estimates, which also include opportunity costs, as given for now. We assume that each NUTS 2 region supplies sugar beets in the base year at those marginal costs. But if we change the marginal costs in the base year, we have to change the expected marginal revenues as well, to ensure that observed production quantities are still the 'optimal' outcome of expected profit maximisation.

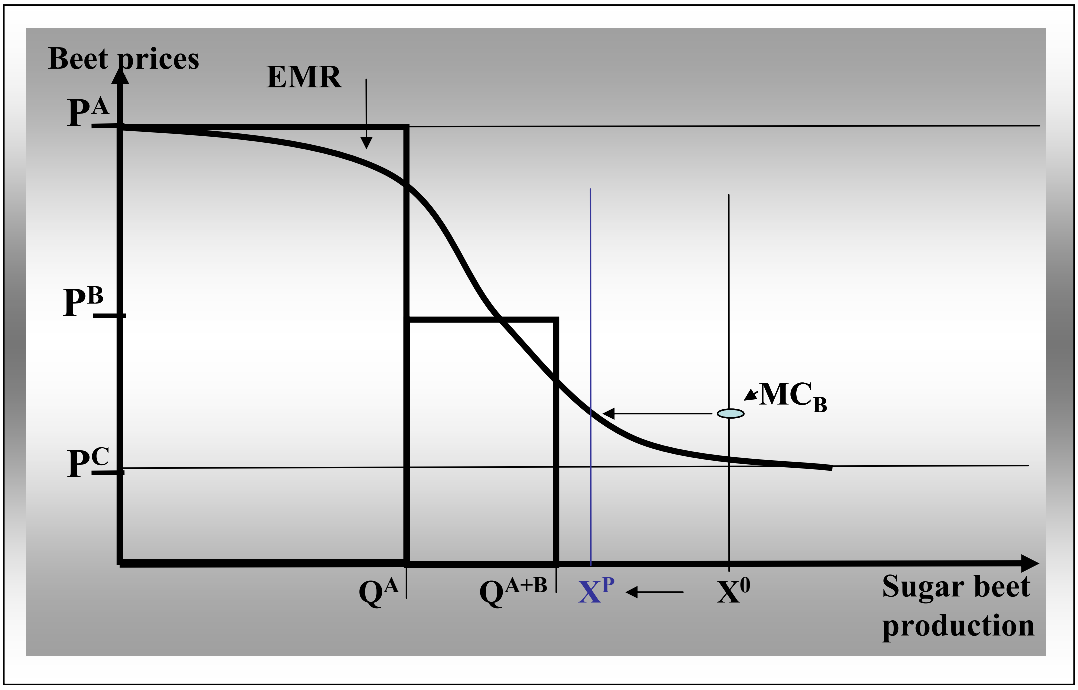
To ensure this, we assume that the inconstancy between observed marginal costs and expected marginal revenues can be explained by dividing observed sugar supply quantities into two parts: one is based on the expected profit maximum and the second originates in the combination of all the hypotheses discussed in section 4 that may explain deviations from the expected profit maximum. This can be seen as a two-step decision procedure. In the first step, farmers plan their supply according to the theory of maximising expected profits and in the second step they decide upon the additional sugar quantities they want to supply in order to deal with the various risks or other specialties of sugar beet production.

The technical resolution of the calibration procedure for one NUTS 2 region is shown in Figure 5.4. We denote the expected profit maximal production in the base year $X^{P.}$ This production quantity is rather simple connected with the observed base year supply (X^0) as follows:

$$X^P(1+\beta\ ) = X^0 \tag{5.4}$$

For each NUTS 2 region, the parameter β is defined such that the expected marginal revenues equal marginal costs (MC_B) in X^P. If β equalled zero, it would mean that there is no difference between observed marginal costs and expected marginal revenues. β is selected as a constant in simulations. By making this assumption, we imply that the combined effect of all those aspects that trigger additional sugar supply react proportionally to X^P to changes in prices or quotas. In other words, quota or price changes would reduce the expected profit maximal production quantity by 10%, and the part of beet supply that results from other aspects than expected profit maximisation is reduced by 10% as well. This linear coherence is, of course, a simplification of 'real' behaviour but as we were not able to quantify the contribution of the different motives to supply C-sugar to the total sugar supply, it is deemed to be the best we can do without making further arbitrary assumptions.

Figure 5.4: Calibration of the CAPRI model to marginal cost estimates

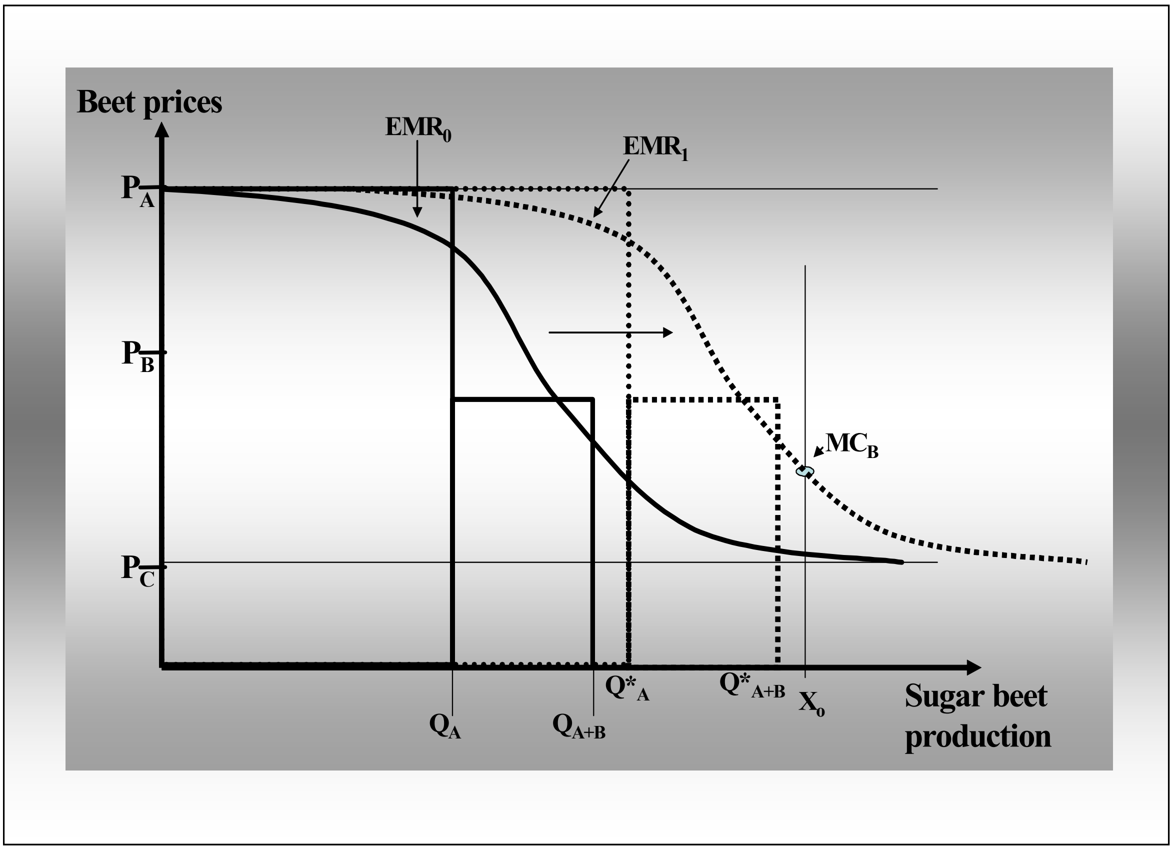


Source: Author's illustration

The following alternative to our calibration method was carried out by ADENÄUER et al. (2004). In order to reconcile the observed production with marginal costs estimates, the authors calibrate the CAPRI model to estimates taken from BUREAU et al. (1997). The idea of their concept is to define a virtual quota mark up such that the expected marginal revenue function equals the estimated marginal costs of sugar beet production at the observed supply level. The quota rent of this additional quota can be interpreted similarly as insurance that beet growers pay for the motives discussed before – or may especially reflect the rumour that processing firms distribute more sugar beet delivery rights than necessary to fill their corresponding sugar quotas (see section 4.3.5).

As shown in Figure 5.5, the expected marginal revenue (EMR) function is simply moved to the right (EMR_0 to EMR_1). The virtual quota mark up is defined relative to the actual quota and is selected as a constant value in simulations as well. The marginal cost MC_B corresponds now to the marginal estimate from BUREAU et al. (1997). While the actual quota endowment was at Q_{A+B}, ADENÄUER et al. (2004) envisage that the beet grower behaves as if his quota endowment is at Q^*_{A+B}.

Figure 5.5: Determination of virtual quota mark ups



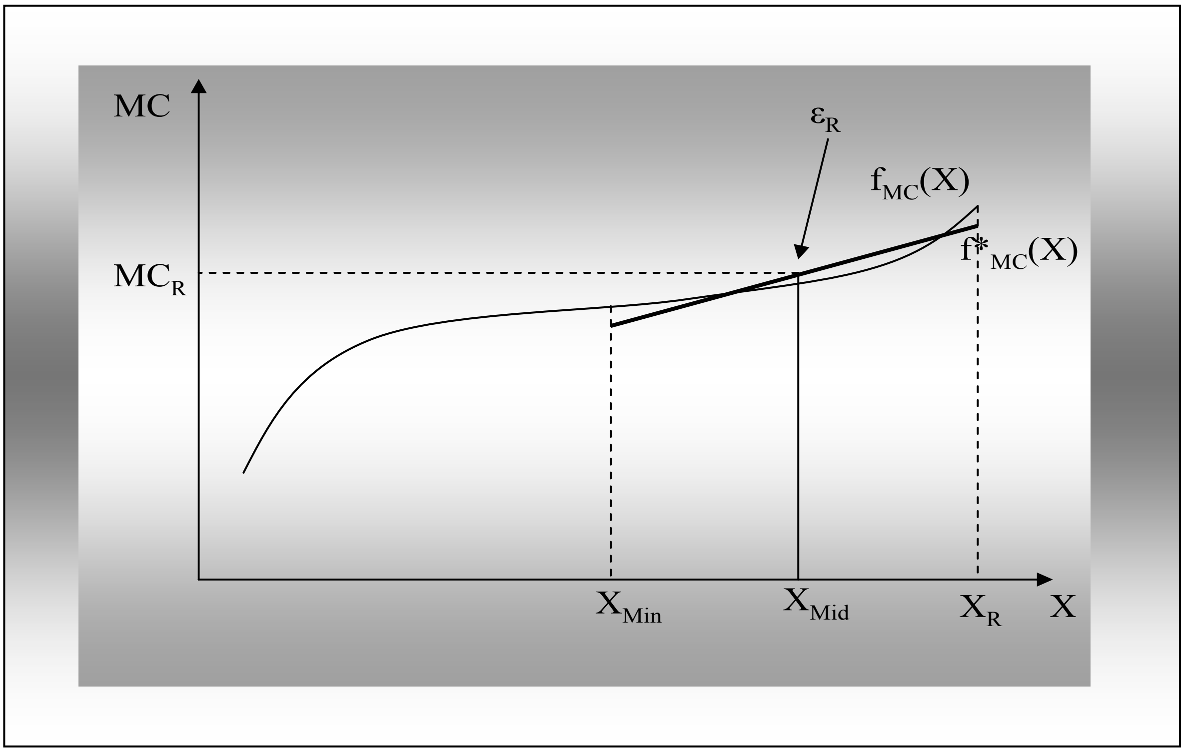
Source: ADENÄUER *et al. (2004)*

It could be shown that the calibration method used in ADENÄUER et al. (2004) leads to a supply response that is very similar to the one we use in the current study. The differences turned out to be negligible. The only mathematical reason why the versions differ at all is found in the yield variance which in our case equals the yield variation coefficient times X^P rather than times X^0 in the virtual quota mark up version.

5.2.3 Introducing Supply Elasticities from FADN

The last adjustment of the supply part is to introduce elasticity estimates from FADN during calibration. Those were calculated as follows: given marginal cost estimates for a number of FADN farms for the three-year average in 1999 as derived in section 3.3, it is possible to compute regional marginal cost curves by horizontal aggregation of their production quantities. Sugar quantities of each farm are hereby weighted by the farm specific factor of representativeness.

Figure 5.6: Regional marginal costs curves from FADN



Source: Author's illustration

The resulting functions have a general shape similar to $f_{MC}(X)$ in Figure 5.6. X denotes the sugar beet production and MC marginal costs. There are a few farms with low marginal costs – lots with an average magnitude and again a fewer number with high marginal production costs of sugar beets. The implementation of these curves as marginal cost curves for a region implies that marginal costs for each farm are assumed to be constant and adjustments on farms are disregarded. A farm would therefore stop sugar beet production if marginal revenues fall below their marginal costs in our model. Our goal is now to ensure that the supply response of our regional supply models approximates those curves. We apply the following method to transfer at least some information from FADN to CAPRI. First, we estimate a linear function ($f^*_{MC}(X)$) but only over 40% of the farms that have the highest marginal costs (X_{Min} to X_R). We choose only the right part of $f_{MC}(X)$ because the regional supply quantity (X_R) is located there and if the model supply response is to aim at simulating the abandoning and starting of farms, it is the more relevant scope. The next step is to calculate the marginal costs $f^*_{MC}(X_{MID})$ and the supply elasticities ε_R at the same point. Both are passed over into the calibration process of CAPRI. This method is only applied to regions with at least 30 observations. In all other regions, we use marginal costs and elasticities derived from applying that calculation to the whole Member State.

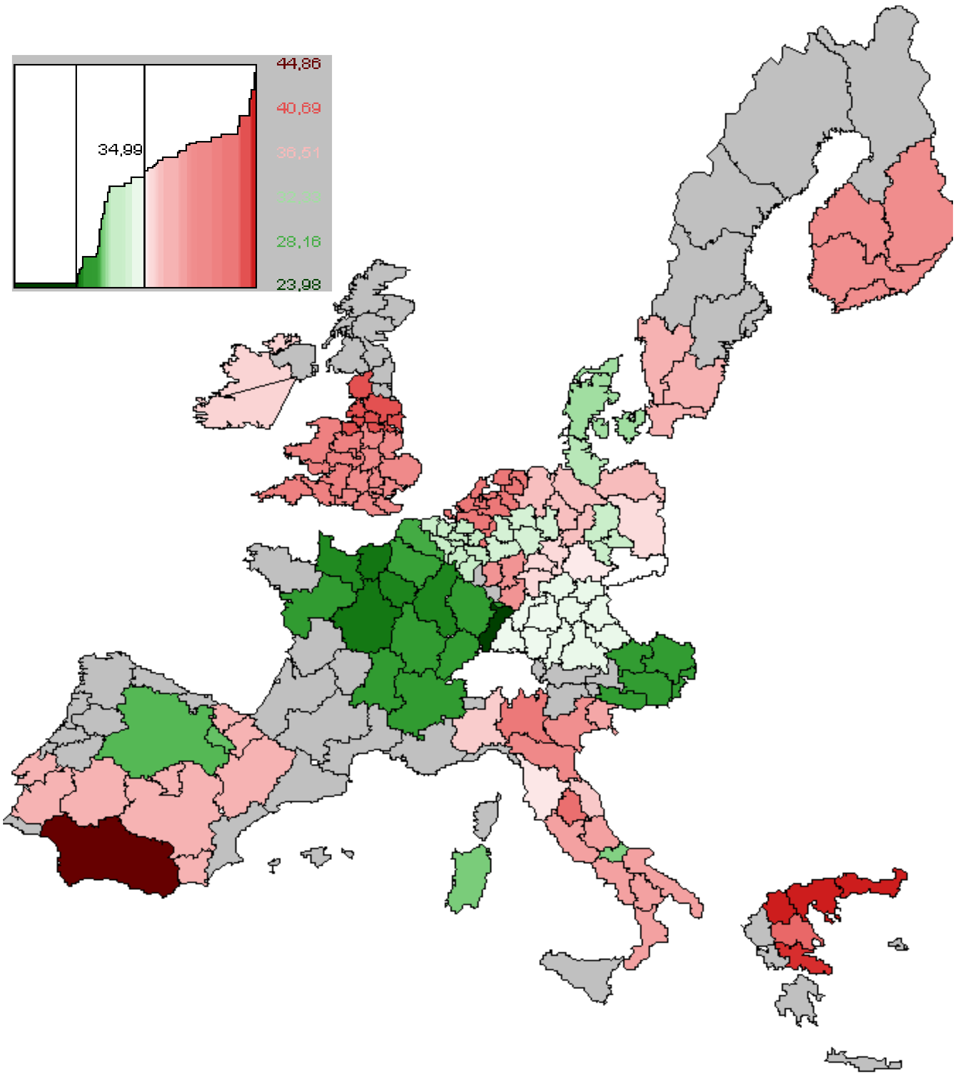
Table 5.2: Regional estimates of marginal costs and supply elasticities

Region		NUTS code	Supply elasticity	Marginal costs (€/ton of beets)
AUSTRIA		AT000000	2.00	26.95
BELGIUM		BL000000	1.09	33.79
GERMANY		DE000000	2.02	35.40
	BADEN-WUERTTEMBERG	DE100000	1.89	34.77
	BAYERN	DE200000	1.37	34.67
	HESSEN	DE700000	3.51	35.60
	NIEDERSACHSEN	DE900000	2.61	36.32
	NORDRHEIN-WESTFALEN	DEA00000	1.96	34.17
	RHEINLAND-PFALZ	DEB00000	3.14	37.85
	SACHSEN-ANHALT	DEE00000	2.14	33.85
DENMARK		DK000000	2.07	32.38
Greece		EL000000	1.45	42.39
	ANATOLIKI MAKEDONIA- THRAKI	EL110000	1.57	43.25
	KENTRIKI MAKEDONIA	EL120000	1.57	43.25
	DYTIKI MAKEDONIA	EL130000	1.57	43.25
	THESSALIA	EL140000	1.57	39.64
SPAIN		ES000000	1.03	36.74
	NORESTE	ES200000	1.77	33.19
	RIOJA	ES230000	2.50	29.64
	CENTRO (E)	ES400000	0.91	32.81
	CASTILLA-LEON	ES410000	0.79	28.88
	SUR	ES600000	1.01	44.85
FINLAND		FI000000	1.84	38.13
FRANCE		FR000000	2.23	26.89
	CHAMPAGNE-ARDENNE	FR210000	1.90	25.84
	PICARDIE	FR220000	2.58	27.24
	HAUTE-NORMANDIE	FR230000	2.33	25.15
	CENTRE	FR240000	5.09	25.21
	BASSE-NORMANDIE	FR250000	2.89	25.98
	ALSACE	FR420000	10.29	23.99
IRELAND		IR000000	3.71	35.77
ITALY		IT000000	1.98	37.37
	NORD OVEST	IT100000	1.10	35.95
	NORD EST	IT300000	2.51	37.58
	VENETO	IT320000	3.01	38.02
	FRIULI-VENEZIA GIULIA	IT330000	2.01	37.14
	TOSCANA	IT510000	2.03	35.32
	UMBRIA	IT520000	1.98	39.35
	MARCHE	IT530000	2.00	36.10
	MOLISE	IT720000	1.31	31.12
NETHERLANDS		NL000000	1.55	38.95
SWEDEN		SE000000	1.48	36.73
UNITED KINGDOM		UK000000	1.64	38.57

Source: Author's calculations.

Table 5.2 gives the resulting regional levels of marginal production costs and supply elasticities for those EU Member States that were included in the FADN analysis and all sugar producing NUTS 2 regions, where more than 30 observations of marginal cost estimates were available.[70] The information given in Table 5.2 is further visualised in Figure 5.7. The green shaded regions have marginal production costs below 35 €/t of sugar beets and the red ones range above that value. In most countries, we do not find much regional heterogeneity while in Germany and Spain, for example, it is much more relevant. The Spanish region *Rioja* is one of the regions with the lowest marginal production costs as well as all the French and Austrian regions, most parts of Germany, Belgium and Denmark.

Figure 5.7: Regional distribution of marginal costs of sugar beet production



Source: CAPRI modelling system and author's calculations

[70] Note that the marginal cost estimates presented in Table 5.2 differ from those given in Table 3.6 on page 45 for two reasons. (1) In the current section, we include only the 40% of farms with the highest marginal costs in the calculation of weighted averages and (2) those in Table 3.6 are based on average sugar contents, while we refer here to the national effective sugar contents per ton of beets.

5.2.4 Sensitivity Analysis of Marginal Costs and Supply Elasticities

In Figure 5.2 we have already seen how important the choice of prior elasticities is in the calibration process. We further know that the magnitude of marginal production costs in the base year influences the supply response of the model as well. To quantify the importance of the values that both variables take in the calibration, we perform a sensitivity analysis, exemplary for Denmark[71]. For this purpose, we calculate the supply response and effective supply elasticities based on a 10% quota reduction ceteris paribus in the base year. Marginal costs are reduced in five steps from 95% of the A-beet base year price to 105% of that of C-beets. PMP slopes are calibrated with prior elasticities from 1 to 5. As mentioned above, there is a difference between prior elasticities and those arising from the calibration. How the effective point elasticities, calculated from a 10% quota reduction, differ from the prior ones is apparent from Table 5.3.

Table 5.3: Supply elasticities depending on marginal costs and prior elasticities for Denmark

prior elasticity marginal costs (€/ton of beets)	1	2	3	4	5
16	0.38	0.75	1.11	1.47	1.81
24	0.56	1.11	1.64	2.17	2.67
32	0.74	1.47	2.18	2.86	3.53
40	0.93	1.83	2.70	3.55	4.39
48	1.11	2.18	3.23	4.25	5.25

Source: Author's calculations

Except for the last line, we see that effective (EMR-) elasticities are generally lower than the initial ones. That difference is higher, the lower marginal costs are. Not very surprisingly, we find that elasticities are higher, the higher marginal costs are, meaning that regions that produce at higher costs in the base year will react stronger to price and quota changes than those with lower ones. Given the existence of a gap between prior and effective elasticities

[71] It turned out that this sensitivity analysis leads to similar results in different EU regions so that the results for Denmark can be transferred to other European regions at least in relative terms.

combined with the wish that our regional supply models mimic the supply curves from FADN, we iteratively adjust the prior elasticities in the calibration, until the calculated effective elasticities meet those presented in Table 5.2.

