EU Sugar Policy Reform: Quota Reduction and Devaluation[1]

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Abstract
The research presented is part of a larger study aiming at the analysis of reform options for the EU sugar policy regime. This paper focuses on the effects of quota reduction and support price cuts. A thorough theoretical analysis investigates the implications of farm heterogeneity for aggregate supply modeling purposes under the current sugar regime. It can be shown that the treatment of sugar quantities produced under the different quotas and without quota can be treated as different products in an aggregate profit function analysis. Marginal and discrete price and quota effects are derived. Subsequently, the derived behavioral characteristics are implemented in the framework of the agricultural sector model CAPSIM to provide a broader policy evaluation. Preliminary simulation results are presented for the EU at aggregate level.

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1 Introduction

The EU sugar market regime has withstood any agricultural policy reform in the last 4 decades despite some effort by agricultural economists pointing at the implied negative welfare effects (e.g. Koester and Schmitz 1982, Mahler 1994, Bureau et al. 1997). The “secret” of the production quota based policy was to not touch what seems to worry politicians more than diminished consumer rents: the budget. But suddenly the invulnerability of the regime is threatened, mainly by committed tariff preferences and import guarantees to developing countries. Under the “everything but arms” (EBA) agreement of the EU with the least developed countries the EU has accepted duty free imports of “everything but arms”, and what is most important here, this includes sugar. This policy might significantly increase budget costs of the current sugar market regulation through increased interventions cost and export subsidies. This in turn could conflict with existing WTO agreements and current negotiation strategies. Consequently, the European Commission has a strong interest in evaluating likely consequences of different reform options for the sugar market policy (European Commission 2001). These options include quota reduction, decreased support price, and allowing for tradable quotas.

This paper aims at providing some theoretical and preliminary quantitative insights to the impacts of these options on sugar beet production, income, and welfare at the aggregate level.[3] It is organized as follows: First, a brief overview on the current EU sugar policy is given. Then, theoretical implications for aggregate modeling of producer behavior under the quota regime are presented. Farm specific profit maximization models are aggregated

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[3] Even though CAPSIM simulations will also contribute to the official assessment of the reform options by the Commission, the current specification of the modeling system and the interpretation of options has been solely under the responsibility of the authors. Given that the model is still under construction and that certain policy parameters are still excessively simplified for official use it is very likely that the final CAPSIM results on these options will look different. Therefore, this paper does not allow any inference on the future assessment of the Commission.

observing the distribution of efficiency and quota allocation across farms leading to comparative static results for quota reduction and support price cuts. Based on these theoretical considerations, the representation of sugar supply behavior in the European Sector Model CAPSIM is motivated. Subsequently, aggregate results for scenarios with quota reduction and support price cuts are presented. Finally, conclusions are drawn and research paths to improve upon the current modeling state and to evaluate additional reform options are outlined.

2 Common Market Organization (CMO) for Sugar in the EU

2.1 Brief Sketch of Current Measures

The EU's common market organization for sugar (CMO-sugar) is part of the common agricultural policy (CAP) and was put in place in 1967. It was designed to harmonize the sugar policy between the member states while keeping producer support at least as high as with previous national measures. Similar to CMO's for other products, *minimum support prices* with an accompanying *intervention purchase system* were implemented. The internal market was protected by *import tariffs* and *export refunds*. However, in addition to these typical CMO instruments, a *production quota system* limited the quantity eligible for price support through intervention mechanism and thereby the costs of intervention purchases. At the same time, the quota allocation to member states implied a certain national market share regardless of efficiency. It was mainly the cost saving nature of the quota system which allowed the CMO sugar to move basically unchanged through major reforms of the CAP - the MacSherry reform in 1992 and Agenda 2000.