Table 5.4: Supply response induced by a 10% cut in quotas for different marginal costs and prior supply elasticities in Denmark

prior elasticity / marginal costs (€/ton of beets)	1	2	3	4	5
16	-1.3%	-2.5%	-3.4%	-4.1%	-4.8%
24	-6.2%	-7.7%	-8.4%	-8.7%	-9.0%
32	-7.0%	-8.2%	-8.7%	-9.0%	-9.2%
40	-6.6%	-7.9%	-8.5%	-8.8%	-9.0%
48	-4.1%	-5.6%	-6.5%	-7.1%	-7.5%

Source: Author's calculations

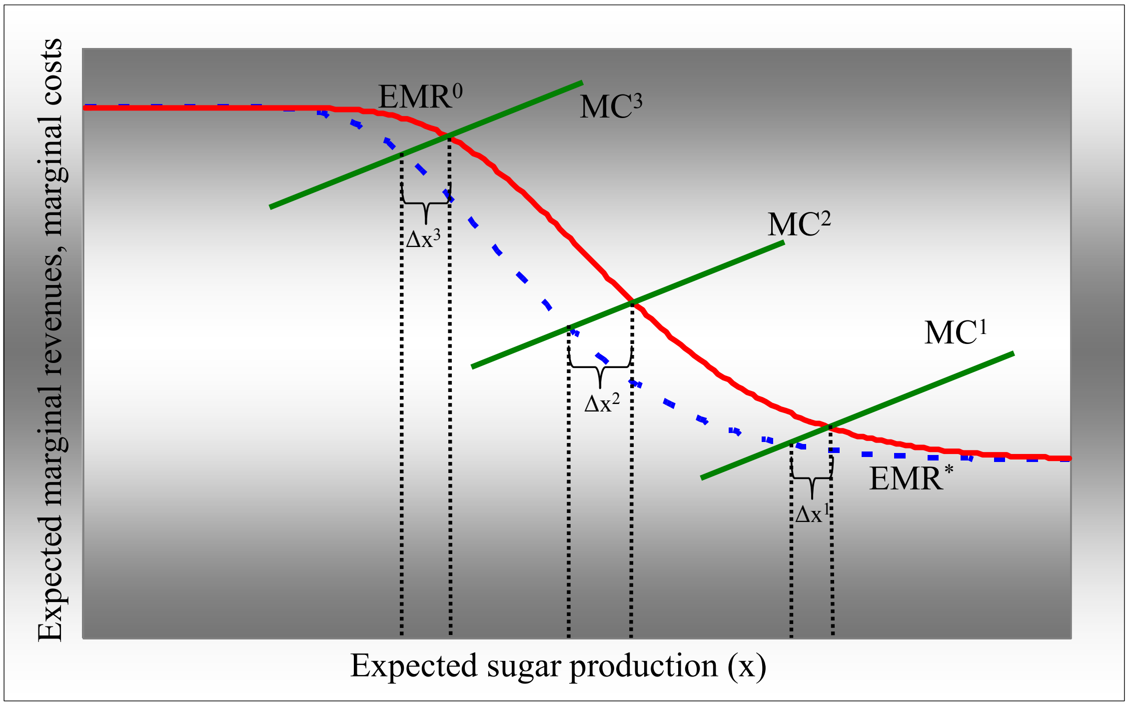
In Table 5.4 the supply response of Denmark to a quota reduction of 10% depending on assumed marginal costs and elasticities is given. The importance of the choice of both variables with respect to model results is obvious. We can make Denmark follow a 10% quota cut by only 1.3% up to 9.2%. It makes a great difference which marginal costs are assumed in the base year. We find that marginal costs are more important to that respect than elasticities, because within one row the maximal and minimal supply reduction varies only by about 3% while it varies about 6% in the columns. If we exclude the two outermost rows from our examination, the supply response varies considerably less. Fortunately, estimated marginal costs fall generally in a range around the mid-point between A- and C-beet prices so that we might conclude that we are acting in a range where the resulting supply response is not that sensitive to a small misspecification of marginal costs. Elasticities range generally from 1 to 4 with two outliers in Italy and two in France. The vast majority of regions shows supply elasticities[72] between 1.5 and 2.5 (Table 5.2).

It might surprise the reader that the supply reduction induced by a 10% quota reduction is not inversely proportional to marginal costs. It reaches a maximum when marginal costs rise

[72] Supply elasticities are not price elasticities in the context of expected profit maximisation. They have to be interpreted as the relative change of sugar beet supply if the Expected Marginal Revenue increases by 1%.

but is reduced afterwards. This phenomenon can be explained by the theory of expected profit maximisation. Figure 5.8 illustrates how the expected marginal revenue function of expected sugar production changes, if quotas are reduced (EMR^0 to EMR^*). Three marginal cost functions (MC^1, MC^2, and MC^3), which have the identical slope but differ in terms of their intercept, are plotted as well. Δx is then the respective supply change induced by the quota cut. Obviously Δx^2 has the largest magnitude which provides us further insights into the simulated supply response in Table 5.4.

Figure 5.8: Sugar beet supply response to a quota reduction depending on marginal production costs



Source: Author's illustration

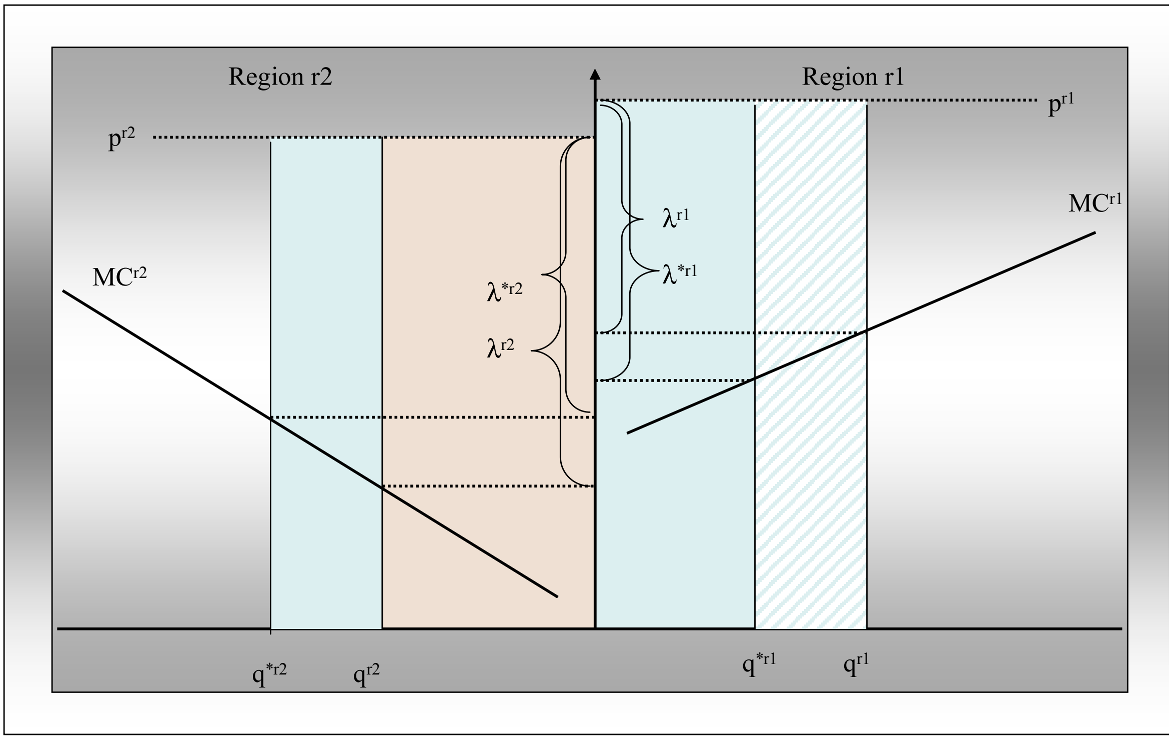
With this small sensitivity analysis we can show that the supply response of sugar beet production with respect to changes of expected marginal revenues strongly depends on marginal production costs and supply elasticities in the calibration point. Thus, marginal costs are the more sensitive variable.

5.2.5 Quota Trade Module

Trading sugar quotas has not been an option within the limits of the CMO Sugar so far, despite the well known positive welfare effects. Nonetheless, it has been discussed in the past (e.g. BUREAU et al. 1997). Since quota trade is an option of sugar market reforms, the introduction of a sugar quota trade module into CAPRI is required. The general economic conditions that lead to quota trade are illustrated in Figure 5.9.

For the moment, we will abstract from expected profit maximisation, the two different quota types and C-sugar and go back to a simple textbook example of any product that is bound by a production quota. We find two regions (or farms), r1 and r2 with quota endowments that amount to q^{r1} and q^{r2}. Marginal production costs in region r1 (MC^{r1}) are higher than in r2 (MC^{r2}). Moreover, we find in region r1 a higher product price (p^{r1}) than in r2 (p^{r2}).

Figure 5.9: Quota trade in the two region case



Source: Author's illustration

The quota rents in both regions are given by λ^{r1} and λ^{r2}. The one in region r2 is obviously higher than that in r1. Differences in quota rents are a requirement for quota trade. A producer will demand quota rights as long as the unit price is lower than the unit quota rent and he will offer them as long as the quota market price is above the quota rent. Consequently, in market equilibrium, quota rents are equalised and equal to the unit market price for quotas. This equilibrium is given in Figure 5.9 at a quota rent of λ^{*r1} ($=\lambda^{*r2}$) and regional quota endowments of Q^{*r1} and Q^{*r2}. In the diagram we assume that quota trade is established without any transaction costs. If those were reflected, the market price for quotas would no longer equal the quota rents in all regions but equal the difference between quota rents and transaction costs.

Transaction costs are disregarded in the CAPRI quota trade module, because we do not know anything about their magnitude. The computation of quota rents in the framework of sugar beet production and expected profit maximisation is less straightforward than in the simplified case given in Figure 5.9. Nonetheless, if we interpret quota rents as the additional profit of an additional unit of quotas, it can be calculated as the first derivative of expected profits (EP_S) with respect to the quota endowment (q) which can be decomposed into the difference between the first derivative of expected revenues (ER_S) and that of total costs (C_S) with respect to q. In our one quota case[73] this leads to:

(5.5)
$$\frac{\partial EP_S(q,Ey(q))}{\partial q} = \frac{\partial ER_S(q,Ey(q))}{\partial q} - \frac{\partial C_S(Ey(q))}{\partial q}$$

Expected revenues are a function of the quota endowment and the expected sugar production which itself depends on the quota endowment. Total costs are not directly linked with the quota endowment, but with the expected production. The latter two derivatives can be decomposed using partial differentials and the chain rule into:

(5.6)
$$\frac{\partial ER_S(q,Ey(q))}{\partial q} = \frac{\partial ER_S(q,\overline{E}y(q))}{\partial q} + \frac{\partial Ey(q)}{\partial Ey}\frac{\partial Ey(q)}{\partial q}$$
$$\frac{\partial C_S(Ey(q))}{\partial q} = \frac{\partial C_S(q)}{\partial Ey}\frac{\partial Ey(q)}{\partial q}$$

Marginal revenues equal marginal cost in the expected profit maximum. Cosequently, the difference of the revenue and costs differentials equals the partial derivative of expected revenues (equation (4.11)) with respect to the quota endowment. This application of the *envelope theorem*[74] simplifies the calculation of quota rents to:

(5.7)
$$\frac{\partial ER_S}{\partial q} = \frac{\partial\left[p^Q Ey_S - \left(p^Q - p^C\right)\left[\left(1-F(q)\right)\left(Ey_S - q\right) + \left(\sigma^S\right)^2 f(q)\right]\right]}{\partial q}$$

Notations are the same as in section 4.1.2. The terms that contain the quota variable are the normal distributions F(q) and f(q). Their derivatives with respect to the variable q are given by:

[73] We compute the quota trade module for only that case, because we simulate quota trade only in combination with a merger of A and B quotas to one single quota.

[74] Originally proposed by the Canadian economist Jacob Viner (1931) and later developed by the American economist Paul Samuelson.

(5.8) $$\frac{\partial F(q)}{\partial q} = f(q)$$

which follows from the definition of the cumulated normal distribution and by

(5.9) $$\frac{\partial f(q)}{\partial q} = \frac{\partial\left[\frac{1}{\sqrt{2\pi(\sigma^s)^2}} e^{\frac{-(q-Ey^s)^2}{2(\sigma^s)^2}}\right]}{\partial q} = f(q)\left[-\frac{(q-Ey^s)}{(\sigma^s)^2}\right]$$

Substituting (5.8) and (5.9) into (5.7) the first derivative of expected revenues with respect to the quota endowment can be written as

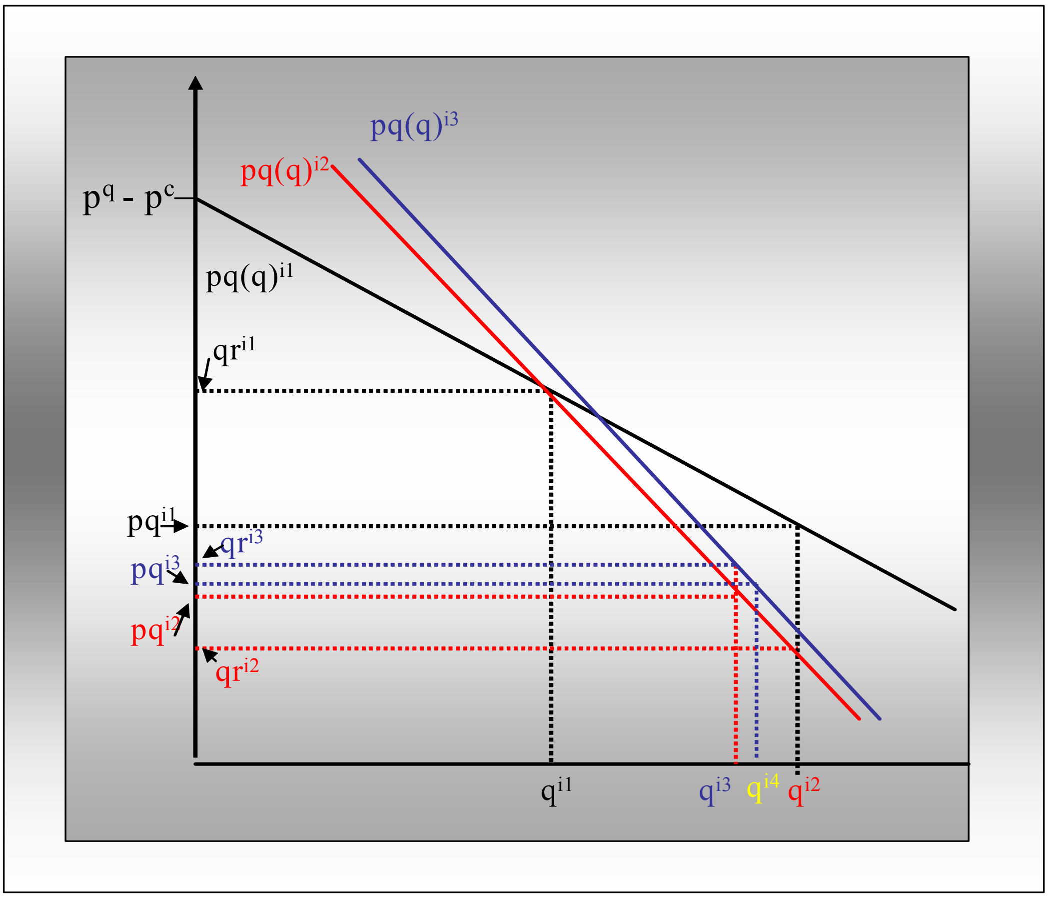
(5.10) $$\begin{aligned}\frac{\partial ER_S}{\partial q} &= -\left(p^Q - p^C\right)\left[\left(-f(q)\right)\left(Ey_S - q\right) - \left(1-F(q)\right) + \left(\sigma^S\right)^2 f(q)\left[-\frac{(q-Ey_S)}{(\sigma^s)^2}\right]\right]. \\ &= \left(p^Q - p^C\right)\left(1-F(q)\right)\end{aligned}$$

This final formula for the quota rent is nothing but the difference between the two prices, which gives the maximal possible quota rent, multiplied by the cumulated probability that production exceeds the quota. It can be used to simulate quota trade in CAPRI based on the considerations in Figure 5.9. Thereby, the first best solution seems a simultaneous optimisation of regional expected profits, where the regional quota endowment becomes a variable and an additional restriction that forces regional quota rents to be equalised across all regions is implemented. In this sense, unfortunately, a simultaneous optimisation of the regional supply models is technically infeasible due to a number of equations and variables introduced. We therefore introduce a quota trade module in CAPRI which is solved in every iteration between the supply and the market model that converges to the quota trade equilibrium. The equation system is given by:

(5.11) $$\begin{aligned}&pq^r = \alpha^r + \beta^r q^r \\ &\text{s.t.} \\ &pq^{eu} = pq^r \\ &q^{eu} = \sum_r q^r\end{aligned}$$

Regional quota prices (pq^r) are defined in a linear quota demand function dependant on exogenous parameters α^r and β^r and the regional quota endowment q^r. The two other restrictions guarantee that regional quota prices are equal to the uniform quota trade price pq^{eu} and that the sum over all regional quota endowments equals the total quota endowment at EU level. All regions r are included in the model where sugar beets have been produced in the base year. This model is based on sugar rather than on sugar beets. The parameters α^r and β^r are adjusted for every iteration as presented in Figure 5.10.

Figure 5.10: Iterative solution of sugar quota trade in CAPRI



Source: Author's illustration

Exemplary for one region, the iterative convergence of the quota trade module is achieved as follows: The regional quota rent of a ton of sugar from the supply module calculated with formula (5.10) is given in the first iteration by qr^{i1}. We know that it corresponds to a quota endowment of q^{i1}. In the first iteration, α^r is defined as the maximal quota rent because we know that quota rents shrink if quotas are reduced, so their maximum should be achieved at zero quotas. Parameter β^r is defined so that the curve $pq(q)^{i1}$ runs through the point defined by qr^{i1} and q^{i1}. When α^r and β^r are specified the quota trade model is solved and a quota trade price (e.g. pq^{i1}) and new regional quota endowments (q^{i2}) are achieved. Those quotas are then passed over to the next iteration of the supply module and quota rents are calculated again (qr^{i2}). Parameters α^r and β^r are then redefined such that the quota/quota rent combinations of the last two iterations are met by the demand function $pq(q)^{i2}$. Quotas are then traded again and a new quota price (pq^{i2}) is found at a new quota endowment (q^{r3}) which is given back again to the supply part which in turn feeds back new quota rents (qr^{i3}). From the third step, the definition of α^r and β^r follows the principle to exactly meet the combination of quota rents and quotas from the last supply model results and such that squared differences between the combinations of the last four iterations (if existent) and the values given by the quota demand function are minimised. Thereby squared differences are weighted giving the previous iteration a higher weight than before and so on. Convergence is achieved when quota rents from the supply module are equalised across all regions and equal to the quota trade price.

As mentioned before, the implemented quota trade system is simplified. It assumes that processing firms follow the most profitable sugar beet production location without any costs and that transaction costs do not exist. Nonetheless, with its help we are able to shed light on how quotas may move between regions and which prices are likely to be paid for a ton of sugar quota.

5.2.6 Sugar Trade in the World Market Model

As introduced in section 5.1.3, the world market module of CAPRI uses the Armington assumptions on heterogeneous goods for simulating bilateral trade flows. Sugar, however, is a quite homogenous good. In order to address this, we use higher elasticities of substitution for sugar than for other products. They are set to 10 for both levels in all trading blocks of the model.[75]

High MFN tariffs and the safeguard clause prevented any non preferential sugar imports into the EU-15 in the past. Preferential agreements on sugar imports are regulated in the CMO Sugar and laid out in CEC (2004a). In the following paragraphs, we introduce the reader to the various preferential agreements that exist today and will become relevant in 2009. We further address how those agreements are handled technically in CAPRI.

- The ACP protocol. Originating in the Commonwealth agreements governing the import of raw cane sugar into the United Kingdom for processing and marketing, this agreement allows the ACP country group to export up to about 1.3 million tons of white sugar equivalent at a minimum import price at least 645 € into the EU-15. Further Special Preferential Sugar (SPS) that is destined to cover the net demand of sugar in the French overseas territories up to 0.3 million tons is added. Although the latter type of sugar is imported at slightly higher in quota tariffs and its quantity depends on the net demand in the target regions, we simply define a TRQ for the ACP country group in CAPRI at about 1.6 million tons white sugar equivalent with zero in quota tariff.

- At the time of their accession to the European Community, Finland negotiated that they are allowed to import about 85000 tons of raw cane sugar for refining from Brazil and Cuba at an in quota tariff of 98 € per ton. A price guarantee is not given for those quantities. Since Cuba and Brazil are members of the CAPRI regional aggregate *'free trade developing'*, we allocate a TRQ with those quantities and tariffs to that county group.

- At the end of 2001, all import duties for products originating in the West Balkans were abolished. Imports from those countries into the EU have risen to 270000 tons in 2003 and induced the last cut in European sugar production quotas in 2001. The West Balkan countries are members of the *'rest of the world'* aggregate. Although in reality not existent, we introduce a tariff rate quota[76] with zero in quota tariffs for this country aggregate as well and define it at the observed three-year average imports (104000 t according to EU Commission (2004a) from Western Balkans in the base year 2001 and expand it in simulations to an expected import quantity in 2009. HENRICHSMEYER et al. (2003) expect this quantity to range between 0.4 and 0.8 million tons. We adopt the average value of 0.6 million tons.

- The Everything but Arms[77] initiative allows the 46 Least Developed Countries (LDCs) to export all products (but arms) into the European Community without any duty or quota. For sugar, special assignments regulate that this state is reached stepwise by the year 2009. The high price level on EU sugar markets offers the LDCs a great incentive to export sugar into the EU. Export quantities into the EU are limited by domestic production in order to avoid swap transactions (rule of origin). In CAPRI, most of the LDCs are found in the regional aggregate ACP. A

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[75] Even higher elasticities of substitution might be realistic to mimic almost homogeneous goods in the Armington approach. However, model convergence turned out to be difficult to achieve for higher elasticities than 10.

[76] In the Commission's reform proposal of 2004, it is recommended to introduce a tariff rate quota for imports from the West Balkans. This, and the relatively small amount of total imports makes the introduction of an TRQ for the *'rest of the world'* aggregate even more reasonable.

[77] Council Regulation (EC) Nr. 2501/2001, OJL 346, p 1, Article 9 (4) and (5).

smaller part is spread among the *'rest of the world'* (ROW) and the *'free trade developing'* (CAD) aggregate. The fact that not all ACP countries are LDCs and that the redefining of country groups with respect to questions on sugar markets was not feasible within the scope of this study, makes modelling the EBA initiative difficult. It will now be explained how we will proceed in order to simulate EBA.

SOMMER (2003) identifies an additional export potential of LDC countries of about 2.4 million tons of raw sugar equivalent. Hereby it is assumed that LDCs export their entire production into the EU and supply their own sugar demand from the world market. Although he further points out that expected exports are mainly in terms of raw sugar and that those are limited by the capacities of European refineries, we assume that those 2.4 million tons are a reasonable magnitude for expected additional imports and they are in line with the assumptions made by HENRICHSMEYER et al. (2003a).[78] Our strategy to take into consideration those additional sugar imports into the EU-15 when we simulate reform options for the year 2009, involves adding a certain amount to the tariff rate quota of those country aggregates that include LDCs, because all regional aggregates in CAPRI that contain LDCs include a considerable number of regions to which quota and duty free EU market access is not granted. We would overestimate EU sugar imports if we simply allowed the entire aggregates to import sugar at zero tariffs without any quota. We calibrate the market model such that TRQs are fully used in case EU prices stay at the same high level as today.

5.2.7 Limitations of Modelling the Sugar Sector with CAPRI

The introduction of several modifications in the CAPRI modelling system has made the model suitable to analyse changes in agricultural policy with respect to the CMO Sugar. Although the modelling of sugar beet supply, world markets for sugar and the processing industry are adjusted to take into consideration all specialties of the CMO Sugar, there are a number of limitations and unresolved issues. Besides the general limitations of an applied economic model, the representation of the sugar sector is specifically limited due to:

- A strong dependency of sugar beet supply response to estimated marginal production costs and supply elasticities in the base year. Although the specification

[78] Based on SOMMER (2003) and HENRICHSMEYER et al. (2003), we expect additional sugar imports from LDC countries in 2009 under current EU market prices to reach about 2.5 million tons white sugar equivalent assuming some additional imports in 2009 compared to those from Sommer (2003) calculated for 2001. The TRQs of the three country aggregates containing LDCs are then enhanced by this value multiplied by the share of average (1998-2001) exports of LDCs of an aggregate in total average LDC-sugar exports in the same period.

of both variables is based on farm data, their estimation avails itself of some crucial simplifications. Nonetheless, from the author's point of view, it is the best we could do within the scope of the present study.

- The general contradiction of assuming sugar to be a homogenous good and the Armington approach. We try to reduce this problem by using higher elasticities of substitution than for other products. But it cannot be ruled out that the Armington assumptions applied to the sugar sector lead to an underestimation of substitution of sugar from different import regions and, in turn, to an underestimation of price changes. But since sugar imports into the EU are mainly controlled by TRQs, the problem may be of minor importance for the EU market.

- The need to observe base year trade quantities to allow for trade flows in simulations. In reality, the formation of new bilateral sugar trade flow may be conceivable if sugar market prices change. Such effects are disregarded but probably of minor importance for EU imports as long as non preferential sugar imports are blocked by high tariffs.[79]

- Simplifications and aggregation problems of the world market modelling. A disadvantage that occurs if we want to analyse the impacts of 'Everything but Arms' or similar bilateral trade agreements is that the global players affected by the concession (the Least Developed Countries) are not a single regional aggregate in our world market model. The trade impacts are therefore strongly dependant on exogenous assumptions regarding the definition of TRQs as described in section 5.2.6.

- A rather simplified representation of the sugar processing industry. We principally disregard them as a global player on the sugar market by simply assuming them to pass a constant share of their revenues over to the farmer. Processing costs, however, are not explicitly modelled.

- The quota trade representation. If quota trade is established across the entire European Union, processing firms will be heavily involved in that business. Our quota trade model assumes that each farmer (each region) owns sugar quota and

[79] The problem of those zero observations in the Armington approach is analysed in WITZKE et al. (2005).

quota trade is strongly dependant on the sugar beet production costs, disregarding problems that occur if processing enterprises have to close or concentrate in other regions.

- The 'perfect market assumption'. We assume the European sugar market to be competitive. BLUME et al. (2003), however, analyse the question how it can be possible to observe sugar prices in the European Member States that lie considerably above the intervention price and differ among countries. They conclude that we face tacit collusion between sugar selling firms. Such effects are ignored as well.

Although these are a number of points that might enhance the discrepancy between the model response and reality, the representation of the specialities of the CMO Sugar in our model is a significant contribution compared to existent approaches (e.g. FRANDSEN et al., 2003). In the following section, we will apply the CAPRI modelling system to a number of selected reform options of the CMO Sugar.

5.3 Scenario Definition

In order to quantify the impacts of relevant reform options of the CMO Sugar as implied by the heading of section 5, we need to identify those options. But first and foremost, we have to define a reference to which we compare these scenarios. Generally, the base year could serve as a reference. The base year in our case is 2001 while we forecast the year 2009. Between those two years there are a number of exogenous developments, captured by yield-, price- or demand trends, GDP growth or inflation or general changes in the political environment. If we compared our policy scenarios to the base year, all those effects would be implicitly existent and might blur the effects of interest. Consequently, the reference must be dated in 2009 as well and include all those exogenous shocks to isolate the policies of interest. The assumptions on which our reference run is based, as well as the definition of three simulation scenarios, are outlined in the next sections.

5.3.1 The Reference Scenario

There are a number of exogenous shifts that are based on estimates of the European Commission and other sources like FAPRI or the World Bank. Those are mainly population growth and price trends as well as trends on production and consumption quantities. Those are used to calibrate the market model in the year 2009. The reference run further includes the full implementation of the CAP reform of 2003. The main measures of the 2003 CAP reform include an adoption of a single decoupled direct payment, a reduction of administrative prices and a payment modulation system. The most important measure is the substitution of the different direct payments or premiums received according to the Agenda 2000 settings with a 'single payment per farm' beginning in 2005. Such single farm payments are calculated on the basis of 'a reference amount in a reference period 2000-2002'. This implies that the amount of the single farm payment would no longer depend on what and how much the farmer actually produces. The single farm payment is, therefore, said to be 'decoupled' from production. The reform, however, gives each EU Member State the possibility to choose a 'degree of decoupling' among different options. In Table 8.1 in the Annex we show the options of the 2003 CAP reform each Member State of the EU15 has chosen, which are taken into account in the reference and subsequent simulation scenarios. A detailed description of the calculation of the decoupled premium can be found in BRITZ et al. (2002). On all product prices where explicit price forecasts are not available, CAPRI assumes a yearly inflation rate of 1.9% .

Regarding sugar beet production, the exogenous assumptions on yield growth is that it is equal across European regions and amounts to 0.25% per annum which sum up to a 2% increase from the base year (2001) to the simulation year (2009).[80] We further assume that both the import and the export regime are subject to base year regulations. Regarding sugar beet prices, we assume that the estimated coefficients listed in Table 5.1 are the same for 2009. Sugar world market prices are projected to about 205 €/t of sugar.

5.3.2 Scenario I: 'EBA'

The 'EBA' scenario differs from the reference run only in that we implement the duty and quota free access of LDC countries into the EU for sugar. We further allow for additional imports from the West Balkan countries. The idea behind this scenario is to evaluate how the current regulations of the CMO Sugar would deal with additional sugar imports. As re-exports of those imports are not allowed by WTO restrictions, they have to be placed on the European sugar market. Consequently, domestic production of the same amount has to be taken out. This can be achieved in two ways: either the EU sugar market price or sugar quotas have to be reduced. Since the CMO Sugar aims at a high EU sugar price, it includes a mechanism that

[80] CAPRI features an explicit yield forecast tool. Unfortunately, some unresolved problems led to unreasonable trends for sugar beet yields so that we make this exogenous assumption here.

cuts sugar quotas so that high market prices are achieved. This so-called declassification, described in Council Regulation (EC) No 2038/1999 under article 26, distributes the necessary quota cut among EU Member States and sugar types (white sugar, isoglucose and inulin syrup[81]) in a non linear way. More precisely, those EU Member States that own higher B-quota shares are penalised with higher quota cuts than those that own only small B-quota amounts. As visible from Table 5.5, Germany and France bear about 60% of the quota reduction although they own less than 50% of the EU-15 sugar quota. On the other hand Spain, where B-quotas amount only to 4% of A-quotas receives only a 3% reduction even though its total quota endowment amounts to about 7% of EU-15 total quotas. One can see clearly who suffers and who benefits from this regulation.

Table 5.5: Sugar quotas of the base year (2001) and declassification coefficients (EU-15)

	Sugar Quotas				Declassification coefficient		
	A	B	total	B/A	on A quotas	on B quotas	on total quotas
unit	1000 t			%	% of total quota reduction		
EU	**11383**	**2499**	**13882**	**21.9**	**80.3**	**19.7**	**100.0**
BL	669	144	813	21.5	4.6	1.0	5.6
DK	322	95	416	29.5	2.7	0.8	3.5
DE	2585	795	3381	30.8	22.5	6.9	29.4
EL	287	29	316	10.0	1.2	0.1	1.4
ES	954	40	994	4.2	2.6	0.1	2.8
FR	2510	745	3255	29.7	23.3	6.5	29.8
IR	180	18	198	10.0	0.8	0.1	0.9
IT	1301	245	1545	18.8	8.2	1.6	9.8
NL	678	179	856	26.4	5.3	1.4	6.7
AT	311	73	384	23.3	2.3	0.5	2.8
PT	71	8	79	11.1	0.3	0.0	0.3
SE	333	33	366	10.0	1.4	0.1	1.6
FI	132	13	145	10.0	0.6	0.1	0.6
UK	1030	103	1133	10.0	4.4	0.4	4.9

Source: CAPRI modelling system and Council Regulation (EC) No 2038/1999

5.3.3 Scenario II: The Proposal of Franz Fischler (July 2004)

This scenario is based on the proposal made by the retired commissar of agriculture Franz Fischler in July 2004 (CEC, 2004b). The proposal envisages the abolition of intervention for sugar and the replacement of the intervention price by a reference price that serves as a kind

[81] Other types than white sugar do not play a major role on EU sugar markets, so that most of the quota

of price floor to derive minimum beet prices. It is defined at 421€ per ton of white sugar, which corresponds to a 33% reduction compared to the actual intervention price (631 €). A private storage system is introduced where sugar can be stored in case the market price falls below that price floor. Minimum sugar beet prices are reduced by the same relative change from 43.6 €/t of beets down to 27.4 €. These final reductions will be reached in three steps by 2008. Since the CAPRI model is comparatively static and our simulation year is 2009, we assume the full reduction in our simulations.

Quotas are envisaged to be reduced by 16% and A- and B-quotas are merged to one single quota which enters the model exogenously. The declassification as described above is abolished because it basically penalises those countries that are more competitive in sugar production. The EU Member States all receive therefore in contrast to scenario I the same relative reduction in quotas. It is further envisaged to partly compensate sugar beet farmers by a direct payment. National envelopes are defined and each Member State is required to incorporate those payments into the single farm payments defined in the CAP reform 2003 based either on the quota beet production or total beet production in the historical reference period. This premium right belongs to the farmer and will not change even if quotas are traded or the farmer abandons sugar beet production. Assuming that those payments do not affect the crop allocation they are not included in the optimisation process but only in the income calculation and EU budget outlays. Hereby, regional envelopes are derived based on the total sugar beet production in the base year and those are added to the regional sugar beet income of farmers from premiums and to the FEOGA outlays for premiums as well.

A reduction of subsidised exports to 400.000 tons of white sugar is further proposed and implemented in this scenario. The private storage system and the conversion scheme that compensates sugar factories that are forced to stop production are not modelled, the former because EU prices in the simulations did not fall below the reference price and the latter because the modelling of the sugar industry is simplified and not able to represent the closing of sugar factories.

The last important change is the introduction of a quota trade system. According to this, quotas are allowed to be transferred between all sugar processing firms across the European Union. Again, due to the simplified representation of processing, we assume in the model that sugar beet producer can trade quotas and that they do this according to their quota rents as described in section 5.2.5. The assumption that sugar quotas are traded according to the

reductions affect white sugar from sugar beets.

difference between production costs and expected marginal revenues of sugar beet farmers implies that sugar processing firms are keen on remaining in regions where sugar beet production is the most competitive.

5.3.4 Scenario III: The Proposal of Mariann Fischer Boel (June 2005)

This scenario is based on the proposal made by the European Commission in June 2005 (CEC, 2005). In some points it goes beyond the Fischler proposal, in other points it adheres closer to the existing system. It is not compulsory to reduce sugar quotas, for example. On the other hand, institutional prices are reduced further (-39%). This greater reduction is said to be necessary in order to keep imports at a lower level.

Both proposals include the introduction of a private storage system, the merger of A- and B-quotas into one single quota as well as a compensation payment to sugar beet farmers. The latter is in scenario III higher, because a higher price reduction has to be compensated. A comparison between the national envelopes for direct income supports for farmers in scenarios I and II is given in Table 8.2 in the annex.

It is further proposed to introduce a restructuring scheme that compensates processing firms that have to abandon sugar production because they are not able to cover their production costs at lower sugar prices. The EU Commission offers to buy their quota endowment out of the market at a price of 730 € in 2006/07. If a processing firm decides to leave the industry later than 2006/07, they only receive a reduced price for quotas. The price is reduced in three linear steps to 420 € in 2009/10 which is the last year the Commission offers the restructuring aid. The money necessary to create a new restructuring fond that would cover the costs of the scheme is collected from the remaining companies by charging a quota duty per ton over three marketing years. Additionally, for those EU Member States that are known as C-sugar producers, an additional quota amount is made available which they can buy from the Commission at the same prices at which the Commission buys quotas. Those funds are allocated to the restructuring fond as well. The sum of those additional quota amounts made available is limited to 1 million tons.

Since the sugar processing industry is hardly represented in our model and the actors in the envisaged restructuring scheme are the processing firms, we have to make some assumptions about how restructuring might take place. We assume the following: If prices went down to the proposed level, some processing firms would not be able to continue production. In our model, quotas would simply be not fully used in less competitive regions. It is therefore reasonable to assume in our model that the unused quota quantities would be sold. Exactly this is our assumption.[82] We reduce regional quota endowments to the level where quotas are at least filled at 95%.[83] By assuming that only regional competitiveness of sugar beet farmers regulates the quota amounts drawn out of the market, we assume that

- at least one processing firm remains in those regions where sugar beets are still cultivated and transportation costs do not increase;
- processing firms do not redistribute quotas from less competitive farmers in a region to the more competitive ones;
- the competitiveness of processing is correlated with that of farmers in a region;
- other reasons that might lead to a closure of processing firms are negligible.

In order to represent the possibility for the C-sugar producing countries to buy additional quotas, we distribute the amount of 1 million tons among those regions according to their C-sugar supply in the base year. The costs for buying new quotas, as well as the revenues from selling them, are not included in the allocation mechanism of CAPRI, because we assume that processing firms bear those costs alone. This means we do not have to change the price linkage function implemented in the model. In 2009, which is our simulation year, the restructuring is not yet finished but the comparative static character of the model is not able to capture the transition period. We have to assume that the transition has been already completed.

In the Commission's proposal, there is no statement concerning subsidised exports and the lost WTO panel. It only says '*Without prejudice to the EU's stated intention to phase-out agricultural export subsidies in the framework of the Doha Development Agenda (DDA), the report of the WTO requires certain changes in order to ensure that EC export subsidy commitments are respected*'. We interpret this to mean that the Commission assumes the CMO changes addressed above are sufficient to meet the WTO limits on subsidised exports including the panel decision (OXSFAM, 2004). According to that decision 1.3 million tons of subsidised exports remain 'legal'.

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[82] Although quota trade is not an option here, one could alternatively imagine fixing the quota price in the respective module at the envisaged price at which quotas are drawn out of the market distributed over a planning period of 10 years. The problem here is that we cannot apply the whole price and compare it to farmer quota rents, because we do not know anything about how the processing industry and farmers share existing quota rents. It turned out that even a 50/50 distribution was so high that half of the European quotas vanished.

[83] A slight undersupply might be likely due to some risk considerations.

As this latest reform proposal was published shortly before the present study was finished, we have to be content with the simplified representation of restructuring. Nonetheless, it may be valuable to compare its impacts to the Fischler proposal in scenario II, especially to identify the difference of a quota trade scheme based on farmers' quota rents, compared to the assumptions that quotas are adjusted until they are not under-filled at regional level.[84] An overview of the most important differences between the addressed scenarios is given in Table 5.6. A more detailed description of parameters that enter the model – those that are equal among scenarios and those that change – is available from the author upon request.

Table 5.6: Overview on policy assumptions in the analysed scenarios

	Reference (2009)	Scenario I	Scenario II	Scenario III
CAP reform	Member State MTR implementation - Further decrease in administrative prices			
Intervention price*/basic beet price	631 €/t S / 48 €/t SB		421 €/t S / 28 €/t SB	385 €/t S / 25 €/t SB
Production quotas	1400.000 t	endogenous adjustment	16% cut to reference	endogenous through restructering assumptions
			merger of A and B quotas, no declassification, partial compensation	
Quota trade	no	no	yes	no
Tariffs and TRQ for LDCs	current WTO commitments	duty and quota free access for LDCs		
Subsidised exports	current WTO commitments		limit: 400.000 t (+ C sugar exports)	limit 1300.000 t (including C exports)

Source: Author's illustration and CEC (2004b and 2005)

**The intervention price is called reference price in scenario II and III and is subject to a private storage system and not to intervention*

[84] The results from sections 3 and 1 suggest that quota rents are not necessarily correlated with the C-sugar production so that we expect different results for both scenarios.

5.4 Results of Impact Analysis

In this section we present the model results of the analysed scenarios. We will concentrate on the changes in sugar and sugar beet prices, sugar production and quotas, the EU sugar market balance, LDC imports and analyse the impacts on sugar consumers, sugar beet farmers and the FEOGA budget. The analysis is carried out at EU-15[85] level and for some indicators even for EU Member State and NUTS 2 regions. We start with a comparison of the reference scenario to the base year situation.

5.4.1 The Reference scenario

The reference scenario, as described above, is mainly a projection of the base year sugar and sugar beet production quantities to the year 2009 under the conditions of the CAP reform 2003. In Table 5.7 we summarise the reallocation of certain products / product groups in the reference scenario and compare them to the base year. We observe the effects of the CAP reform from 2003 that are found in other studies as well (for example, the Mid Term Review published by DG Agri in CEC, 2003): a strong decrease in cereal land allocation combined with an increase of fodder production on arable land. It is comprehensible that land cultivated with cereals is decreasing due to increasing yields and the decoupled payment scheme.[86] But it seems contra intuitive that the area which is set free is mainly reallocated with fodder production because the animal sector loses a great deal of relative competitiveness as well. The reason for that is found in a reduction of production intensity in the animal sector. Compared to the agenda 2000 situation, it becomes cheaper to produce fodder on arable land so that production intensity is likely to decrease.

More detailed information on the effects of the CAP reform from 2003 is found in the above quoted DG Agri report where an impact analysis of the Mid Term Review (MTR) is

[85] The version of the CAPRI model that we use includes only the EU-15 Member States in the supply part. The new member countries are a single regional aggregate in the market part. Unfortunately, it was not possible to aggregate both to only one market within the scope of this study. Furthermore, it turned out to be almost impossible to make the regional aggregate of the new Member States react proportionally to the EU-15 market, which mainly is due to the Armington assumptions. The final assumptions on the sugar market of the new Member States are that they are not joined. Over all scenarios their production trade figures stay almost constant according to our results. Nonetheless, the error we make with that assumption might be considered relatively small, because before the accession those countries produced at lower sugar prices than those guaranteed by the CMO. Their quota endowment was defined according to the production quantity in a base period. One might therefore expect that the sugar production in those countries will not be heavily reduced, if quotas and prices go down because sugar revenues are still above those in the base year.

carried out with different models, among them the CAPRI model. But since an MTR analysis is not a focus of this study, we are content with knowing that the political environment of our reference point is the latest CAP reform.

Table 5.7: Land allocation in the reference and the base year (EU-15, 1000 ha)

	Base year (2001)	Reference (2009)	
	value		*change to Base year*
Cereals	37519	34709	*-2810*
Oilseeds	5306	5137	*-169*
Sugar beet	1881	1900	*19*
Potatoes	1275	1296	*22*
Fodderproduction	59886	62334	*2448*
Set aside	5609	5661	*51*
Non Food	487	420	*-67*
Other uses	20537	21326	*789*

Source: CAPRI modelling system

Sugar beet land allocation in the reference scenario is increasing. This is due to two overlapping effects. Increasing sugar beet yields tend to reduce sugar beet land allocation. But the dominating effect is that of increasing competitiveness due to the new premium scheme. Generally, those crops gain in competition, where premiums were lower in the Agenda 2000 situation than after the CAP reform. Sugar beets are included in this group of crops because they did not receive any premium in the past and are now eligible for the decoupled premium. As a consequence, sugar beet production increases at European level by about 3% as apparent from Table 5.8.

[86] Cereals lose relative competitiveness because the new per ha amount of premiums is lower than that applied to cereals in the base year under Agenda 2000 conditions.