The quotas allocated to each member state define the sugar quantities that can be sold in the EU and consequently limit the supply in this market. Production quantities above the quota, the so called C-sugar, are allowed, but must be sold on the world market. The two types of quota, A and B, are differentiated by the levies applied to cover the cost of export and production refunds[4] of quota sugar:

- a basic levy of up to 2% of the intervention price applied to both A- and B-sugar (always applied since 1990/91)
- a variable levy with a maximum of 37.5% of the intervention price applied to B-sugar (lowest percentage since 1990/91 was 30.4% in 1991/1992)
- an additional levy as percentage of the basic and B-sugar levy in case those were not sufficient to cover the cost (applied 3 times since 1990)

The B-quota in percent of the A-quota differs between member states (highest is Germany with 30.8% and lowest in Spain with 4.2%). Higher B-quota shares reflect perceived comparative advantages of certain member states with respect to sugar production at the time of implementation. They were supposed to allow for an expansion of production at relatively low product prices. National quota quantities have been nearly unchanged for the last 20 years. During the same time period there has been only one incidence of intervention purchases. Apparently, the sugar export with refunds is more attractive for sugar processors.

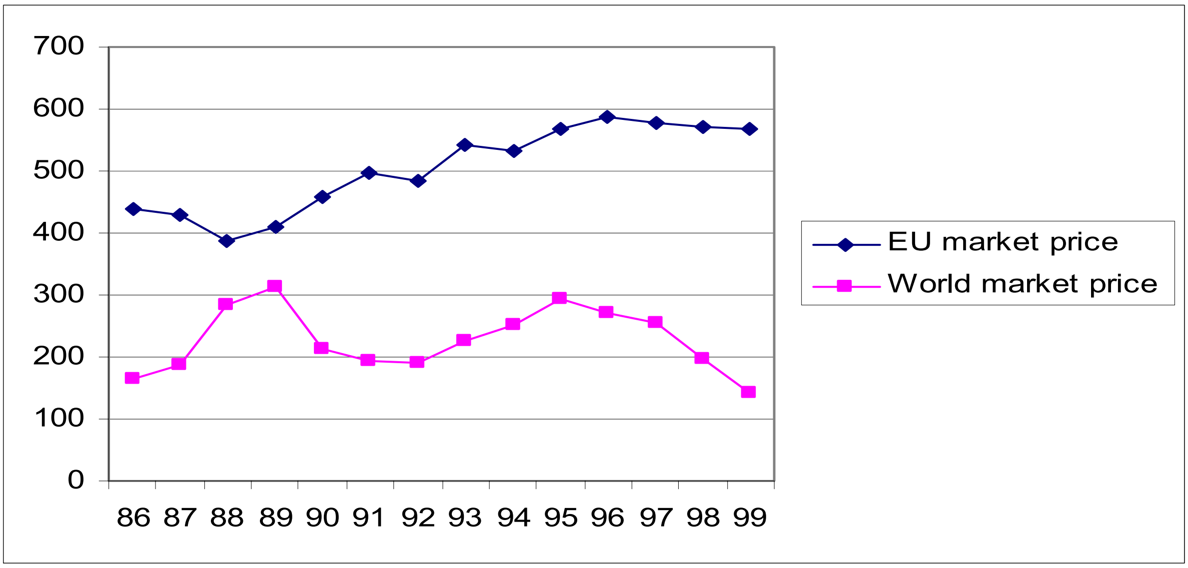
The member states allocate the quotas to sugar processors, which in turn give delivery rights to sugar beet producers. The share of A and B quota for producers typically equal the national shares. Sugar processors are legally bound to pay minimum beet prices to producers, which calculate as 58% of the intervention price minus the relevant levies. Typically, producers receive A-quota prices until their individual A-quota is filled, then B-quota prices apply until the overall quota is exhausted. All remaining quantities delivered are paid depending on the sugar prices obtained on world markets in the respective marketing year. In

[4] The sugar using chemical and pharmaceutical industries receive production refunds to compensate for the additional cost caused by the high sugar prices within the EU.

some member states, average pricing schemes are applied (for example on A and B quota quantities in the Netherlands and Belgium).