Table 5.8: Key indicators on the EU-15 sugar (beet) markets – Reference and base year

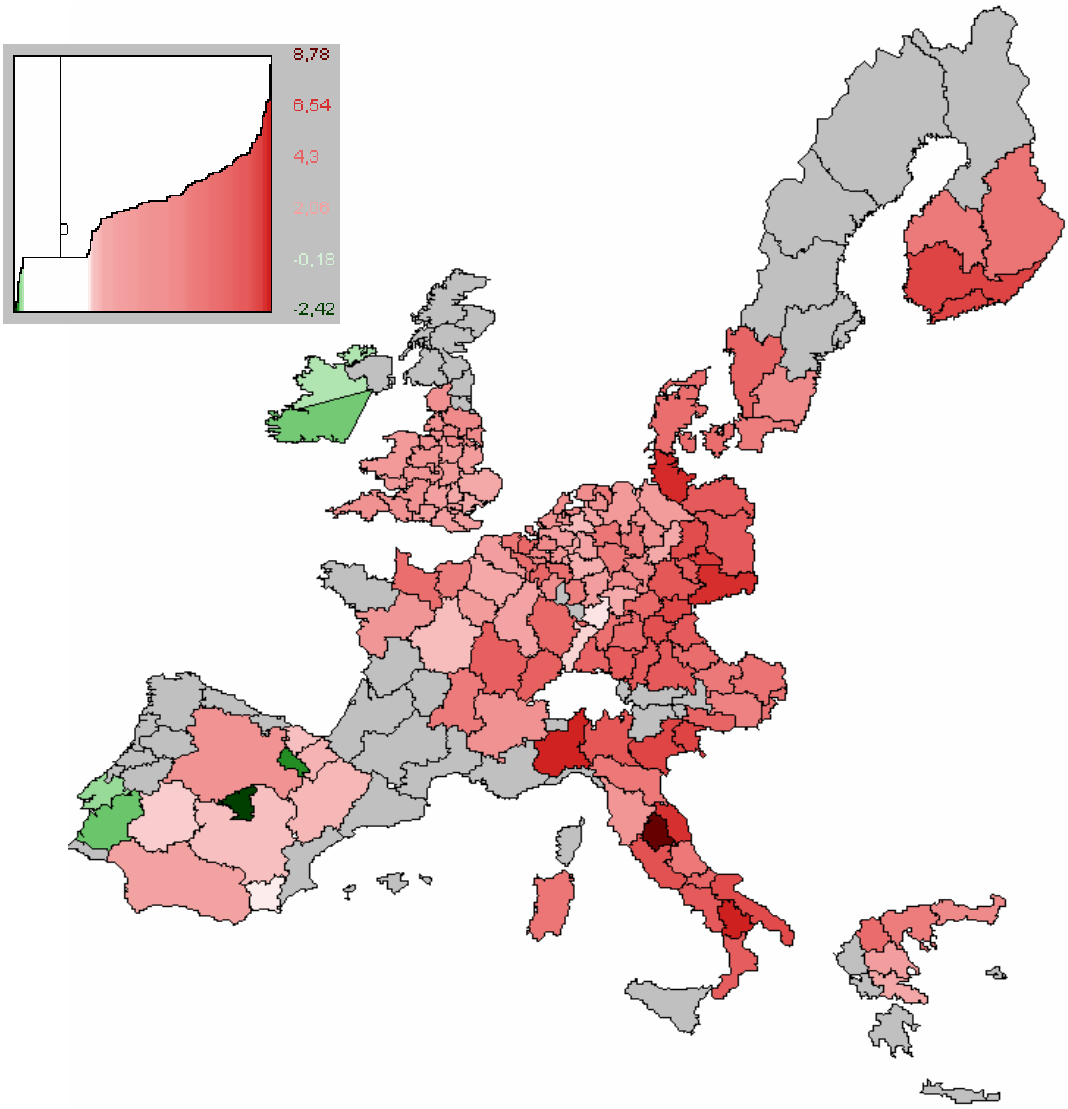
		Unit	Base year (2001)	Reference (2009)	
			value*	value	% change to base
Sugar beet	**A sugar beet**				
	producer price	€/t	59.12	51.77	*-12.4*
	production	1000t	80181	80175	*0.0*
	B sugar beet				
	producer price	€/t	54.45	47.17	*-13.4*
	production	1000t	16370	16909	*3.3*
	C sugar beet				
	producer price	€/t	18.41	15.53	*-15.7*
	production	1000t	15875	18633	*17.4*
	Sugar beet total				
	average price	€/t	52.69	45.26	*-14.1*
	production	1000t	112425	115716	*2.9*
Sugar	**EU price**	€/t	807	708	*-12.3*
	World market price	€/t	226	190	*-15.9*
	Quota	1000t	13882	13882	*0.0*
	Domestic supply	**1000t**	**16068**	**16534**	***2.9***
	Belgium	1000t	933	966	*3.6*
	Denmark	1000t	509	529	*3.9*
	Germany	1000t	4041	4178	*3.4*
	Greece	1000t	322	332	*3.0*
	Spain	1000t	1075	1098	*2.1*
	France	1000t	4196	4284	*2.1*
	Ireland	1000t	211	210	*-0.5*
	Italy	1000t	1415	1482	*4.8*
	Netherlands	1000t	961	986	*2.6*
	Austria	1000t	431	447	*3.7*
	Portugal	1000t	85	84	*-1.4*
	Sweden	1000t	415	429	*3.3*
	Finland	1000t	153	161	*5.4*
	United Kingdom	1000t	1322	1350	*2.1*
	Imports	**1000t**	**1818**	**1821**	***0.2***
	Total supply	**1000t**	**17886**	**18355**	***2.6***
	Domestic demand	**1000t**	**12951**	**12967**	***0.1***
	Exports	**1000t**	**4935**	**5388**	***9.2***
	Subsidiesed	1000t	2618	2673	*2.1*
	C sugar exports	1000t	2317	2715	*17.2*
	Total demand	**1000t**	**17886**	**18355**	***2.6***

**Monetary values in the base year are inflated (1.9% per annum)*

Source: CAPRI modelling system

For a better comparison of the change of price incentives in the reference relative to the base year, we inflate the base year monetary values. The nominal increase of the EU sugar market price from 695 to 708 € is in fact a decrease (from 807 to 708 €) in real monetary terms. Revenues per hectare from sugar (quota) beet production are consequently decreasing as well. Even this is overcompensated by the decoupled premium scheme making sugar beet production more competitive. The degree of overcompensation naturally differs among EU Member States and regions. As visible in Table 5.8, not all EU-15 Member States extend sugar beet production. In Portugal and Ireland, it is reduced. Those regional differences are further illustrated in Figure 5.11.

**Figure 5.11: Relative change of sugar beet supply:
Reference scenario (2009) to base year (2001), EU-15 NUTS 2 in %**



Source: CAPRI modelling system

Apparently, apart from the Portuguese and Irish regions, production is reduced in two other Spanish regions as indicated by the green colour. The darkest red regions, which are those where sugar beet production shows the strongest increase relative to the base year production, are located in Italy, although Italian regions were estimated to be among the high cost producers (compare Table 5.2). But regional differences occur not only as a result of sugar beet production costs. They also depend on the relation of price reduction for beets to the comparative advantage of the new premium scheme or the changes in opportunity costs to sugar beet production. The domestic sugar demand of the EU-15 is projected to increase by 0.1%.

Table 5.8 further illustrates that sugar beet prices react proportionally to the EU- and the world market price for sugar, respectively.[87] The latter is decreasing in both real and nominal terms. This is because the rising EU sugar supply triggers more C-sugar exports which, in turn, puts pressure on the world market price. Sugar production quotas, as indicated above, do not change and sugar imports stay basically at base year levels as well.

To summarise, the reference run is characterised by

- slightly increasing sugar beet production in most EU-15 regions due to the CAP reform which benefits those arable crops that have not received premiums beforehand;
- price decrease for sugar and sugar beets in real terms;
- increasing C-sugar exports and
- domestic demand and imports that stay on base year levels.

5.4.2 Scenario I: 'EBA'

The 'Everything but Arms' scenario differs from the reference run in that we assume that quota and duty free access for all products including sugar are granted to the LDC group. We further expect additional imports from the Western Balkan countries. To maintain the high EU sugar prices, a reduction of European sugar quotas is necessary which is ensured by the declassification mechanism (see section 5.3.1).

As intended by the quota reduction, arable land assigned to sugar beet production is decreasing as shown in Table 5.9. The 282 000 ha allocated to sugar beet production in the reference run can be switched to other crops. Mainly cereals and fodder on arable land substitute for sugar beets. Although the sugar beet area is reduced by about 15% we see that the area released from sugar beet production leads only to very small relative changes in area for possible substitutes. This again stresses that the sugar beet sector plays only a minor role in agriculture as a whole. One argument of the sugar beet lobby frequently proclaimed in order to achieve solidarity between non sugar beet farmers and those that cultivate beets is that even the former group of farmers would suffer from a politically induced substitution of sugar beets by, say, cereals. This would create a greater supply of cereals that would put pressure on prices. This argument might be considered weak because even if the total area that is cultivated with sugar beets today were moved to cereals, it would only mean a 5% increase in cereal production. This would not put too much pressure on cereal markets. To confirm this hypothesis, Table 8.4 on page 180 shows the development of producer prices for arable crops over all scenarios analysed. There it is apparent that resulting price reductions are comparably small.

Table 5.9: Land allocation in the reference and scenario I (EU-15, 1000 ha)

	Reference (2009)	**Scenario I**		
			change to Reference	*relative change to Reference*
Cereals	34709	34754	*45*	*0.13%*
Oilseeds	5137	5169	*32*	*0.62%*
Sugar beet	1900	1618	*-282*	*-14.84%*
Potatoes	1296	1299	*2*	*0.19%*
Fodderproduction	62334	62457	*123*	*0.20%*
Set aside	5661	5696	*35*	*0.63%*
Non Food	420	427	*7*	*1.55%*
Other uses	21326	21364	*38*	*0.18%*

Source: CAPRI modelling system

[87] A real world market price for sugar does not exist within the Armington approach. We use the unit value of all sugar exports of the EU-15 as a proxy for it.

Due to the minor importance of the sugar sector, we refrain from presenting tables such as Table 5.9 or Table 5.7 in the following scenarios, because the picture looks very much the same. For those who are still interested in the figures of all scenarios please see Table 8.3 on page 179.

Regarding sugar prices in the current scenario, we see in Table 5.10 that our goal to maintain the price level of the reference is not entirely reached. The EU-15 sugar market price falls by 0.6 % to 704 €. Nonetheless, this can be considered basically the same price level.[88] The change in sugar beet prices is somewhat confusing at first sight. A- and B-beet prices are increasing although sugar prices are going down and a difference between both prices no longer exists. The explanation for this phenomenon is found in the levy mechanism. According to HENRICHSMEYER et al. (2003a) European sugar producers would no longer have to pay for subsidised exports because it is not quota sugar that is exported, but LDC imports. Those would be financed by the EU budget. Consequently, as the supply of EU quota sugar falls short of sugar demand and no B-sugar has to be exported, no levies are collected. As a result, there is no longer a price differentiation between A- and B-sugar beets and the joint price is above the A-beet price found in the reference scenario where levies were collected even on A-beets. The distinction between A- and B-sugar is therefore obsolete in the current scenario. C-beet prices stay basically at the same level as in the reference because the world sugar market price hardly changes either.[89]

The necessary quota cut in the current scenario amounts to about 20% or 2.7 million tons. This is slightly lower than the 3 million tons of additional imports. One reason is that in the reference, more quotas were not filled in some Member States than in the current scenario. The main reason, however, for the difference of about 300000 tons is due to a general problem of the Armington assumptions. In Table 5.10 we have added a line called aggregation error. This error occurs because the physical market balance does not necessarily come out even. The Armington approach only ensures that the market balance in terms of utility adds up to zero. As EU sugar is assumed to have other utility than imported sugar, the error becomes larger, the farther we move away from the quantity framework of the reference.

[88] Due to technical feasibility, it was not possible to meet the reference price exactly.

[89] One might have expected that it increased because the reduced EU supply should reduce the pressure on world market prices. Indeed, all sugar prices countries outside the EU-15 increase in the current scenario, but we use the unit value of all exports leaving the EU at different prices which exists due to the Armington assumptions. This value depends not only on price developments in the exporting regions, but also on the change of the export pattern as well. If the share of exports to countries with lower prices increases, it is possible that the average unit value of all exports will decrease, even though all export prices are increasing.

Table 5.10: Key indicators on the EU-15 sugar (beet) markets - Reference and scenario I

		Unit	Reference (2009)	Scenario I	
			value	value	*% change to Reference*
Sugar beet	**A sugar beet**				
	producer price	€/t	51.77	52.98	*2.3*
	production	1000t	80175	65077	*-18.8*
	B sugar beet				
	producer price	€/t	47.17	52.98	*12.3*
	production	1000t	16909	13765	*-18.6*
	C sugar beet				
	producer price	€/t	15.53	15.49	*-0.3*
	production	1000t	18633	19236	*3.2*
	Sugar beet total				
	average price	€/t	45.26	45.63	*0.8*
	production	1000t	115716	98079	*-15.2*
Sugar	**EU price**	€/t	708	704	*-0.6*
	World market price	€/t	190	189	*-0.3*
	Quota	1000t	13882	11190	*-19.4*
	Domestic supply	**1000t**	**16534**	**13993**	***-15.4***
	Belgium	1000t	966	824	*-14.7*
	Denmark	1000t	529	436	*-17.4*
	Germany	1000t	4178	3415	*-18.2*
	Greece	1000t	332	308	*-7.2*
	Spain	1000t	1098	1049	*-4.5*
	France	1000t	4284	3410	*-20.4*
	Ireland	1000t	210	190	*-9.6*
	Italy	1000t	1482	1315	*-11.3*
	Netherlands	1000t	986	813	*-17.5*
	Austria	1000t	447	381	*-14.7*
	Portugal	1000t	84	79	*-6.0*
	Sweden	1000t	429	395	*-8.0*
	Finland	1000t	161	149	*-7.3*
	United Kingdom	1000t	1350	1229	*-8.9*
	Imports	**1000t**	**1821**	**4792**	***163.2***
	India	1000t	10	10	*-0.2*
	ACP	1000t	1620	4052	*150.1*
	Rest of the world	1000t	104	610	*486.5*
	Free trade developing	1000t	87	120	*38.0*
	Total supply	**1000t**	**18355**	**18785**	***2.3***
	Domestic demand	**1000t**	**12967**	**12972**	***0.0***
	Exports	**1000t**	**5388**	**5423**	***0.7***
	Subsidiesed exports	1000t	2673	2620	-2.0
	C sugar exports	1000t	2715	2803	3.2
	Aggregation error	1000t	0	390	
	Total demand	**1000t**	**18355**	**18785**	***2.3***

Source: CAPRI modelling system

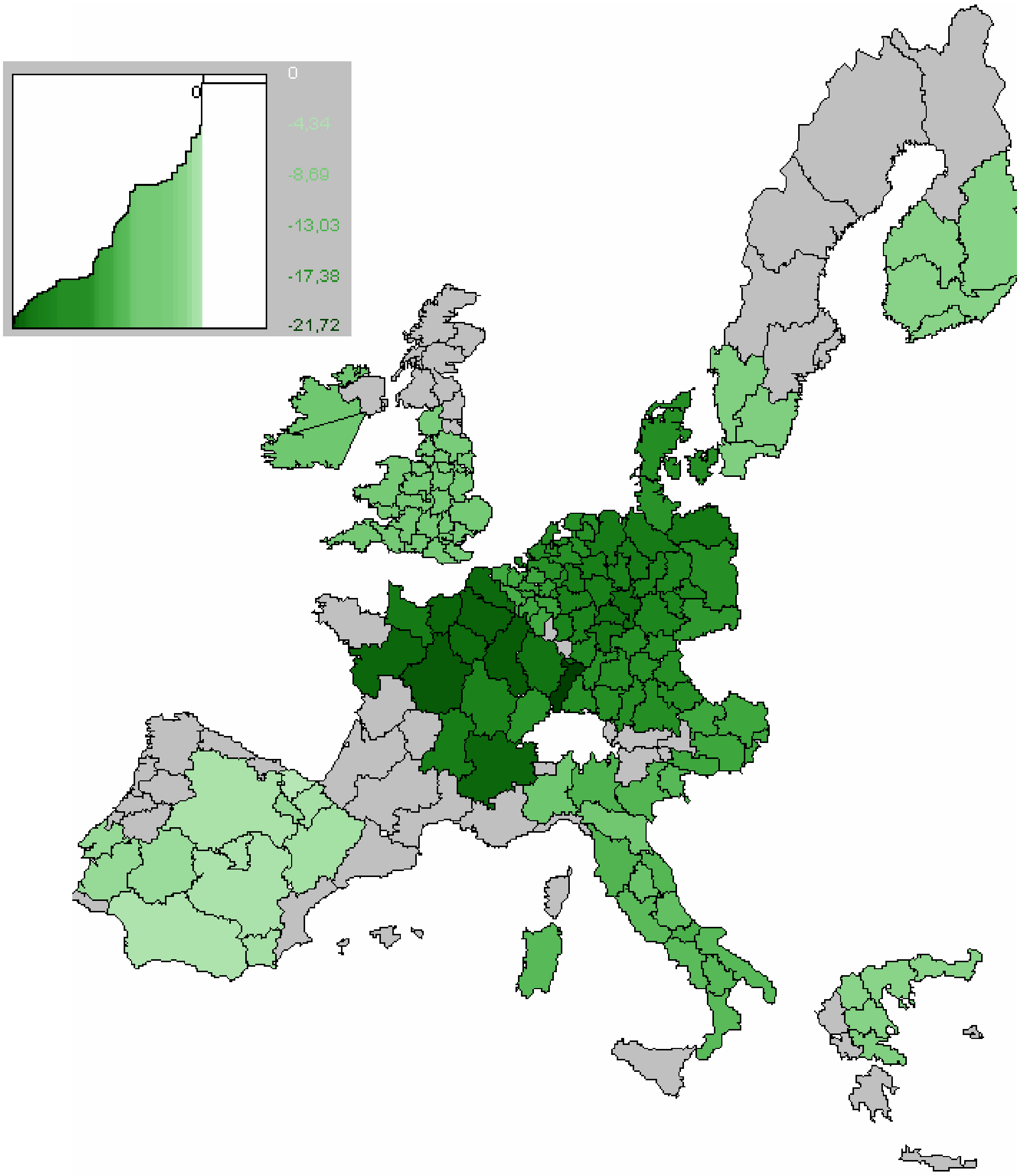
The origins of imports are given in Table 5.10 as well. We see that most additional imports stem from the ACP county aggregate that contains most of the LDCs. Imports from the *free trade developing* group rise, too, because this aggregate contains some LDCs as well as the *rest of the world*. Most of the increase of the latter group, however, stems from the Western Balkans.

The differences in supply reduction among EU-15 Member States mainly come from the declassification mechanism. As noted before, the countries that own larger B-quotas receive a higher quota reduction according to this mechanism. France and Germany, for example, receive a quota reduction of about 24% while in Spain the reduction amounts only to about 8%. It is apparent that EU sugar production follows the quota cut slightly dampened indicating a substitution of former quota sugar with C-sugar.

In Figure 5.12 the effect of the declassification is illustrated. In the darker green shaded regions, the supply reduction of sugar beets is stronger than in brighter ones. Regional differences within Member States seem to be negligible. The only striking region is *Alsace* in France. But taking into account the results on supply elasticities given in Table 5.2, we find that this region shows extremely high estimated supply elasticities. It is therefore not surprising that this region shows the largest relative supply reduction in France.

Summarising this scenario, the CMO Sugar in its current design is able to cope with additional sugar imports, but it penalises those countries that are assumed to be more competitive in sugar beet production. We should further keep in mind that the scenario is not a long-term equilibrium. It is to be expected that the LDCs will be able to extend their production even more than assumed in our analysis. Further quota cuts would be likely, especially if the exporting countries find a way to evade the *rule of origin* that limits exports from a country based on its domestic sugar production in order avoid swap transactions. EU welfare positions are analysed in the overview of all scenarios in section 5.4.5.

Figure 5.12: Relative change of sugar beet supply: Scenario I to reference, EU-15 NUTS 2 in %



Source: CAPRI modelling system

5.4.3 Scenario II: The Proposal of Franz Fischler (July 2004)

As indicated above, the Fischler proposal is characterised by a decrease in European sugar quotas by 16%, combined with a decrease in institutional prices by 33% and partial compensation. Furthermore, trade of sugar quotas between sugar companies of the European Union is introduced.

Analysing the key indicators on European sugar markets, we find in Table 5.11 that the EU market price for sugar amounts to 434 €, which is higher than the proposed reference price (421 €). The same accounts for the average sugar beet price for quota beets, which is found above the minimum beet price of 28 €/t. C-sugar beet prices are slightly increasing due to an increase of the world market price for sugar. As a consequence of resulting price changes and the quota reduction combined with the trade option, European sugar supply is going down by 21%. This is a greater decrease than was found in scenario I. We further see that imports basically reach the level of the reference run. They are considerably lower than in scenario I because the incentive to supply sugar into the EU is greatly decreased by the lower market price. The tariff rate quota allocated to the Western Balkan regions is reduced to 174 000 tons in this scenario, so that they supply considerably less than in the EBA scenario. The total EU sugar supply, given by the sum of domestic production and imports, amounts to about 15 million tons, 3 million less than in the reference.

Domestic sugar demand slightly increases due to lower prices. The most affected position in the market balance, however, are sugar exports. The proposal includes a reduction of subsidised sugar exports to 400 000 tons or 85% of the reference quantities. Furthermore, C-sugar production greatly decreases, so that total exports are reduced by 3.5 million tons. Note that the Armington aggregation error is nearly zero again, because the quantity framework of imports and domestic use of quota sugar is closer to the reference.

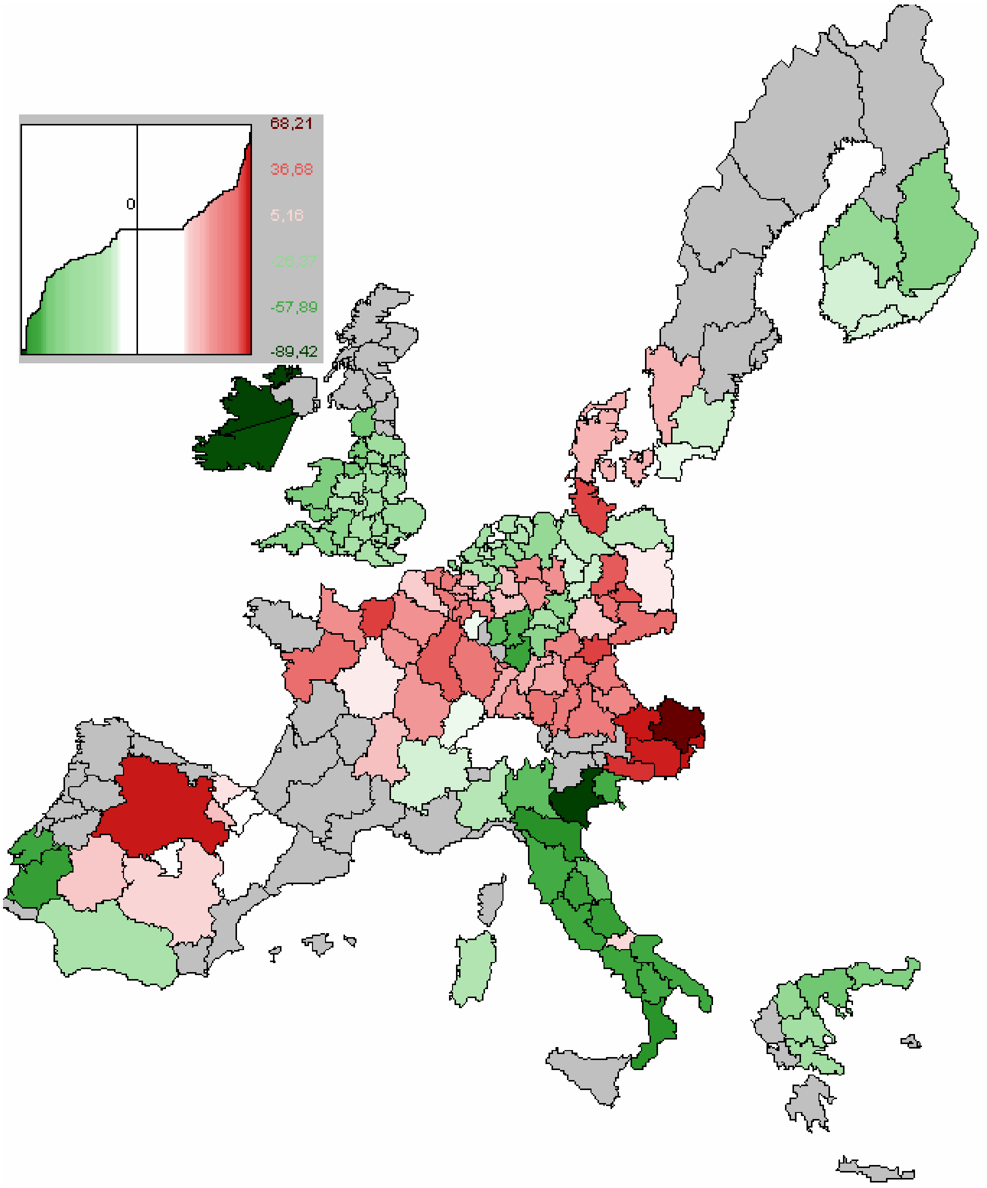
We further recognise that the relative decrease of sugar production varies greatly among EU-15 Member States. Large reductions are found in Ireland, Italy, Portugal and Greece, while Belgium, Spain and France show lower relative supply reductions. Those differences arise from different production costs but also from the introduction of tradable quotas. The impact of the trade regime on quota reallocation is shown in Figure 5.13.

Table 5.11: Key indicators on the EU-15 sugar (beet) markets - Reference and scenario II

		Unit	Reference (2009)	Scenario II	
			value	value	% change to Reference
Sugar beet	**A sugar beet**				
	producer price	€/t	51.77	31.80	*-38.6*
	production	1000t	80175	65534	*-18.3*
	B sugar beet				
	producer price	€/t	47.17	31.80	*-32.6*
	production	1000t	16909	14652	*-13.3*
	C sugar beet				
	producer price	€/t	15.53	15.73	*1.3*
	production	1000t	18633	10109	*-45.7*
	Sugar beet total				
	average price	€/t	45.26	30.00	*-33.7*
	production	1000t	115716	90295	*-22.0*
Sugar	**EU price**	€/t	708	434	*-38.7*
	World market price	€/t	190	204	*7.4*
	Quota	1000t	13882	11661	*-16.0*
	Domestic supply	**1000t**	**16534**	**13049**	***-21.1***
	Belgium	1000t	966	904	*-6.4*
	Denmark	1000t	529	460	*-12.9*
	Germany	1000t	4178	3445	*-17.5*
	Greece	1000t	332	184	*-44.6*
	Spain	1000t	1098	1042	*-5.1*
	France	1000t	4284	4006	*-6.5*
	Ireland	1000t	210	22	*-89.7*
	Italy	1000t	1482	495	*-66.6*
	Netherlands	1000t	986	637	*-35.3*
	Austria	1000t	447	536	*19.9*
	Portugal	1000t	84	27	*-67.7*
	Sweden	1000t	429	329	*-23.4*
	Finland	1000t	161	114	*-29.0*
	United Kingdom	1000t	1350	847	*-37.3*
	Imports	**1000t**	**1821**	**1933**	***6.2***
	India	1000t	10	5	*-48.2*
	ACP	1000t	1620	1638	*1.1*
	Rest of the world	1000t	104	174	*67.6*
	Free trade developing	1000t	87	116	*33.3*
	Total supply	**1000t**	**18355**	**14981**	***-18.4***
	Domestic demand	**1000t**	**12967**	**13113**	***1.1***
	Exports	**1000t**	**5388**	**1863**	***-65.4***
	Subsidiesed exports	1000t	2673	416	*-84.4*
	C sugar exports	1000t	2715	1446	*-46.7*
	Aggregation error	1000t	0	6	
	Total demand	**1000t**	**18355**	**14981**	***-18.4***

Source: CAPRI modelling system

**Figure 5.13: Regional sugar quotas:
Scenario II relative to reference quotas cut by 16% in %**



Source: CAPRI modelling system

The equilibrium price for traded quotas turned out to be 28 € per ton of sugar quota which has to be interpreted as a yearly rental price. As can be seen in Figure 5.1, where the red shaded regions are quota buyers and the green ones sell parts of their quota, quotas flow from the Italian, Irish, Greek, Finnish, Portuguese, Dutch, some German, Spanish and French regions to Austria, France, parts of Germany and Spain as well as to Belgium, Denmark and western Sweden. As a reference quota endowment we do not choose those from the reference run, but reduce them by 16%, because the proposal includes a 16% quota reduction. The highest relative quota increase is found in Austria in *Niederöstereich,* while the highest relative quota reduction is found in *Veneto* in Italy. The small Italian region *Molise* is the only region in Italy that belongs to the quota buyer group.[90]

Table 5.12 shows the national quota flows. We see that only 12% of EU sugar quotas change their holder. In absolute terms, most quota quantities are bought by France, while Austria buys the most in relative terms compared to the reference run quota reduced by 16%. The Spanish region *Rioja* is the NUTS 2 region that buys the highest absolute quota amount across Europe. This is partly founded in the absolute size of that region and partly in relatively low marginal production costs in the base year. Italy sells more than half of their quotas due to high production costs and Ireland gets rid of 88% of their quotas.

All in all, the results from the quota trade analysis are basically a mirror of the marginal cost estimates given in Table 5.2 and Figure 5.7. Again we have to point out that the limited representation of processing firms, who are in fact the holders of quota rights and therefore the actors when it comes to tradable quotas, limits the interpretability of our results. Only if more competitive processing enterprises are located where the more competitive sugar beet farmers are found, we would be close to a realistic picture of quota trade. Our results therefore only intend to show the direction where quotas might go rather than being a good indication of the absolute amounts of trade flows.

To summarise the results of scenario II, the decrease of institutional prices reduces sugar beet imports from third countries compared to scenario I. Although sugar beet prices decrease considerably compared to the same scenario, EU-15 sugar supply increases. This partly comes from higher quota amounts at EU level but especially from higher quotas in more competitive regions because the abolition of declassification as well as the introduction of a quota trade scheme benefits those regions. Sugar exports decrease considerably which reduces the pressure on world sugar market prices so that they tend to increase. The income effects of the current scenario will be discussed in the welfare analysis given in section 5.4.5.

[90] This region is the only one across Europe where marginal cost estimates were lower than the respective expected marginal revenue at base year production rendering a higher competitiveness than without the calibration to marginal costs.

Table 5.12: Trade of sugar quotas between EU-15 Member States

	Sugar quotas traded	
	absolute (1000 t)	**relative to quota (%)**
EU15	1 428.8	12
Belgium	153.3	22
Denmark	41.1	12
Germany	167.8	6
Greece	-80.5	-30
Spain	259.7	31
France	592.7	22
Ireland	-146.0	-88
Italy	-813.3	-63
Netherlands	-133.7	-19
Austria	214.0	66
Portugal	-34.8	-52
Sweden	-9.8	-3
Finland	-10.2	-8
United Kingdom	-200.5	-21

Source: CAPRI modelling system

5.4.4 Scenario III: The Proposal of Mariann Fischer Boel (June 2005)

The latest proposal of the EU Commission goes beyond the Fischler Proposal in terms of price reduction, but in terms of quota reduction it is more moderate. There is no obligatory quota reduction at all. A reduction of European quotas is achieved by offering a restructuring scheme whereby processing firms can sell their quota rights. On the other side, there is a bonus for ‘classical C-sugar supplying countries’. They are allowed to buy an additional amount of sugar quotas.

In Table 5.13 we observe that although institutional prices for sugar and sugar beets are proposed to be reduced to 385 €/t (25 €/t), the resulting prices are still higher. This is mainly because the pressure from LDC imports is greatly reduced. At the equilibrium price the EU-15 is only faced with about 900 000 tons of sugar imports. [91]

[91] Generally, the substitution of import sugar with domestic production compared to the reference scenario has two reasons: (1) the revenues for exporters to the EU are reduced due to a lower EU sugar price and (2) EU-15 sugar becomes more attractive for EU consumers by this reduction as well. Both effects lead to a sensitive model response of sugar imports on changing prices.

EU-15 sugar exports decrease considerably compared to the reference and WTO limits are perfectly met. Domestic demand increases due to lower market prices. Furthermore, we observe increasing sugar prices on world markets and greatly reduced C-sugar beet production. The main reason for this development is that classical C-sugar producing countries are able to buy additional quotas. C-sugar production is consequently partly substituted by quota production in those countries. The only reason why there is still C-sugar left stems from the fact that only 1 million tons of additional quotas are made available. Most C-sugar quantities as apparent from Table 5.15 are still produced in France and Germany in this scenario.

Changes in sugar production per EU-15 Member State are again projected to be very heterogeneous. The most striking effect is that France supplies even more sugar than in the reference due to an quota extension of 20% or 665 000 tons as apparent from Table 5.14. In that table and in Figure 5.14 we show in which regions quotas have been reduced and in which they are increasing. We assume France, Germany, Austria, Belgium and Denmark to be eligible for buying quotas[92]. In Figure 5.14 we see that the relative changes in sugar quotas range from +39% (to the reference) in *Kaernten* in Austria to a -90.5% in *Veneto*, Italy. Italy comes up with a supply reduction of about 70% and Ireland almost completely stops supplying sugar.

Spain reduces sugar production by 18%. This large reduction compared to the previous scenario is due to the possibility to buy quotas. We do not allocate Spain to the group that is eligible to buy quotas although the region *Rioja* would like to, according to their production costs. Consequently, *Rioja* cannot compensate the supply reduction of the other Spanish regions as in scenario II. EU sugar quotas are finally reduced by 1.3 million tons. If we assume that all those quotas are sold in the first year of the restructuring scheme where quota sellers receive 730 €/t, the costs for buying quotas will amount to about 950 million €.

The analysed proposal benefits those countries known to be the relevant sugar producers in Europe, above all France, but also Germany Austria, Belgium and Denmark. The following section will provide a better overview of the differences between the analysed scenarios and EU-15 welfare impacts.

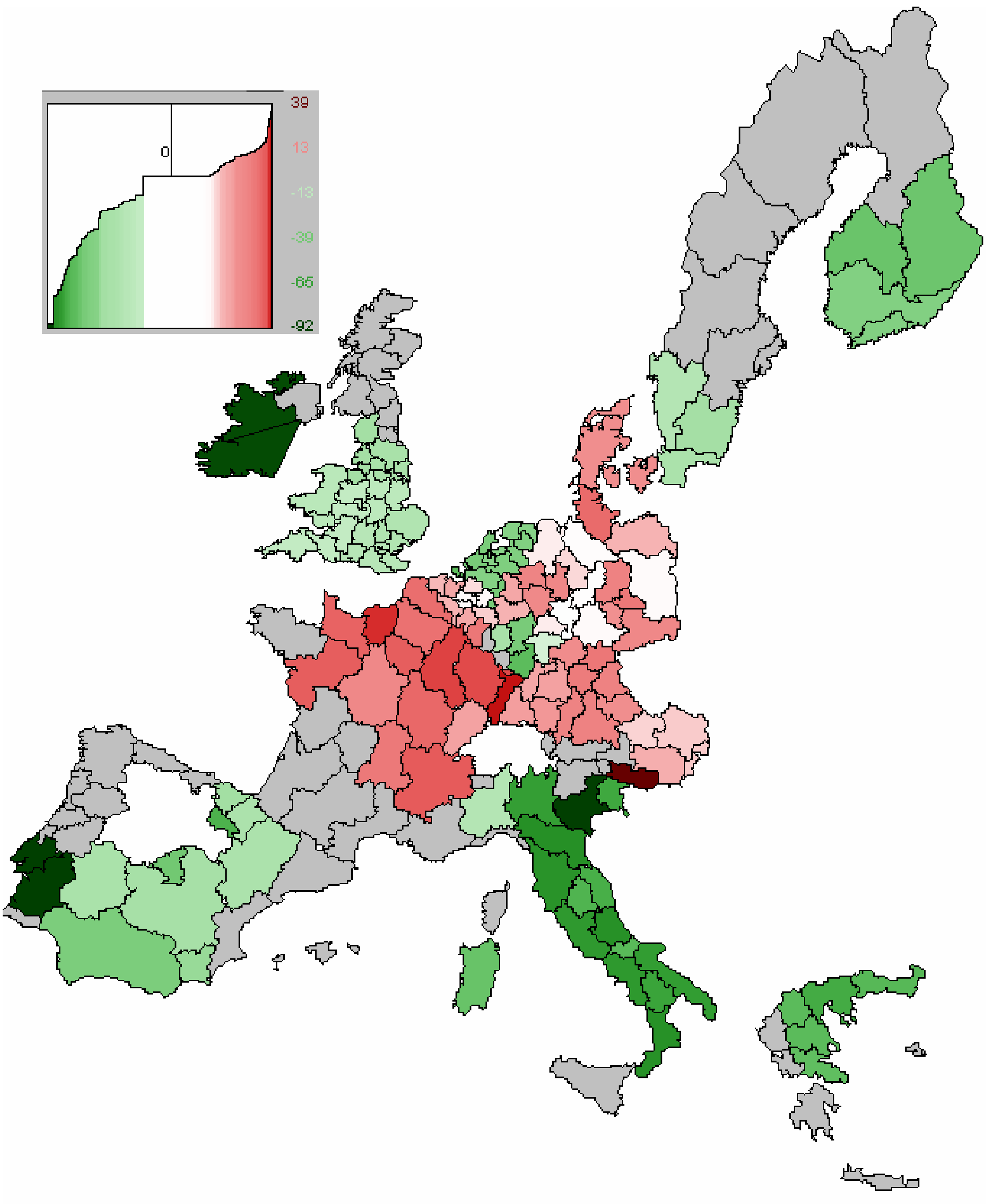
[92] The United Kingdom belongs to that group as well, but it turned out that they are not keen on buying quotas in the model, because the low prices led to a quota under-fill so that we assume that they will sell quotas rather than buy them.

Table 5.13: Key indicators on the EU-15 sugar (beet) markets – Reference and scenario III

		Unit	Reference (2009) value	Scenario III value	Scenario III % change to Reference
Sugar beet	**A sugar beet**				
	producer price	€/t	51.77	29.66	-42.7
	production	1000t	80175	70311	-12.3
	B sugar beet				
	producer price	€/t	47.17	29.66	-37.1
	production	1000t	16909	16548	-2.1
	C sugar beet				
	producer price	€/t	15.53	15.78	1.6
	production	1000t	18633	5851	-68.6
	Sugar beet total				
	average price	€/t	45.26	28.79	-36.4
	production	1000t	115716	92711	-19.9
Sugar	**EU price**	€/t	708	404	-42.9
	World market price	€/t	190	204	7.8
	Quota	1000t	13882	12581	-9.4
	Domestic supply	**1000t**	**16534**	**13406**	**-18.9**
	Belgium	1000t	966	891	-7.7
	Denmark	1000t	529	501	-5.3
	Germany	1000t	4178	3754	-10.1
	Greece	1000t	332	157	-52.6
	Spain	1000t	1098	901	-18.0
	France	1000t	4284	4328	1.0
	Ireland	1000t	210	22	-89.7
	Italy	1000t	1482	454	-69.4
	Netherlands	1000t	986	597	-39.5
	Austria	1000t	447	429	-4.0
	Portugal	1000t	84	9	-89.6
	Sweden	1000t	429	320	-25.3
	Finland	1000t	161	99	-38.6
	United Kingdom	1000t	1350	945	-30.0
	Imports	**1000t**	**1821**	**968**	**-46.9**
	India	1000t	10	1	-85.5
	ACP	1000t	1620	657	-59.4
	Rest of the world	1000t	104	200	92.1
	Free trade developing	1000t	87	109	25.5
	Total supply	**1000t**	**18355**	**14373**	**-21.7**
	Domestic demand	**1000t**	**12967**	**13129**	**1.3**
	Exports	**1000t**	**5388**	**1317**	**-75.6**
	Subsidiesed exports	1000t	2673	474	-82.3
	C sugar exports	1000t	2715	843	-69.0
	Aggregation error	1000t	0	-73	
	Total demand	**1000t**	**18355**	**14373**	**-21.7**

Source: CAPRI modelling system

Figure 5.14: Regional sugar quotas: Scenario III relative to reference in %



Source: CAPRI modelling system

Table 5.14: Change in sugar quotas of EU-15 Member States

	Change in sugar quotas	
	absolute (1000 t)	**relative to quota (%)**
EU15	-1 300.6	-9
Belgium	38.9	5
Denmark	51.4	12
Germany	162.5	5
Greece	-164.3	-52
Spain	-132.4	-13
France	652.3	20
Ireland	-176.7	-89
Italy	-1 080.2	-70
Netherlands	-298.8	-35
Austria	15.5	4
Portugal	-70.6	-89
Sweden	-69.0	-19
Finland	-48.9	-34
United Kingdom	-180.3	-16

Source: CAPRI modelling system

5.4.5 Comparison of the Analysed Scenarios

The tables showing the key indicators on European sugar (beet) markets presented in the previous sections are repeated in Table 8.5 on page 181. For a better overview they are summarised within one table. In terms of the reduction of domestic sugar production, scenario I shows the lowest value. This is because only quotas are reduced and prices stay at reference levels. As soon as EU sugar prices decrease, sugar supply also decreases. As mentioned before, the sugar supply is reduced at a greater rate in scenario II as compared to III. Even though EU sugar prices are decreasing in the latter case, this occurs due to more parts of the European sugar supply originating in more competitive countries.

World sugar market prices increase in the order of presented scenarios. They are very close in scenario II and III. EU sugar imports considerably decrease from scenario I to III due to lower EU sugar market prices. Concerning sugar exports and WTO limits of subsidise exports, we clearly see that scenario I retains the high sugar export quantities from the reference scenario and the base year. It would therefore violate the latest panel decision ruling that C-sugar as well as re-export of preferential imports have to be counted under the existing limit of 1.3 million tons. Due to this problem and the high incentive to export sugar to the EU for the LDCs, scenario I is not a realistic option of the CMO Sugar in the future. In scenario II subsidised sugar exports are reduced to 400 000 tons of re-exports + about 1.4 million tons of C-sugar summing up to about 1.8 million tons of sugar exports. We see the allowed (post panel decision) 1.3 million tons are overshot by 300 000 t. Consequently, the Fischler proposal is too moderate in terms of supply reductions in order to cope with WTO commitments. Scenario III finally meets the WTO restrictions per definition, but basically due to a higher price reduction on EU sugar markets and the additional quota amounts made available for C-sugar producing countries. In scenarios I and II the EU-15 remains a net exporter of sugar, while in scenario III sugar imports exceed exports by about 70 000 tons

Domestic sugar demand slightly increases in scenarios II and III given the lower prices consumers have to pay. The supply reduction at regional level varies greatly across regions and scenarios. Generally speaking, the regional differentiation of supply reduction in scenario I is mainly driven by the declassification that benefits those countries that hold less B-sugar quotas. In scenario II those countries are benefited that have the highest quota rents and in scenario II, the advantage is found in the countries classified as classical C-sugar regions.

Table 5.15 summarises the development of C-sugar production in the analysed scenarios. For most Member States the rule holds that C-sugar production decreases from scenario I to III, whereas in some of them, C-sugar production is higher in scenario III than it is in II. Spain, for example, buys quotas in scenario II while we do not allow this in III. Consequently, C-sugar production is higher in scenario III.

Table 5.15: C-sugar production in analysed scenarios per EU-15 Member State

	Reference	Scenario I		Scenario II		Scenario III	
	1000 t	1000 t	*% change to Reference*	1000 t	*% change to Reference*	1000 t	*% change to Reference*
Belgium	153.1	161.9	*5.7*	68.3	*-55.4*	39.4	*-74.3*
Denmark	112.1	114.9	*2.4*	69.2	*-38.3*	33.0	*-70.6*
Germany	796.9	825.9	*3.6*	437.3	*-45.1*	210.6	*-73.6*
Greece	16.0	28.6	*79.1*	-1.1	*-107.1*	5.7	*-64.1*
Spain	104.3	129.4	*24.1*	-52.0	*-149.8*	39.3	*-62.3*
France	1028.9	956.6	*-7.0*	679.4	*-34.0*	421.3	*-59.1*
Ireland	11.7	14.6	*24.5*	1.1	*-90.8*	0.0	*-100.0*
Italy	-63.1	33.4	*%*	10.4	*%*	-11.4	*%*
Netherlands	129.5	138.8	*7.2*	51.8	*-60.0*	39.1	*-69.8*
Austria	62.7	72.5	*15.7*	-0.8	*-101.3*	29.1	*-53.5*
Portugal	4.5	7.5	*65.9*	-4.8	*-205.3*	-0.1	*-102.0*
Sweden	62.5	70.6	*13.0*	30.7	*-50.9*	22.8	*-63.5*
Finland	15.8	20.9	*32.3*	2.6	*-83.8*	2.5	*-84.4*
United Kingdom	217.1	227.6	*4.8*	95.7	*-55.9*	-7.0	*-103.2*

Source: CAPRI modelling system

So far we have not reflected on the impacts of the analysed scenarios on EU-15 welfare. Table 5.16 summarises the most relevant positions. We will concentrate on a few agricultural income indicators, the equivalent variation of consumers (explained in BRITZ et al., 2005) and the relevant positions of the FEOGA budget with respect to the analysed topic. All figures indicate the absolute change to the reference scenario. The first line shows the changes in total agricultural income including compensation payments. We see that the strongest reduction is found in scenario II. The following development of the input side corresponds to that of the outputs. Finally, we show the gross value added including premiums of total agriculture and sugar beet production. Both decrease from the left to the right side of the table.

Table 5.16: Impacts of analysed scenarios on EU-15 welfare (M€)

	Scenario I	Scenario II	Scenario III
	absolute difference to reference	absolute difference to reference	absolute difference to reference
Agriculture			
Total output + premiums	-1116.4	-1771.0	-1510.2
of which from sugar beet	*-796.6*	*-2554.0*	*-2585.4*
Total input	-456.9	-641.7	-566.3
of which for sugar beet	*-366.8*	*-546.9*	*-496.8*
Gross Value Added + premiums	-659.5	-1129.3	-943.9
of which from sugar beet	*-429.9*	*-2007.1*	*-2088.6*
FEOGA budget outlays			
Total	293.8	91.2	280.9
of which on Premiums	8.2	1055.0	1214.4
of which on exports subsidies for sugar	-41.0	-1295.5	-1297.0
producer levies	441.4	441.4	441.4
other outlays	114.9	109.8	77.9
Consumer			
Equivalent variation	465.9	3696.0	3987.3
EU Welfare*	**-356.8**	**2016.2**	**2758.1**
Gross Value Added + premiums per Member State			
Belgium	-21.8	-44.4	-29.5
Denmark	-27.8	-37.0	-28.5
Germany	-213.1	-326.4	-260.0
Greece	-17.2	-59.2	-60.7
Spain	-35.9	-81.9	-97.7
France	-205.0	-267.3	-208.2
Ireland	-5.7	-25.4	-20.8
Italy	-43.5	-93.6	-77.5
Netherlands	-18.4	-44.8	-38.8
Austria	-16.0	-16.6	-23.3
Portugal	-3.8	-9.0	-8.4
Sweden	-8.5	-15.5	-11.5
Finland	-6.8	-12.4	-10.0
United Kingdom	-35.8	-95.8	-69.0
Gross Value Added + premiums of sugar beets per Member State			
Belgium	-23.9	-102.8	-113.3
Denmark	-16.4	-53.0	-51.3
Germany	-161.7	-503.4	-490.2
Greece	-9.2	-82.6	-90.3
Spain	-6.7	-139.3	-176.6
France	-126.9	-378.4	-376.1
Ireland	-3.3	-49.2	-49.3
Italy	-29.8	-298.8	-311.3
Netherlands	-26.4	-128.3	-137.7
Austria	-11.5	-33.9	-50.3
Portugal	-0.5	-12.2	-13.2
Sweden	-1.5	-38.9	-41.6
Finland	-1.8	-19.7	-21.4
United Kingdom	-12.1	-169.8	-167.2

**EU Welfare does not include processing*

Source: CAPRI modelling system.