Figure 1 presents average EU and world sugar prices over the last 20 years illustrating the success of the policy in isolating the European sugar market and providing an income premium to sugar beet producers and sugar processors relative to world market conditions.

Figure 1: White Sugar Prices (Euro/t) in the EU and on the World Market



This brief sketch of the CMO-sugar already hints at potential difficulties in projecting effects of various reform options. Empirical model specification is hampered by the fact that no variation in quota allocation across member states and within member states as well as significant price variation for EU producers has been observed. Also, the heterogeneity of farms determines the efficiency gain to be expected from any deregulatory measure. At first look, it seems questionable whether an aggregate analysis is capable at all to represent sugar beet supply behavior in an adequate way. We will now look at this problem in a formal way.

2.2 Sugar Beet Supply – Farm and Aggregate Level

Let the farm level cost function of farm i be:

$$(1)\qquad C^i(\mathbf{w}, \mathbf{y}^i_{-s}, y^i_s) = \min_{x^i}\left\{ \mathbf{w}'\mathbf{x}^i : T^i(\mathbf{x}^i, \mathbf{y}^i_{-s}, y^i_s) = 0 \right\}$$

where

C^i	=	farm level cost function
T^i	=	farm level technology
$\mathbf{w}$	=	column vector of input prices
$\mathbf{x}^i$	=	column vector of input quantities
$\mathbf{y}^i_{-s}$	=	column vector of non sugar outputs
y^i_s	=	sugar beet production

Observing quantitative restrictions inherent in the sugar CMO, but neglecting aversion to the potential risk of loosing the quotas in case of incomplete use, we may express the farm level behavioral model as the following profit maximization problem:

$$\pi^i\left(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,q^i_a,q^i_b\right)=$$

(2) $$\max_y\left\{\ \mathbf{p}_{-s}{}'\mathbf{y}^i_{-s}+p_a y^i_a+p_b y^i_b+p_c y^i_c-C^i(\mathbf{w},\mathbf{y}^i_{-s},y^i_s):\ y^i_s=y^i_a+y^i_b+y^i_c,\ y^i_a\le\alpha^i Q_a,\ y^i_b\le\alpha^i Q_b\right\}$$

where

y^i_a	=	production quantity of A sugar beet
y^i_b	=	production quantity of B sugar beet
y^i_c	=	production quantity of C sugar beet
Q_a	=	aggregate quota for A sugar beet
Q_b	=	aggregate quota for B sugar beet
α^i	=	share of farm i in the aggregate quotas ($\alpha_i=q^i_a/Q_a=q^i_b/Q_b$)
p_a	=	price of A sugar beet
p_b	=	price of B sugar beet
p_c	=	price of C sugar beet
$\mathbf{p}_{-s}$	=	column price vector of non sugar products

First order conditions reveal – depending on quota endowment and the position of the marginal cost curve with respect to sugar production $C^i_s=\partial C^i/\partial y^i_s$ – that the farm will operate according to one of the following five cases:

1) $q^i_a+q^i_b<y^i_s\Rightarrow p_c=C^i_s<p_b<p_a$

2) $q^i_a+q^i_b=y^i_s\Rightarrow p_c\le C^i_s\le p_b<p_a$

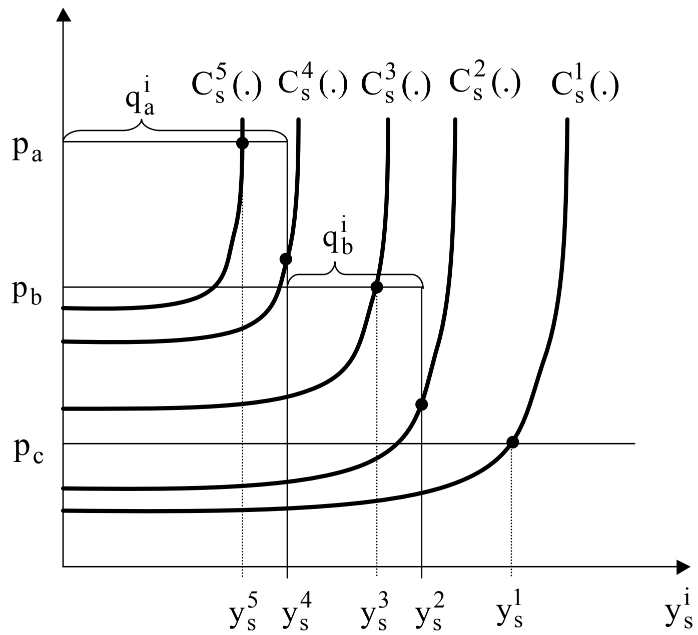
3) $q_a^i < y_s^i < q_a^i + q_b^i \Rightarrow p_b = C_s^i < p_a$

4) $y_s^i = q_a^i \Rightarrow p_b \le C_s^i \le p_a$

5) $y_s^i < q_a^i \Rightarrow C_s^i = p_a$

These cases are ordered to represent increasing marginal cost and may be depicted graphically as in figure 2.

Figure 2: Five different farm types in view of the EU sugar CMO



In a certain region we observe several farm types at the same time because quota endowments and farm efficiency follow a distribution with significant variance. It is quite clear that the regional aggregate response to changing prices or quota quantities depends on this distribution and treating each region as homogenous in terms of one of the five farm types (see, for example, Frandsen et al. 2001) will cause some aggregation error. Before we develop an aggregate modeling strategy for the evaluation of reform options we first want to investigate what implications follow from farm heterogeneity. To this end we derive the aggregate regional profit function for a heterogeneous population of farms.

It will be helpful to recognize that each of the above farm types is responsive – at the margin – to only one sugar related exogenous variable. Type 1, for example, reacts to marginal changes of the price of C-sugar beet, p_c. The other sugar related variables (p_a, p_b, q_a^i, q_b^i) only determine which type applies. Unless there are large changes in these variables, transforming type 1 farms to another one, maximum profit may be determined from

$$\begin{aligned}&\tilde{\pi}^i\left(\mathbf{w},\mathbf{p}_{-s},p_c\right) \;+\left(p_a-p_c\right)\;\alpha^i Q_a+\left(p_b-p_c\right)\;\alpha^i Q_b= \\ &\max_{\mathbf{y}}\;\left\{\;\mathbf{p}_{-s}'\mathbf{y}_{-s}^i+p_c y_s^i-C^i(\mathbf{w},\mathbf{y}_{-s}^i,y_s^i)\right\}+\left(p_a-p_c\right)\;\alpha^i Q_a+\left(p_b-p_c\right)\;\alpha^i Q_b\end{aligned} \tag{3}$$

Sugar beet supply is determined by the price of C-sugar beet p_c which enters a price dependent profit function whereas quotas and prices for A- and B-sugar beet only determine the additional pure rent income. For farm type 2 the combined A- and B-sugar beet quotas determine a quantity dependent restricted profit function $\underline{\pi}^i$ and sugar beet supply:

$$\begin{aligned}&\underline{\pi}^i\left(\mathbf{w},\mathbf{p}_{-s},\alpha^i(Q_a+\;Q_b)\right)\;+p_a\;\;\alpha^i Q_a+p_b\;\;\alpha^i Q_b= \\ &\max_{\mathbf{y}}\;\left\{\;\mathbf{p}_{-s}'\mathbf{y}_{-s}^i-C^i\left(\mathbf{w},\mathbf{y}_{-s}^i,\alpha^i(Q_a+\;Q_b)\right)\;\right\}+p_a\;\;\alpha^i Q_a+p_b\;\;\alpha^i Q_b\end{aligned} \tag{4}$$