At EU level we can therefore conclude that this development is highly correlated with the reduction of EU sugar market prices. From the producers' point of view, Scenario I would harm them the least. The latter two lines are split up into EU Member States at the bottom of Table 5.16. Scenario I is still favourable in all countries in terms of the reduction of both the total agricultural gross value added (GVA) and that of sugar beet production. But the ranking of scenario II and III is not equal across Member States. In terms of total agricultural GVA, almost all countries show lower reductions in scenario III. Only for Greece, Spain and Austria the opposite is true. This is the result of the combined effect of reductions in the GVA from sugar beets and the income possibilities of alternative production activities. Concerning the GVA from sugar beet production, scenario III is only favourable in Denmark, Germany, France and the United Kingdom. Disregarding those regional differences, the reform proposals II and III in particular lead to income losses for European farmers of about one billion €.

FEOGA budget outlays are slightly higher than in the reference scenarios. Reduced expenditures on subsidised exports in all scenarios due to reduced export quantities and/or smaller differences between world market and EU market prices contribute to savings. On the other hand, there are two effects that raise FEOGA expenditures: (1) the introduction of compensatory payments in scenario II and III and (2) producer levies, which are collected in the reference but not in scenarios I to III, reduce the FEOGA income. In terms of FEOGA expenditures, all reform options are slightly unfavourable compared to the reference. The lowest costs arise from scenario II. In addition, expenditures and the new compensation payments for sugar beet farmers in scenarios II and II can completely be covered by the savings on subsidised export expenditures.[93]

Finally, consumers benefit in all analysed scenarios compared to the reference due to lower prices for sugar and sugar products. In scenario I this gain in equivalent variation is not sufficient to compensate the losses on the producer and the budget side so that total welfare is reduced. But in scenario II and III, where prices considerably decrease, the equivalent variation of consumers increases such that positive welfare gains of 1.5 and 2.3 billion € respectively are achieved.

[93] Note that the costs for the restructuring scheme in scenario III are not included here.

The overall welfare of the EU-15 therefore considerably increases in scenarios II and III.[94] Since our analysis focuses on the EU-15, we will only add some general remarks about the effects of the analysed scenarios on third countries. Producers in countries where sugar is produced at world market prices certainly gain from increasing world market prices, at least in scenarios II and III. On the other hand, consumers have to pay higher prices there. What is most interesting is the impact on those countries that have preferential access to the EU sugar market. Of course, producers in those countries suffer from the reductions of EU market prices. But we refrain from evaluating the magnitude of welfare impacts that the reform proposals might have on third countries due to the somewhat simplified representation of the world sugar market.

5.4.6 Comparison to Other Studies

Recently BROCKMEYER et al. (2005) presented a paper providing a brief literature review on research that analyses the CMO Sugar (see Table 5.17). The quoted studies are categorised according to the type of models the respective authors use in their analysis. The first group uses partial equilibrium models that only examine sugar, while the second group uses the same modelling approach but including the whole agricultural sector, while the last group uses general equilibrium models that cover the whole economy. In the right column of Table 5.17, the scope of each study is characterised. Apparently, the main analysed topic is rather different in all those studies. Naturally ADENÄUER et al. (2004) is very close to our simulations so we refrain from further comparison. As also stated by GOHIN and BUREAU (2005) there is much of variation in model results that result not only from different scenario definitions. FRANDSEN et al. (2003), for example, find only very small supply reductions in France, Germany, Austria and the United Kingdom even though sugar prices and quotas are reduced considerably in their selected scenarios. Only quota rents are reduced for those countries. This result, as stated various times above, is an outcome of the profit maximisation hypothesis that underlies their study. The countries mentioned before are assumed to be competitive at C-sugar prices so that it is not surprising that the authors do not identify a supply effect when quotas or prices for quota sugar are reduced. Compared to their

[94] It is frequently noted by the lobby of sugar beet farmers that final consumers of sugar that appears mainly in processed products like beverages, chocolate or cake would not benefit from lower sugar prices because the sugar using industry would not lower the prices for their products but enhance their profit margin instead. This cannot be entirely ruled out, although it is to be expected that competition would eventually drive down prices. At any rate, if they did not reduce prices, the welfare gain would be on the part of primary sugar users.

analysis, our model can be considered an improvement, because it is closer to reality in terms of policy representation and behavioural models.

Table 5.17: Overview of papers analysing the EU sugar market regime

Author(s)	Model Type	Sugar Policy			Scope
		Quota System	TRQs	Self Financing System	
BUREAU et al (1996)	PE[1] sugar model	x	—	—	Cross-border transferability of quotas
BORRELL and PEARCE (1999)	PE sugar model	—	—	—	Global liberalization of the world sugar market
OECD (2003)	PE sugar model	—	x	—	Reduction of in-, out-of-quota tariff and export subsidies, TRQ expansion
POONYTH et al (2000)	FAPRI PE	x	x	—	Quota versus intervention price reduction to comply with WTO
WITZKE and HECKELEI (2002)	CAPSIM PE	x	—	x	Quota reduction and support price cuts
ADENÄUER et al (2004)	CAPRI PE	x	x	—	Effects of EBA initiative on the EU sugar sub-sector
LEVANTIS, JOTZO and TULUPÈ (2003)	FIJIGEM GE[2]	—	x	—	Replace trade preferences by other forms of aid
VAN DER MENS-BRUGGHE et al (2003)	LINKAGE GE	—	x	—	OECD quota expansion, tariff reduction
ELBEHRI and PEARSON (2000)	GTAP GE	—	x	—	TRQ reforms
FRANDSEN et al (2003)	GTAP GE	x	x	x	Price cuts and quota reductions
TSIGAS and BOUGHNER (2003)	GTAP GE	—	x	—	US trade liberalization due to trade agreements
KERKELÄ and HUAN-Niemi (2004)	GTAP GE	—	x	—	Complete unilateral liberalization of the EU sugar market regime

1) Partial Equilibrium Model. 2) General Equilibrium Model.

Source: BROCKMEYER et al. (2005)[95]

GOHIN and BUREAU (2005) exactly identify different approaches of C-sugar modelling in the various studies as one reason for such striking differences in model results besides other model assumptions and scenario definitions. They explain C-sugar production by assuming a mark up on C-sugar prices which is estimated econometrically and assumed to be linear dependant on quotas and prices. Principally this procedure reflects all those motives we described in section 4 and is very similar to the approach HENRICHSMEYER et al. (2003a) use.

[95] The authors state that ADENÄUER et al. (2004) do not reflect the self-financing aspect of the CMO Sugar. In fact they do reflect it, because they use the same CAPRI model with respect to this issue as we do.

Those studies along with WITZKE and KUHN (2004), ADENÄUER et al. (2004) and ADENÄUER (2005) are the only ones known to us where C-sugar production is explained by other aspects than C-sugar prices or constant shares of quota sugar (VIERLING, 1996).

There is a wide spread in model results from studies that analyse sugar reform options in terms of world market price response as well. For example, POONYTH et al. (2000) analyse a scenario where EU supply is only reduced by about 3% and this induces a world market price increase of 9%. Our results only show an increase of 7% that corresponds to a supply reduction of -21%. A large increase in sugar world market prices might be questionable especially against the background of the Brazilian competitiveness in sugar production. There are many who say that Brazil would be able to double their production without high additional marginal costs (e.g. USDA, 2003). It might, therefore, be likely that the long-term impact on world market prices if the EU starts to be a net importer is not as high as expected by the authors.

Recently ISERMEYER et al. (2005) prepared a study that evaluates the impacts of certain reform scenarios on German agriculture. They make use of the RAUMIS model, an agricultural sector model for Germany. Their scenario II is very close to ours, although they do not include tradable quotas because it is not an EU wide analysis. They project the German sugar beet supply to be reduced by 23% even at slightly lower prices. We forecast only a reduction of 17% but include the tradable quota regime. Their modelling of C-sugar assumes a restriction on C-sugar production such that C-beets would not appear if their price fell below 7.5 €/t. Using such a restriction, they are able to reconcile observed C-beet production with higher marginal costs than C-beet prices. This modelling of C-sugar is more a technical rather than an economic explanation for C-beet production.

HENRICHSMEYER et al. (2003a) carried out a study for the EU Commission which is currently not available publicly. Although the author of the current study acted as a co-author, we are not allowed to refer to any model results given in that study. We can only say that the modelling of C-sugar is based on the fear of losing quota rights in case farmers do not fill their quotas and that our supply response to quota or quota price changes is slightly stronger.

In the attempt to compare our results to other studies, it becomes apparent that differences in scenario definitions, model assumptions and set up make such a comparison problematic. In order to show the improvements implied by our modelling of European sugar supply compared to other studies that rely on profit maximisation, we mimic the scenarios analysed by FRANDSEN et al. (2003) with the CAPRI supply part. They define two scenarios. One is characterised by a price cut of sugar beet prices in Europe induced by a reduction in border protection, and the other one assumes a reduction in sugar quotas. In both scenarios, B-sugar exports no longer appear so that a distinction between A- and B-quotas becomes obsolete. Consequently, A- and B-prices amount to the same value. In order to mimic those two scenarios we take over the price and quota changes from FRANDSEN et al. (2003) given in tables 4, 5 and 6 of that study. Price changes here are meant as relative changes in the basic beet price, which is the incentive price for A-quota sugar in their model. Consequently, we apply those relative price changes to our A-beet price in the reference and set the B-beet price equal to that for A-beets. C-beet prices change in the quoted study although their relative change is not presented in any of their tables. We assume that C-beet prices do not change, knowing that this triggers some imprecision.

Table 5.18: CAPRI sugar beet supply response compared to FRANDSEN et al. (2003)

	Price cut scenario				**Quota cut scenario**			
	relative change in		relative supply change		relative change in		relative supply change	
	sugar beet prices	sugar quotas	Frandsen	Adenäuer	sugar beet prices	sugar quotas	Frandsen	Adenäuer
EU total	-	0.0	-18.7	-6.0	-	-13.1	-0.4	-11.2
Belgium	-24.0	0.0	-0.1	-6.6	3.0	-13.0	-12.9	-12.2
Denmark	-24.0	0.0	0.0	-5.3	4.0	15.9	-14.1	15.4
Germany	-23.0	0.0	-1.6	-4.7	0.0	-16.3	0.0	-13.7
Greece	-14.0	0.0	-73.6	-4.5	-1.0	-8.1	5.6	-5.5
Spain	-24.0	0.0	0.0	-6.6	2.0	-5.3	-2.0	-3.9
France	-24.0	0.0	-0.7	-5.0	0.0	-15.0	0.1	-13.4
Ireland	-9.0	0.0	-87.1	-4.5	0.0	-8.2	0.8	-8.6
Italy	-7.0	0.0	-30.5	-10.0	-2.0	-12.0	1.3	-13.0
Netherlands	-16.0	0.0	-76.1	-6.3	-1.0	-14.8	7.0	-14.2
Austria	-23.0	0.0	-0.7	-3.5	0.0	-13.7	0.0	-11.0
Sweden	-8.0	0.0	-59.9	-1.9	-2.0	-8.1	0.3	-4.2
Finland	-18.0	0.0	-24.4	-3.8	0.0	-8.0	1.1	-6.2
United Kingdom	-24.0	0.0	-1.3	-2.6	0.0	-13.1	0.1	-7.0

All figures are expressed in %, results for Portugal are not presented in FRANDSEN et al. (2003)

Source: FRANDSEN et al. (2003) and CAPRI modelling system

Table 5.18 shows the price and quota changes relative to the respective reference for both analysed scenarios. In the price cut scenario FRANDSEN et al. (2003) forecast a reduction in sugar beet supply of about 19%, mainly stemming from Greece, Ireland, Italy, the Netherlands, Sweden and Finland, which are assumed to have marginal production costs that lie between A- and B-beet prices (compare Table 3.5 and Table 3.6). At the same time, those countries assumed to be competitive at C-beet prices hardly react at all. The CAPRI modelling system estimates an overall supply reduction of only 6%. A comparison across EU Member States shows here that differences between countries are not as large as in FRANDSEN et al. (2003). This is primarily due to the assumptions on marginal production costs and supply elasticities. Concerning the more competitive countries like France, Germany, Austria and Denmark, which show no response in FRANDSEN et al. (2003), the CAPRI model forecasts a sugar beet supply reduction even in those regions. Why is that? C-sugar production is reduced, because the difference between prices received for quota sugar and those for C-sugar is shrinking. From the farmers' point of view, this means that it costs less if quotas are not entirely filled so that they can abandon parts of C-sugar production.

The disadvantage of a model based on profit maximisation is even more apparent from the quota cut scenario. FRANDSEN et al. (2003) project the EU sugar beet supply to be reduced by 0.4% if the overall quota is cut by 13%. Some countries even enhance their production. The authors explain this by rising producer prices due to the abolition of levies. While this argument is compelling, it cannot explain why in the Netherlands, for example, production increases although producer prices decrease. It is more than questionable that production would increase in any country if quotas are reduced, even if prices are slightly increasing, as long as quotas are filled in the reference situation. In our model, the quota cut induces a supply reduction in all selected EU Member States. Generally the relative supply reduction is smaller than the respective quota cut, except for Italy and Ireland.

To summarise, we have shown that the inclusion of expected profit maximisation and of other aspects triggering C-sugar production into the CAPRI model has led to a more comprehensive framework with respect to the supply reaction of C-sugar than found in other studies, especially FRANDSEN et al. (2003).

5.5 Summary

The current section provides an overview of the CAPRI modelling system as well as the adjustments we incorporate in order to be able to analyse reform options of the CMO Sugar. The supply part for agricultural goods in CAPRI generally relies on a profit maximisation framework which we have shown in section 3 to be insufficient to reconcile observed supply behaviour in the past with production costs. Therefore, our behavioural assumption for sugar beet production is expected profit maximisation combined with a distinction of sugar beet supply resulting from expected profit maximisation and from other incentives to supply C-beets. In addition, we take over marginal production costs and supply elasticities from the

FADN analysis carried out in section 3 as well as regional sugar quotas. We further introduce a price linkage between sugar and sugar beet prices and a quota trade module based on differences in regional sugar quota rents. A number of adjustments in the CAPRI market module allow for an ad hoc simulation of the EBA initiative and all other imports that enter the EU-15 in the past and future.

Next, three different future reform options of the CMO Sugar are analysed. The first one retains the CMO Sugar in its current regulations but includes the EBA agreement. The second one is based on a reform proposal which was posted by the EU Commission in 2004 and the last scenario reflects their latest reform proposal. We show that each of the analysed scenarios implies a reduction in European sugar supply and in the agricultural income as well. The impact on the EU budget is relatively small because savings in expenditures on subsidised exports are compensated by expenditures on compensation payments. Nonetheless, apart from the first scenario, the reduced prices for EU sugar allow for considerable gains for consumers so that overall welfare will increase in the EU-15.

Finally, we provide a brief comparison of our model results to other studies and discover that a direct comparison is hardly possible due to great differences in models and scenario definitions. According to GOHIN and BUREAU (2005), the considerable differences found in literature concerning the analysis of the European sugar market are partly due to the representation of C-sugar supply. Therefore, we compare our model, which includes several explanations for C-sugar production, to that of FRANDSEN et al. (2003) who account for C-sugar by assuming that marginal production costs equal C-sugar prices and acknowledge that our model offers a more plausible supply reaction.

6. Summary, Limitations and Conclusions

6.1 Summary

This study analyses the European sugar sector from several perspectives. After the research topic is briefly described and some background information is given, we provide an introduction to the Common Market Organisation for sugar. The main components of that CMO are prohibitive tariffs that protect the European Union from any imports from countries that might be much more competitive in sugar production than the EU itself. The prohibitive tariffs further guarantee that the EU sugar market price reaches price levels that amount to three times the world market price for sugar. Sugar production is subject to a two-quota system that limits the EU supply, on the one hand, and finances all exports of quota sugar, on the other. A speciality of the sugar quota system is that, in contrast to the milk quota system, it is possible to sell sugar quantities that are produced beyond the quotas (so-called C-sugar) on the world market at prevailing prices. Subsidised exports were limited in the past to about 1.3 million tons of quota sugar plus another 1.3 million tons of preferential imports. C-sugar exports have not been considered subsidised so far. Preferential agreements with some countries or country groups, such as the African Pacific and Caribbean countries, allow for limited EU market access of extra EU sugar. In the past most Member States of the EU-15 supplied more sugar than the amount of their quotas and most of the C-sugar originated in France and Germany. Sugar generally comes from farms producing sugar beets and signing contracts with sugar processing firms on beet delivery right and prices.

One topic of this study is to analyse the impacts that certain reform options of the CMO Sugar might have on the European sugar supply. A pre-condition to this is to understand why European farmers supply large amounts of C-sugar beets although there is a general agreement among economists and farm management specialists that marginal production costs of sugar beet production exceed C-beet prices. Consequently, we further analyse farm data from the FADN of the European Commission. Here we show that sugar beet production plays a major role with respect to farm income for those farms that cultivate beets, while the sugar sector in agriculture as a whole is of minor importance. In section 3, an estimation of single farm sugar beet quotas and delivery rights is carried out. Results show that in all EU-15 Member States, some farms do not fill their quotas, while others supply a large quantity of C-sugar. Farm heterogeneity is therefore not negligible with respect to aggregated supply response to quota or price changes. This is further stressed by an estimation framework of marginal production costs at farm level. After analysing the resulting regional distributions of those estimates, we find that sugar beets are produced at the highest costs in Greece, Italy, Ireland and Finland, while it is cheaper to produce beets in Austria, France, Germany or Denmark.

After we have identified gaps between marginal production costs and marginal revenues in almost all EU-15 countries, we continue with by analysing incentives to supply sugar beets in Europe in section 4. We discuss and evaluate several behavioural hypotheses that go beyond the classic profit maximising hypothesis which has shown to be insufficient to explain observed supply behaviour. First we include yield uncertainty in a framework of expected profit maximisation. We evaluate this behavioural model by means of both national and farm data and come to the conclusion that expected profit maximisation potentially explains parts but not all of the observed C-sugar production. The same conclusion is drawn when we include risk aversion in a framework of utility maximisation. Other possible reasons why farmers supply more sugar than one would expect with regard to production costs might be risk management strategies, yield underestimation, indivisible plots or the fear of losing quota rights in case the quota is not entirely filled. We are able to show that all of those aspects potentially trigger additional C-sugar quantities while we are not able to quantify their effect. A last hypothesis is that sugar processing firms might distribute more quota rights than they de facto own. If this practice exists, C-sugar beet shares in total quotas at farm level are lower than C-sugar shares at the processing level. But again, the magnitude of this effect cannot be quantified because processing firms remain silent on this issue.

The last section of the present study focuses on the empirical analysis of selected reform options of the CMO Sugar. For this purpose, we adjust the agricultural sector model CAPRI according to the findings of the previous sections. We further introduce some modifications necessary to analyse sugar market reform proposals. Next we define three different future options of the CMO Sugar. The first scenario basically retains the current regulations of the CMO but includes the EBA agreement. Additional sugar imports from LDCs trigger here sugar quota reductions through the declassification mechanism. The second scenario reflects the reform proposal of Franz Fischler from July 2004. Its main elements are a reduction of European sugar quotas by 16% and institutional prices by 33%. Furthermore, partial compensation is granted to sugar beet farmers which is included in the premium scheme of the latest CAP reform. Moreover, sugar quotas are made tradable among the entire EU. The last scenario, based on the latest reform proposal that came out in June 2005, does not envisage a compulsory quota cut, but a reduction in institutional prices by 37%. Partial compensation is slightly higher than in scenario II. A restructuring scheme offers less competitive processing firms to abandon production by selling their quota rights to the community at fixed prices. Competitive firms in classical C-sugar producing countries are allowed to buy additional quota amounts at the same price. Their quantity is limited to one million tons of sugar at total EU level.

The results of those scenarios are compared to a reference situation in 2009 where Agenda 2000 and the CAP reform 2003 are implemented. This reference is characterised by a slight increase of sugar supply because the decoupled payment scheme benefits those arable crops that did not receive premiums in the base year situation. This effect over-compensates the reduction of sugar beet prices in real terms. All scenarios show a considerable sugar supply reduction of the EU-15. The lowest one is found in scenario I because the EU sugar price level is retained. Scenario I turned out not to be a real future option because the recent WTO panel ruled that C-sugar exports and re-exports of preferential imports have to be counted under the existing subsidised export quota of 1.3 million tons of sugar which is overshot in scenario I by about four million tons. Those limits on exports are almost met in scenario II and perfectly met in scenario III. The question as to which reform proposal is preferable depends naturally one's point of view. The EU budget is comparably burdened in all scenarios. Consumers gain the most in the scenario with the highest price cut, i.e. scenario III. From the farmers' point of view, the preference for scenario II or III varies across Member States.

Finally, we compare our model approach and results to that of other researchers analysing the CMO Sugar. We show that our modified version of the CAPRI model is able to produce a plausible sugar beet supply response to changes of quota beet prices and quantities. Furthermore, the ad hoc representation of the LDCs in the market allows for a representation of the EBA agreement which is not taken into account by most other studies.

6.2 Limitations of the Study and Further Fields of Research

While the findings of the present study contribute to the state of art of analysing sugar beet supply behaviour, it goes with the following limitations which indicate that a careful assessment of results of our study is necessary.

- The estimation of marginal costs of sugar beet production and supply elasticities, which are sensitive variables with respect to the supply response of the agricultural sector model CAPRI, makes use of simplifications. A derivation of a comprehensive, econometrically based method to define marginal production cost functions at regional level would therefore be desirable.[96]

- The representation of the sugar processing level in CAPRI is rather crude. An explicit modelling of the sugar processing level could therefore be envisaged. Ideally, all existing firms that process sugar should be represented in the CAPRI model. This would require information on processing capacities and their cost structure. We further would need to allocate certain regions to processing firms. Such approaches are carried out by ISERMEYER et al. (2005) and von BLUMENCRON (2005), yet only for Germany. Given the current lack of information on the processing level and the prevailing objection of people who are in charge in to disclose information on the cost and profit structure of single plants, it is questionable that the kind of information needed will be available to researchers.

- The Least Developed Countries (LDCs) are not represented in the market part of the CAPRI model as a single country aggregate. A modelling of the *Everything but Arms* is currently only possible with an ad hoc solution by defining a TRQ according to expectations from other studies on the export potential of LDCs. This problem will be solved soon, because newer versions of CAPRI disaggregate the LDCs into a single country block.

- Though the new Member States of the European Union (EU-10) are modelled in a free trade area with the EU-15 the sugar market is not affected, because there are hardly any trade flows in the base year. The EU-10 sugar market remains a single

[96] It was originally planned to include this estimation in the study, but due to time restrictions, it was not possible. Such an estimation should be based on microeconomic theory and reflect our findings concerning the production of C-beets.

market not joined with the EU-15 in our analysis. An inclusion of the EU-10 into the supply part of CAPRI and improved modelling of EU-10 and EU-15 in the market part, has already been done in a newer model version and is able to solve this problem.

6.3 Conclusions

The overall objective of this study is the analysis of reform options of the CMO Sugar and the development of a modelling tool well suited for that purpose. The motivation of that topic is found in the actual need of such analyses due to the upcoming and inevitable reform of European sugar markets. For this purpose, it is necessary to identify the factors that influence sugar (beet) production in Europe. Based on our research, we can draw the following conclusions:

- The analysis of single farm records with respect to sugar beet production shows the importance of sugar beet production for beet producing farms. It further sheds light on the distribution of that importance among farms within Member States of the EU-15.
- The presented estimation of single farm quotas is an improvement over estimations by other authors who analysed sugar beet production. A general advancement is found in the inclusion of time series and some plausible a priori information, as well as the appliance of a new estimation method that can easily handle huge data amounts.
- An estimation of marginal sugar beet production costs and supply elasticities for certain EU-15 regions is carried out and serves as a basis to

    1. show that C-sugar beet production is unlikely to be the outcome of competitiveness at C-beet prices but rather to be dependant on other aspects like yield uncertainty, risk aversion, the expectation that future quota endowments are correlated with the actual C-beet supply, indivisible plots, consequent sugar yield underestimation or processing firms that distribute more delivery rights for quota beets than corresponding to their sugar quota endowment. This analysis goes far beyond what other researchers who analysed European sugar supply found out so far.

2. adjust the agricultural sector model CAPRI to those estimates, reflecting the aspects that may be relevant to explain C-sugar supply in the equations that drive land allocation in the model.

- It can be shown that the adjusted version of the CAPRI model is well suited to analyse reform options of the CMO Sugar. Compared to other modelling approaches, it is able to produce a realistic supply response of sugar beet production to changes in the economic supply incentives.

- Finally, by means of an analysis of three reform scenarios, we are able to identify the impacts on European agriculture, the FEOGA budget, consumers and EU-15 welfare. It can be shown that the agricultural income is greatly reduced in the analysed scenarios, but that sugar beet production would not leave Europe. Sugar consumers are projected to be the winners in those scenarios where sugar prices are reduced.

All in all, we can conclude that our research was successful with respect to the initial questions outlined on page 3. The work provides a great contribution to the analysis of incentives to supply sugar beets in Europe and sugar sector modelling. Nonetheless, the presented limitations of the study identify further research fields that would potentially improve the possibilities to analyse the European and world sugar markets.

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8. Appendix

8.1 Figures and Tables

Figure 8.1: Region-codes in the EU-15

Spain and Portugal:

Austria

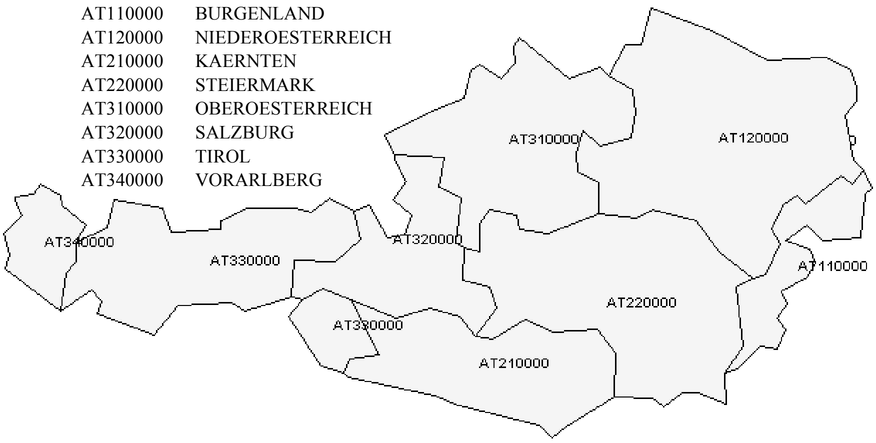


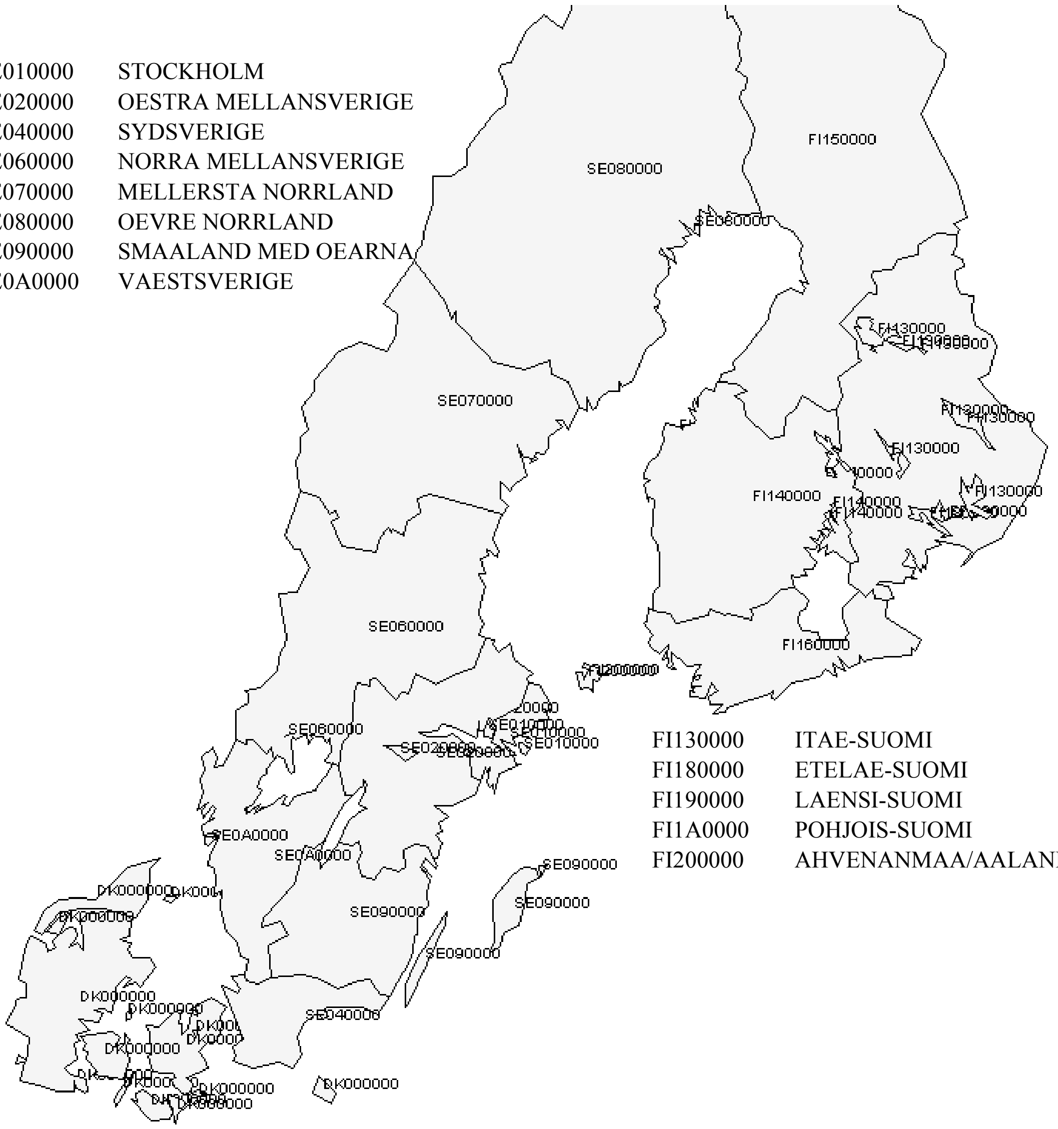
Figure 8.1: Region-codes in the EU-15 (cont.)

Germany:

DE110000	STUTTGART
DE120000	KARLSRUHE
DE130000	FREIBURG
DE140000	TUEBINGEN
DE210000	OBERBAYERN
DE220000	NIEDERBAYERN
DE230000	OBERPFALZ
DE240000	OBERFRANKEN
DE250000	MITTELFRANKEN
DE260000	UNTERFRANKEN
DE270000	SCHWABEN
DE400000	BRANDENBURG
DE710000	DARMSTADT
DE720000	GIESSEN
DE730000	KASSEL
DE800000	MECKLENBURG-VORPOMMERN
DE910000	BRAUNSCHWEIG
DE920000	HANNOVER
DE930000	LUENEBURG
DE940000	WESER-EMS
DEA10000	DUESSELDORF
DEA20000	KOELN
DEA30000	MUENSTER
DEA40000	DETMOLD
DEA50000	ARNSBERG
DEB10000	KOBLENZ
DEB20000	TRIER
DEB30000	RHEINHESSEN-PFALZ
DEC00000	SAARLAND
DED00000	SACHSEN
DEE10000	DESSAU
DEE20000	HALLE
DEE30000	MAGDEBURG
DEF00000	SCHLESWIG-HOLSTEIN
DEG00000	THUERINGEN

Figure 8.1: Region-codes in the EU-15 (cont.)

Sweden, Finland and Denmark:



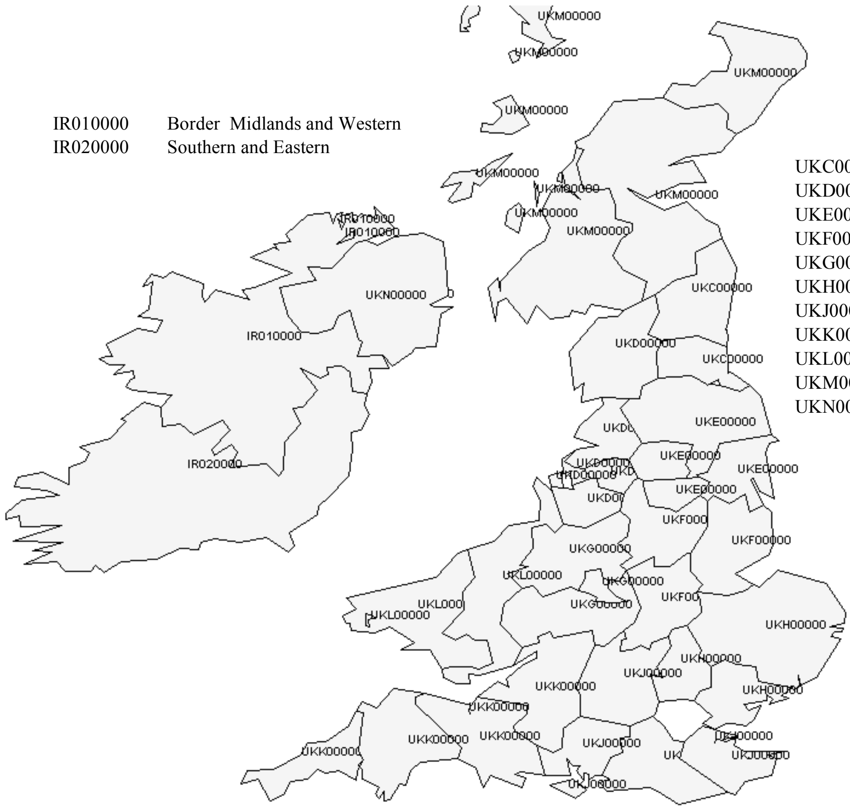
SE010000	STOCKHOLM
SE020000	OESTRA MELLANSVERIGE
SE040000	SYDSVERIGE
SE060000	NORRA MELLANSVERIGE
SE070000	MELLERSTA NORRLAND
SE080000	OEVRE NORRLAND
SE090000	SMAALAND MED OEARNA
SE0A0000	VAESTSVERIGE

FI130000	ITAE-SUOMI
FI180000	ETELAE-SUOMI
FI190000	LAENSI-SUOMI
FI1A0000	POHJOIS-SUOMI
FI200000	AHVENANMAA/AALAND

DK000000	DANMARK

Figure 8.1: Region-codes in the EU-15 (cont.)

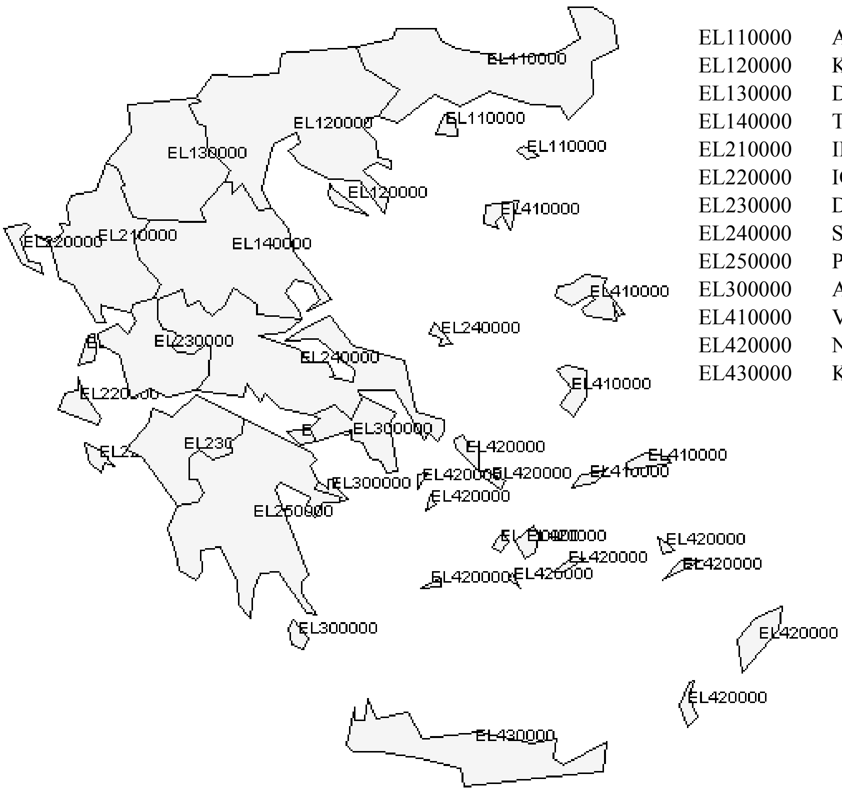
The United Kingdom and Ireland:



IR010000	Border Midlands and Western
IR020000	Southern and Eastern

UKC00000	North East
UKD00000	North West (including Merseyside)
UKE00000	Yorkshire and The Humber
UKF00000	East Midlands
UKG00000	West Midlands
UKH00000	Eastern
UKJ00000	South East
UKK00000	South West
UKL00000	Wales
UKM00000	Scotland
UKN00000	Northern Ireland

Greece:

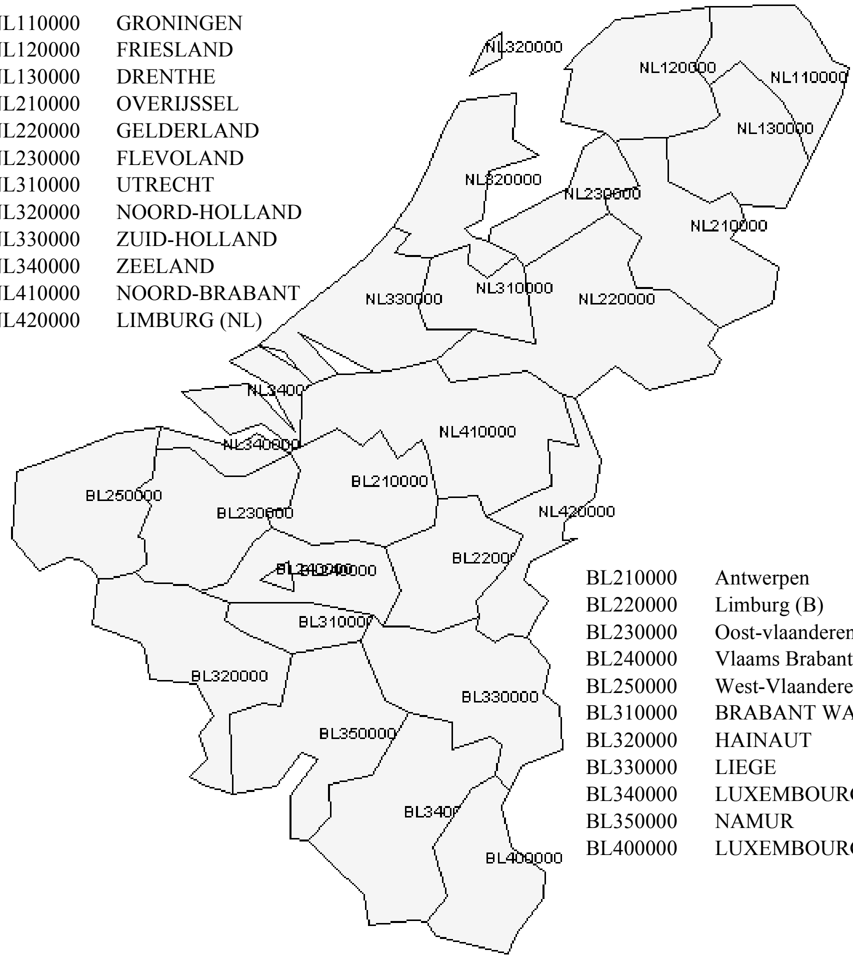


EL110000	ANATOLIKI MAKEDONIA THRAKI
EL120000	KENTRIKI MAKEDONIA
EL130000	DYTIKI MAKEDONIA
EL140000	THESSALIA
EL210000	IPEIROS
EL220000	IONIA NISIA
EL230000	DYTIKI ELLADA
EL240000	STEREA ELLADA
EL250000	PELOPONNISOS
EL300000	ATTIKI
EL410000	VOREIO AIGAIO
EL420000	NOTIO AIGAIO
EL430000	KRITI

Figure 8.1: Region-codes in the EU-15 (cont.)

Benelux countries:

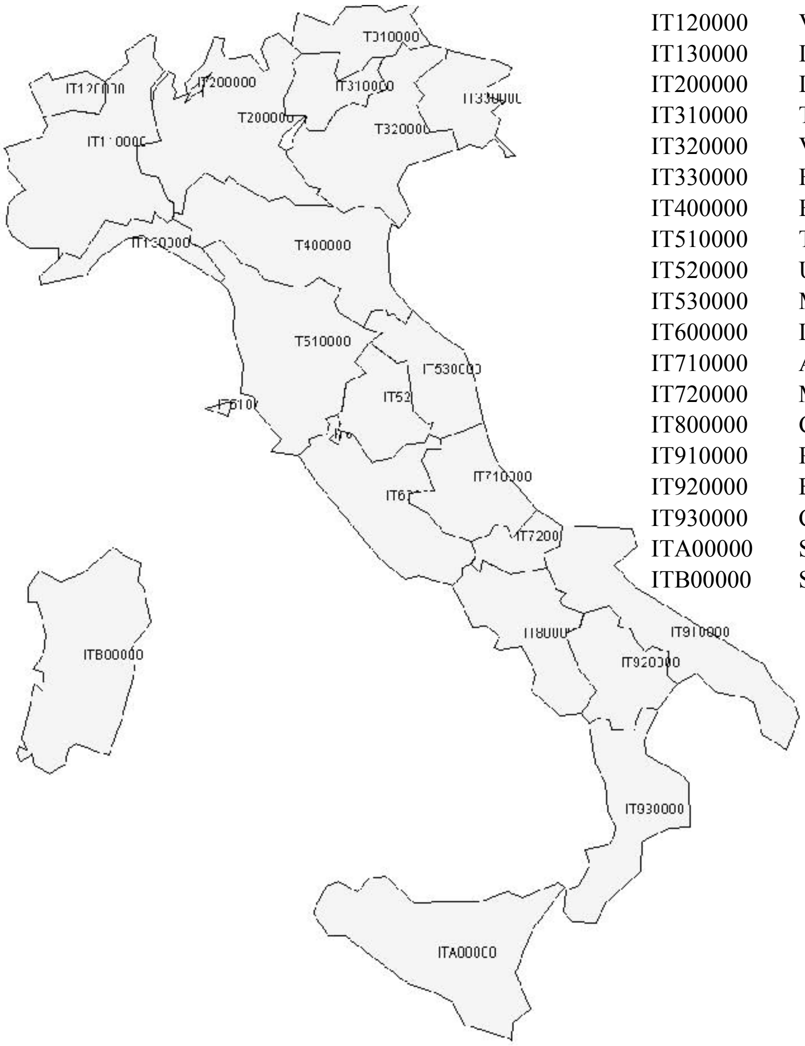
NL110000	GRONINGEN
NL120000	FRIESLAND
NL130000	DRENTHE
NL210000	OVERIJSSEL
NL220000	GELDERLAND
NL230000	FLEVOLAND
NL310000	UTRECHT
NL320000	NOORD-HOLLAND
NL330000	ZUID-HOLLAND
NL340000	ZEELAND
NL410000	NOORD-BRABANT
NL420000	LIMBURG (NL)



BL210000	Antwerpen
BL220000	Limburg (B)
BL230000	Oost-vlaanderen
BL240000	Vlaams Brabant
BL250000	West-Vlaanderen
BL310000	BRABANT WALLON
BL320000	HAINAUT
BL330000	LIEGE
BL340000	LUXEMBOURG (B)
BL350000	NAMUR
BL400000	LUXEMBOURG (GRAND-DUCHE)

Figure 8.1: Region-codes in the EU-15 (cont.)