Profit and behavior for farm type 3, which does not fully exploit its B-quota, again follow from a price dependent profit function $\tilde{\pi}^i$:

$$\begin{aligned}&\tilde{\pi}^i\left(\mathbf{w},\mathbf{p}_{-s},p_b\right)\;+\left(p_a-p_b\right)\;\alpha^i Q_a= \\ &\max_{\mathbf{y}}\;\left\{\;\mathbf{p}_{-s}'\mathbf{y}_{-s}^i+p_b y_s^i-C^i(\mathbf{w},\mathbf{y}_{-s}^i,y_s^i)\;\right\}+\left(p_a-p_b\right)\;\alpha^i Q_a\end{aligned} \tag{5}$$

The price of B-sugar beet determines behavior whereas quota and price for A-sugar beet are important for the pure rent income. Farm type 4 is constrained by it’s A-quota such that behavior and income follow from the solution of:

$$\begin{aligned}&\underline{\pi}^i\left(\mathbf{w},\mathbf{p}_{-s},\alpha^i Q_a\right)\;+p_a\;\;\alpha^i Q_a= \\ &\max_{\mathbf{y}}\;\left\{\;\mathbf{p}_{-s}'\mathbf{y}_{-s}^i-C^i(\mathbf{w},\mathbf{y}_{-s}^i,\alpha^i Q_a)\right\}+p_a\;\;\alpha^i Q_a\end{aligned} \tag{6}$$

Finally we have farms of type 5 which do not even make full use of their A-quota:

(7) $$\tilde{\pi}^{i}\left(\mathbf{w},\mathbf{p}_{-s},p_{a}\right) = \max_{\mathbf{y}} \left\{ \mathbf{p}_{-s}'\mathbf{y}_{-s}^{i} + p_{a}y_{s}^{i} - C^{i}(\mathbf{w},\mathbf{y}_{-s}^{i},y_{s}^{i}) \right\}$$

The analysis above reveals that farms belong to certain types according to their marginal cost evaluated at the quota levels. Farm level costs depend on farm efficiency and on the farm's product mix ($\mathbf{y}_{-s}^{i}, \mathbf{y}_{s}^{i}$). Consider the level of non-sugar outputs $\underline{\mathbf{y}}_{-s}^{i}$ = $\mathbf{y}_{-s}^{i}\left(\mathbf{w},\mathbf{p}_{-s},y_{s}^{i}\right)$ which solve the quantity constrained problems in (4) and (6). Furthermore, take farm level efficiency to be an explicit argument of the cost functions C(.):

(8) $$C^{i}\left(\mathbf{w},\mathbf{y}_{-s}^{i},\mathbf{y}_{s}^{i}\right) = C\left(\mathbf{w},\underline{\mathbf{y}}_{-s}^{i}(\mathbf{w},\mathbf{p}_{-s},y_{s}^{i},i),y_{s}^{i},i\right)$$

Profit functions based on these cost functions will inherit the farm index as an explicit argument, for example:

(9) $$\tilde{\pi}^{i}\left(\mathbf{w},\mathbf{p}_{-s},p_{c}\right) = \tilde{\pi}\left(\mathbf{w},\mathbf{p}_{-s},p_{c},i\right)$$

(10) $$\underline{\pi}^{i}\left(\mathbf{w},\mathbf{p}_{-s},\alpha^{i}Q_{a}\right) = \underline{\pi}^{i}\left(\mathbf{w},\mathbf{p}_{-s},\alpha(i)Q_{a}\right) = \underline{\pi}\left(\mathbf{w},\mathbf{p}_{-s},Q_{a},i\right)$$

Now imagine the farms to be ordered according to their marginal cost at the A+B-quota-levels with non-sugar outputs $\mathbf{y}_{-s}^{i}$ optimally adjusted:

(11) $$C_{s}\left(\mathbf{w},\mathbf{p}_{-s},Q_{a}+Q_{b},i\right) = \frac{\partial}{\partial y_{s}^{i}} C\left(\mathbf{w},\mathbf{y}_{-s}^{i}(\mathbf{w},\mathbf{p}_{-s},\alpha^{i}(Q_{a}+Q_{b}),i\right) \overset{?}{=} p_{c}$$