Italy:



IT110000	PIEMONTE
IT120000	VALLE D'AOSTA
IT130000	LIGURIA
IT200000	LOMBARDIA
IT310000	TRENTINO-ALTO ADIGE
IT320000	VENETO
IT330000	FRIULI-VENEZIA GIULIA
IT400000	EMILIA-ROMAGNA
IT510000	TOSCANA
IT520000	UMBRIA
IT530000	MARCHE
IT600000	LAZIO
IT710000	ABRUZZO
IT720000	MOLISE
IT800000	CAMPANIA
IT910000	PUGLIA
IT920000	BASILICATA
IT930000	CALABRIA
ITA00000	SICILIA
ITB00000	SARDEGNA

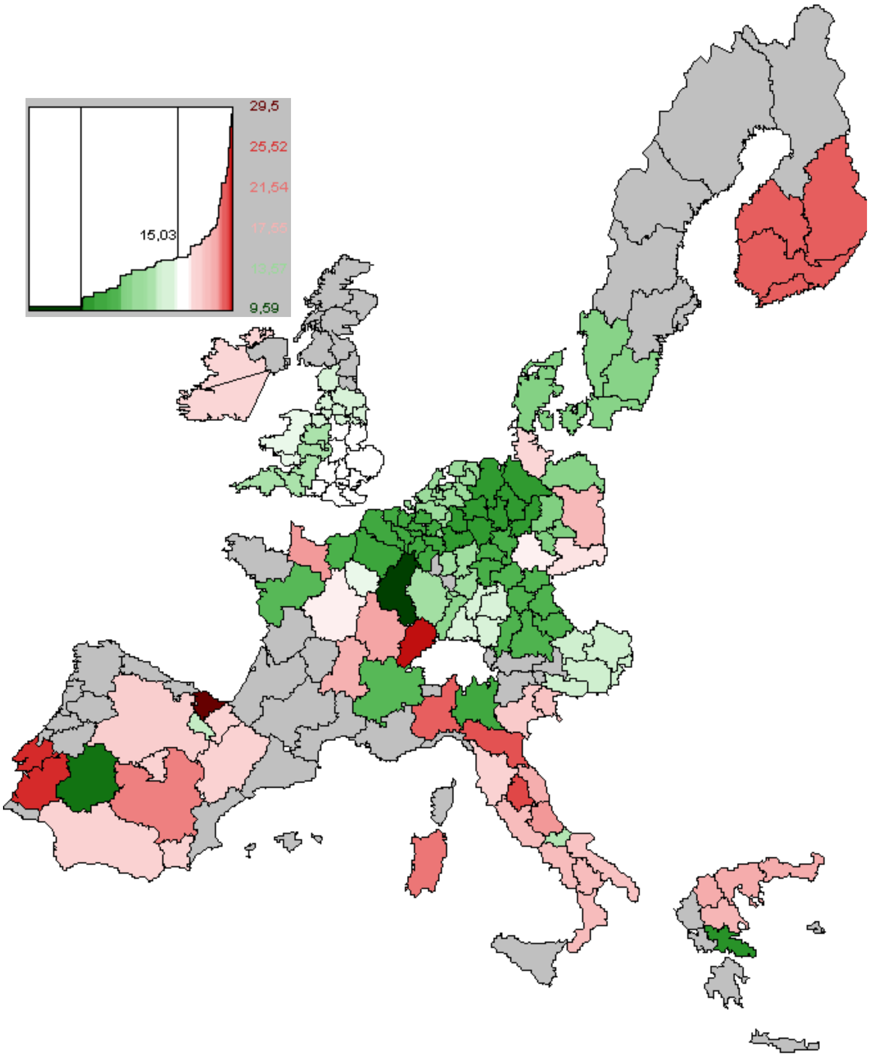
Figure 8.1: Region-codes in the EU-15 (cont.)

France:

FR100000	ILE DE FRANCE
FR210000	CHAMPAGNE-ARDENNE
FR220000	PICARDIE
FR230000	HAUTE-NORMANDIE
FR240000	CENTRE
FR250000	BASSE-NORMANDIE
FR260000	BOURGOGNE
FR300000	NORD-PAS-DE-CALAIS
FR410000	LORRAINE
FR420000	ALSACE
FR430000	FRANCHE-COMTE
FR510000	PAYS DE LA LOIRE
FR520000	BRETAGNE
FR530000	POITOU-CHARENTES
FR610000	AQUITAINE
FR620000	MIDI-PYRENEES
FR630000	LIMOUSIN
FR710000	RHONE-ALPES
FR720000	AUVERGNE
FR810000	LANGUEDOC-ROUSSILLON
FR820000	PROVENCE-ALPES-COTE D'AZUR
FR830000	CORSE

Source: Author's illustration based on the mapping tool developed by Alexander Gocht, FAL, Braunschweig

Figure 8.2: Estimated relative yield variance from FADN in %



Source: Author's calculations based on FADN data

Table 8.1: Degree of coupling for different premiums after MTR implementation in CAPRI in %

	BL	DK	DE	EL	ES	FR	IR	IT	NL	AT	PT	SE	FI	UK
Direct payment to cereals	0	0	0	25	25	25	0	0	0	0	0	0	0	0
Specific payment for pulses	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Traditional durum wheat premium	0	0	0	40	40	0	0	0	0	0	0	0	0	0
Established payment to durum wheat	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Specific rice premium	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Silage premiums for Sweden and Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Farm income rice premiums	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suckler cow premium	100	0	0	100	100	100	0	0	0	100	100	0	0	0
Special premium to bulls and steers	0	75	0	0	0	0	0	0	0	0	0	75	75	0
Direct income support to dairy cows	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Extensification premium	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct payment for sheep and goat	0	50	0	50	50	50	0	0	0	0	50	0	50	0
Direct payments to energy crops	100	100	100	100	100	100	100	100	100	100	100	100	100	100
National envelope for sheep and goat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
National envelope dairy cows	0	0	0	0	0	0	0	0	0	0	0	0	0	0
National envelope bovine meat cattle	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slaughter premium for adult cattle	40	0	0	40	40	40	0	0	100	40	40	0	0	0
Slaughter premium for calves	40	0	0	40	40	40	0	0	100	40	40	0	0	0
National premium to dairy cows (SE & FI)	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Olive and oilve oil sector	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Fruits and vegetables	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Wine sector	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textile crops	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Starch potatoes	60	60	60	60	60	60	60	60	60	60	60	60	60	60

Source: CAPRI modelling system. Premiums that do not appear in the table are completely decoupled for all regions

Table 8.2: Envelopes for direct income support for farmers (M€)

	Scenario II	Scenario III
BL	62	84
DK	30	34
DE	241	278
EL	26	29
ES	86	96
FR	234	270
IR	16	18
IT	119	136
NL	63	74
AT	29	33
PT	6	6
FI	12	14
SE	30	34
UK	93	103

Source: CEC, 2004b and CEC 2005

Table 8.3: Land allocation in all scenarios (EU-15, 1000 ha)

	Base year (2001)	Reference (2009)		Scenario I			Scenario II		Scenario III	
	value		*change to Base year*		*change to Reference*	*relative change to Reference*		*change to Reference*		*change to Reference*
Cereals	37519	34709	*-2810*	34754	*45*	*0.13%*	34804	*95*	34814	*105*
Oilseeds	5306	5137	*-169*	5169	*32*	*0.62%*	5185	*48*	5179	*42*
Sugar beet	1881	1900	*19*	1618	*-282*	*-14.84%*	1434	*-466*	1472	*-428*
Potatoes	1275	1296	*22*	1299	*2*	*0.19%*	1300	*3*	1299	*3*
Fodderproduction	59886	62334	*2448*	62457	*123*	*0.20%*	62543	*209*	62518	*184*
Set aside	5609	5661	*51*	5696	*35*	*0.63%*	5711	*50*	5701	*41*
Non Food	487	420	*-67*	427	*7*	*1.55%*	432	*12*	431	*11*
Other uses	20537	21326	*789*	21364	*38*	*0.18%*	21375	*49*	21369	*43*

Source: CAPRI modelling system

Table 8.4: Producer prices for arable crops (EU-15 all scenarios)

	Reference run (2009)	Scenario I percent deviation to : Reference run (2009)	Scenario II percent deviation to : Reference run (2009)	Scenario III percent deviation to : Reference run (2009)
	Euro / t	Euro / t	Euro / t	Euro / t
Wheat	103.2	101.3 -1.84%	101.25 -1.89%	101.74 -1.41%
Barley	95.35	93.22 -2.23%	92.93 -2.54%	93.44 -2.00%
Maize	128.4	127.82 -0.45%	127.35 -0.82%	127.43 -0.76%
Other cereals	100.58	97.13 -3.43%	96.58 -3.98%	97.75 -2.81%
Rice	188.05	187.9 -0.08%	187.6 -0.24%	187.6 -0.24%
Starchy products	86.14	85.88 -0.30%	85.81 -0.38%	85.85 -0.34%
Sugar	707.9	703.65 -0.60%	434.54 -38.62%	404.52 -42.86%
Pulses	161.99	159.75 -1.38%	159.99 -1.23%	160.64 -0.83%
Soya	206.1	205.87 -0.11%	204.83 -0.62%	204.82 -0.62%
Sunflower seed	220.11	219.24 -0.40%	218.67 -0.65%	218.8 -0.60%
Rape seed	200.27	198.16 -1.05%	198.17 -1.05%	198.83 -0.72%
Soya oil	574.15	575.09 0.16%	574.28 0.02%	574.08 -0.01%
Sunflower oil	790.76	789.83 -0.12%	789.3 -0.18%	789.44 -0.17%
Rape oil	757.02	754.32 -0.36%	754.88 -0.28%	755.3 -0.23%
Soyameal and cake	226.37	226 -0.16%	225.53 -0.37%	225.58 -0.35%
Sunflower cake	90.32	89.98 -0.38%	89.72 -0.66%	89.76 -0.62%
Rape cape	82.78	81.3 -1.79%	80.43 -2.84%	81.46 -1.59%

Source: CAPRI modelling system

Table 8.5: Key indicators on the EU-15 sugar (beet) markets – all scenarios

		Unit	Base year (2001)	Reference (2009)		Scenario I		Scenario II		Scenario III	
			value*	value	% change to base	value	% change to Reference	value	% change to Reference	value	% change to Reference
Sugar beet	**A sugar beet**										
	producer price	€/t	59.12	51.77	-12.4	52.98	2.3	31.80	-38.6	29.66	-42.7
	production	1000t	80181	80175	0.0	65077	-18.8	65534	-18.3	70311	-12.3
	B sugar beet										
	producer price	€/t	54.45	47.17	-13.4	52.98	12.3	31.80	-32.6	29.66	-37.1
	production	1000t	16370	16909	3.3	13765	-18.6	14652	-13.3	16548	-2.1
	C sugar beet										
	producer price	€/t	18.41	15.53	-15.7	15.49	-0.3	15.73	1.3	15.78	1.6
	production	1000t	15875	18633	17.4	19236	3.2	10109	-45.7	5851	-68.6
	Sugar beet total										
	average price	€/t	52.69	45.26	-14.1	45.63	0.8	30.00	-33.7	28.79	-36.4
	production	1000t	112425	115716	2.9	98079	-15.2	90295	-22.0	92711	-19.9
Sugar	**EU price**	€/t	807	708	-12.3	704	-0.6	434	-38.7	404	-42.9
	World market price	€/t	226	190	-15.9	189	-0.3	204	7.4	204	7.8
	Quota	1000t	13882	13882	0.0	11190	-19.4	11661	-16.0	12581	-9.4
	Domestic supply	**1000t**	**16068**	**16534**	**2.9**	**13993**	**-15.4**	**13049**	**-21.1**	**13406**	**-18.9**
	Belgium	1000t	933	966	3.6	824	-14.7	904	-6.4	891	-7.7
	Denmark	1000t	509	529	3.9	436	-17.4	460	-12.9	501	-5.3
	Germany	1000t	4041	4178	3.4	3415	-18.2	3445	-17.5	3754	-10.1
	Greece	1000t	322	332	3.0	308	-7.2	184	-44.6	157	-52.6
	Spain	1000t	1075	1098	2.1	1049	-4.5	1042	-5.1	901	-18.0
	France	1000t	4196	4284	2.1	3410	-20.4	4006	-6.5	4328	1.0
	Ireland	1000t	211	210	-0.5	190	-9.6	22	-89.7	22	-89.7
	Italy	1000t	1415	1482	4.8	1315	-11.3	495	-66.6	454	-69.4
	Netherlands	1000t	961	986	2.6	813	-17.5	637	-35.3	597	-39.5
	Austria	1000t	431	447	3.7	381	-14.7	536	19.9	429	-4.0
	Portugal	1000t	85	84	-1.4	79	-6.0	27	-67.7	9	-89.6
	Sweden	1000t	415	429	3.3	395	-8.0	329	-23.4	320	-25.3
	Finland	1000t	153	161	5.4	149	-7.3	114	-29.0	99	-38.6
	United Kingdom	1000t	1322	1350	2.1	1229	-8.9	847	-37.3	945	-30.0
	Imports	**1000t**	**1818**	**1821**	**0.2**	**4792**	**163.2**	**1933**	**6.2**	**968**	**-46.9**
	India	1000t	10	10	-0.4	10	-0.2	5	-48.2	1	-85.5
	ACP	1000t	1616	1620	0.2	4052	150.1	1638	1.1	657	-59.4
	Rest of the world	1000t	105	104	-0.9	610	486.5	174	67.6	200	92.1
	Free trade developing	1000t	86	87	0.7	120	38.0	116	33.3	109	25.5
	Total supply	**1000t**	**17886**	**18355**	**2.6**	**18785**	**2.3**	**14981**	**-18.4**	**14373**	**-21.7**
	Domestic demand	**1000t**	**12951**	**12967**	**0.1**	**12972**	**0.0**	**13113**	**1.1**	**13129**	**1.3**
	Exports	**1000t**	**4935**	**5388**	**9.2**	**5423**	**0.7**	**1863**	**-65.4**	**1317**	**-75.6**
	Subsidiesed exports	1000t	2618	2673	2.1	2620	-2.0	416	-84.4	474	-82.3
	C sugar exports	1000t	2317	2715	17.2	2803	3.2	1446	-46.7	843	-69.0
	Aggregation error	1000t	0	0		390		6		-73	
	Total demand	**1000t**	**17886**	**18355**	**2.6**	**18785**	**2.3**	**14981**	**-18.4**	**14373**	**-21.7**

Source: CAPRI modelling system

8.2 Kernel Density Estimates

In this section, we explain how one can draw a smooth distribution of a certain variable if only a finite number of observations are given. As an example, we use the rotational share of sugar beets in the FADN sample of Denmark. The red bars in Figure 8.3 give the weighted number of observations (rotational shares) that fall in 0.01 intervals.[97] Those numbers are scaled so that the sum over all bars equals one and we can interpret them as a discrete density distribution. A tall bar stands for many observations that fall into the respective interval. The shape of this distribution indicates that the shares might be normally distributed. Therefore, we compute a truncated normal distribution with the mean and variance of Denmark given in Table 2.1 calculated by formulas for the truncated normal distribution in Green (1990). This function is plotted with a green line. It becomes apparent that the truncated normal does not fit the 'real' data very well especially in the range between 0.1 and 0.3. It approximates the shape of the discrete distribution, but there might be better solutions like the Kernel density estimator (LEWIS et al, 1988). In particular, we choose the normal kernel defined in equation (8.1). Here **m** denotes the number of observations in a sample and **b** is a smoothing parameter. A larger **b** leads to a smoother pdf but in turn, if **b** becomes too large, the resulting kernel estimate approximates a uniform distribution. Therefore, the choice of parameter **b** is a critical point in computing kernel density estimates. LEWIS et al. (1988) introduce a modified Maximum Likelihood estimation to find the optimal value for the smoothing parameter **b**. It turned out that this method is not suitable for the large number of observations we deal with in some EU Member States because of PC capacity problems. Thus, we finally decided to choose the standard starting value for **b**, also provided by LEWIS et al. (1988) and given in equation (8.2).

$$\text{pdf}(x) = \frac{1}{mb}\sum_{i=1}^{m}\frac{1}{\sqrt{2\pi}}e^{-\frac{(x_i - x)^2}{2b^2}} \quad (8.1)$$

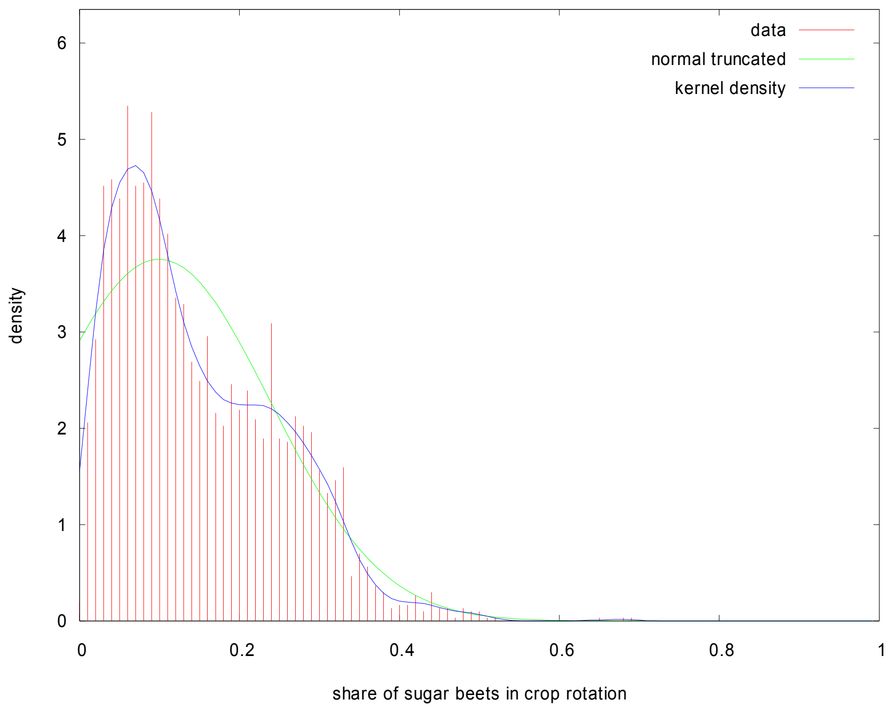
$$b = 2\sigma m^{-0.2} \quad (8.2)$$

where σ is the standard deviation of the tackled sample.

For Denmark, the Kernel density function is plotted with a blue line and it is quite obvious that the 'real' data is better fitted than the truncated normal distribution.

[97] Observations refer to all farms that produce sugar beets in each year they are part of the sample

Figure 8.3: Probability density function of sugar beet rotation shares in Denmark



Source: FADN and author's calculations

8.3 Mathematical Derivation of the Variance of Profits from Sugar Production

As already addressed in section 4.2.1, one can derive the final formula for the variance of expected profits by substituting (4.14), (4.15) and (4.16) into (4.13). While both equations, (4.14) and (4.15), are expressed in terms of variables which are already known from the expected marginal revenue derivation, the formula for the covariance (equation (4.16)) includes a number of variables that we did not introduce before. Based on chapter 21 of Greene (1990), we give in this section the formulas for means of truncated, censored, and squared variables necessary to compute the variance of expected profits in the one-quota case.

First, we repeat the covariance formula:

$$\text{(8.3)} \quad COV\left(y_S, y_S^C\right) = \begin{pmatrix} E_{y_S>q}\left[y_S^2\right] - E_{y_S>q}\left[y_S\right]q - E_{y_S>q}\left[y_S\right]E\left[y_S^C\right] \\ -E\left[y_S\right]E_{y_S>q}\left[y_S\right] + E\left[y_S\right]q + E\left[y_S\right]E\left[y_S^C\right] \end{pmatrix} P\left[y_S > q\right] + \left(E\left[y_S^C\right]\left(E\left[y_S\right] - E_{y_S \le q}\left[y_S\right]\right)\right)P\left[y_S \le q\right]$$

All unknown elements included in this formula have some variables in common, which are now introduced:

(8.4)
$$\alpha = \frac{q - E[y_S]}{\sigma^S}$$

α is used to transform the our normal distribution f(q) into a standard normal distribution. Note that:

(8.5)
$$\phi(\alpha) = \frac{1}{\sqrt{2\pi}} e^{-0.5\alpha^2} = \sigma^S f(q)$$

and that

(8.6)
$$\Phi(\alpha) = F(q)$$

because the value of the cdf at a certain point x of the standard normal distribution is the same than that of a cdf with a different mean and variance, as long as x is shifted proportional.

We adopt the definitions of the standard normal distribution (ϕ) and its cdf (Φ) as used in Greene (1990) to make the derivation of the following variables clearer. Greene (1990) further defines a variable λ that is different depending from which side the variable is truncated or censored:

(8.7)
$$\lambda_{y_S>q}(\alpha) = \frac{\phi(\alpha)}{1-\Phi(\alpha)}$$
$$\lambda_{y_S<q}(\alpha) = \frac{-\phi(\alpha)}{\Phi(\alpha)}$$

then he defines δ as:

(8.8)
$$\delta_{y_S>q}(\alpha) = \lambda_{y_S>q}{}^2(\alpha) - \alpha\lambda_{y_S>q}(\alpha)$$
$$\delta_{y_S<q}(\alpha) = \lambda_{y_S<q}{}^2(\alpha) - \alpha\lambda_{y_S<q}(\alpha)$$

Equation (8.3) contains several times the expectation value of y_S if the distribution is truncated from below or from above at the quota endowment q. Greene (1990) defines them as

(8.9)
$$E_{y_S>q}[y_S] = \left(E[y_S] + \sigma^S\right)\lambda_{y_S>q}(\alpha)$$
$$E_{y_S<q}[y_S] = \left(E[y_S] + \sigma^S\right)\lambda_{y_S<q}(\alpha)$$

Additionally we need the expectation value of the censored variable $y_S{}^C$:

(8.10)
$$E\left[y_S^C\right] = \left(E[y_S] + \sigma^S\lambda_{y_S>q}(\alpha)\right)\left(1-\Phi(\alpha)\right)$$

Finally, we need the expectation value of the squared sugar production if the distribution is truncated from below at the quota endowment q. Generally the expectation value of a squared variable equals the sum of the squared expectation value of that variable and its variance, so that we obtain:

(8.11)
$$E_{y_S>q}\left[y_S{}^2\right] = \left(E_{y_S>q}[y_S]\right)^2 + (\sigma^S)^2\left(1-\delta_{y_S>q}(\alpha)\right)$$

Knowing that $P[y_S>q] = 1-\Phi(\alpha)$ and $P[y_S<q] = \Phi(\alpha)$ we have now expressed all unknown variables in (8.3) in terms of noted variables so that the computation of the covariance is straightforward.

An extension of the one-quota case to a system with more quotas is possible as well. It is necessary to reflect the variance and covariance between all censored and truncated variables. The mathematical derivation for the more-quota case is available from the author upon request.