Farms with $C_s(.) < p_c$ will be of type 1, i.e. producers of C sugar beet. They will be characterized by high farm efficiency and/or low quota endowments. Farms with $C_s(.) > p_c$ will belong to one of the other types. With many farms in a region forming a continuous distribution, the ordered index of a farm just unconstrained by its A+B-quota - that is at the margin of farm types 1 and 2 - may be considered an implicit function of prices and aggregate quotas:

(12) $$C_{s}\left(\mathbf{w},\mathbf{p}_{-s},Q_{a}+Q_{b},i\right) = p_{c} \Leftrightarrow i_{\underline{b}} = i\left(\mathbf{w},\mathbf{p}_{-s},Q_{a}+Q_{b},p_{c}\right)$$

The number of C-sugar beet producers will decline with rising prices of alternative crops ($\partial i_{\underline{b}}/\partial p_{-s} < 0$) and with rising aggregate quotas ($\partial i_{\underline{b}}/\partial Q < 0$) but it will increase with rising prices of C-sugar beet. In an analogous way, we may find the border between the quota constrained farm type 2 and the unconstrained B-producer type 3 according to equality of marginal cost, evaluated at the A+B quota levels, with price p_b:

$$\text{(13)} \qquad C_s\left(\mathbf{w},\mathbf{p}_{-s},Q_a+Q_b,i\right)=p_b \Leftrightarrow i_b=i\left(\mathbf{w},\mathbf{p}_{-s},Q_a+Q_b,p_b\right)$$

Similarly we find the borders between farm types 3 and 4 and between types 4 and 5:

$$\text{(14)} \qquad C_s\left(\mathbf{w},\mathbf{p}_{-s},Q_a,i\right)=p_b \Leftrightarrow i_{\underline{a}}=i\left(\mathbf{w},\mathbf{p}_{-s},Q_a,p_b\right)$$

$$\text{(15)} \qquad C_s\left(\mathbf{w},\mathbf{p}_{-s},Q_a,i\right)=p_a \Leftrightarrow i_a=i\left(\mathbf{w},\mathbf{p}_{-s},Q_a,p_a\right)$$

These borders are the final building blocks to calculate the average profit function for a heterogeneous population of farms by integration over the farm index:

$$\begin{aligned}
&\Pi(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,Q_a,Q_b)\\
&=\int_{i_a}^{n_s}\tilde{\pi}(\mathbf{w},\mathbf{p}_{-s},p_a,i)\,f(i)\,di\\
&+\int_{i_{\underline{a}}}^{i_a}\left(\underline{\pi}(\mathbf{w},\mathbf{p}_{-s},Q_a,i)+p_a\alpha(i)Q_a\right)f(i)\,di\\
&+\int_{i_b}^{i_{\underline{a}}}\left(\tilde{\pi}(\mathbf{w},\mathbf{p}_{-s},p_b,i)+(p_a-p_b)\alpha(i)Q_a\right)f(i)\,di\\
&+\int_{i_{\underline{b}}}^{i_b}\left(\underline{\pi}(\mathbf{w},\mathbf{p}_{-s},Q_a+Q_b,i)+p_a\alpha(i)Q_a+p_b\alpha(i)Q_b\right)f(i)\,di\\
&+\int_{1}^{i_{\underline{b}}}\left(\tilde{\pi}(\mathbf{w},\mathbf{p}_{-s},p_c,i)+(p_a-p_c)\alpha(i)Q_a+(p_b-p_c)\alpha(i)Q_b\right)f(i)\,di\\
\text{(16)}\quad&+\int_{1}^{n_{-s}}\tilde{\pi}(\mathbf{w},\mathbf{p}_{-s},e)\,g(e)\,de
\end{aligned}$$

where $i_{\underline{b}}$, i_b, $i_{\underline{a}}$ and i_a are defined in (12) to (15), n_s is the total number of farms endowed and not endowed with sugar beet quotas, respectively, f(i) is the density of the sugar beet farmers index. As reflected in (16) Average profit and netput behavioral functions also depend on the farmers without sugar beet quotas which may be simply ordered according to their profit forming an index "e" with density g(e). In (16) it is assumed for simplicity that their number n_{-s} is determined by ownership of fixed factors, the distribution of which is considered. Equally it is assumed that the quota allocation $\alpha(i)$ has been fixed, sometime in the past. To account for free entry and exit into farming n_{-s} might be considered the price dependent index of the marginal firm with zero profits (Coyle and Lopez 1987). Total profit and netput supply follow from multiplication with $(n_s + n_{-s})$.

Taking the derivatives of $\Pi(.)$ with respect to prices using Leibnitz' rule, for example p_a, illustrates that Hotelling's Lemma holds for this average profit function as for an individual firm in spite of the sugar quotas:

$$
\begin{aligned}
&\frac{\partial}{\partial p_a}\Pi(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,Q_a,Q_b) = Y_a(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,Q_a,Q_b) \\
&= \int_{i_a}^{n_s} \tilde{y}_a(\mathbf{w},\mathbf{p}_{-s},p_a,i)\, f(i)\, di - \tilde{\pi}(\mathbf{w},\mathbf{p}_{-s},p_a,i_a)\, f(i_a)\frac{\partial i(\mathbf{w},\mathbf{p}_{-s},Q_a,p_a)}{\partial p_a} \\
(17)\quad &+\int_{i_{\underline{a}}}^{i_a} \alpha(i)Q_a\, f(i)\, di + \left(\underline{\pi}(\mathbf{w},\mathbf{p}_{-s},Q_a,i_a) + p_a\, \alpha(i_a)Q_a\right) f(i_a)\frac{\partial i(\mathbf{w},\mathbf{p}_{-s},Q_a,p_a)}{\partial p_a} \\
&+\int_{i_b}^{i_{\underline{a}}} \alpha(i)Q_a\, f(i)\, di + \int_{i_{\underline{b}}}^{i_b} \alpha(i)Q_a\, f(i)\, di + \int_{1}^{i_{\underline{b}}} \alpha(i)Q_a\, f(i)\, di
\end{aligned}
$$

The first integral is the production of sugar beet by unconstrained type 5 farmers to which the A-quota quantities of all other sugar beet farmers are added. The additional effects of p_a through the change in the border $i_{\underline{a}}$ cancel by construction of the farm index i because for the farm on the border of farm types 4 and 5:

$$
\begin{aligned}
&\left(\underline{\pi}(\mathbf{w},\mathbf{p}_{-s},Q_a,i_a) + p_a\, \alpha(i_a)Q_a\right) \\
&= \max_{y_{-s}}\left\{\mathbf{p}_{-s}{}'\mathbf{y}_{-s} - C(\mathbf{w},\mathbf{y}_{-s},\alpha(i_a)Q_a,i_a)\right\} + p_a\alpha(i_a)Q_a \\
(18)\quad &= \max_{y_{-s},y_s}\left\{\mathbf{p}_{-s}{}'\mathbf{y}_{-s} + p_a y_s - C(\mathbf{w},\mathbf{y}_{-s},y_s,i_a)\right\} \\
&= \tilde{\pi}(\mathbf{w},\mathbf{p}_{-s},p_a,i_a)
\end{aligned}
,
$$

because the optimal sugar production $y_s^* = \alpha(i_a)\, Q_a$ for $i = i_a$. Production of "A sugar beet" falls short of the A quota if there are some type 5 farmers who voluntarily do not fully exploit their A-quota.

The average production of B- and C- sugar beet can be derived analogously (with terms related to borders already cancelled out) to obtain

$$
\begin{aligned}
&\frac{\partial}{\partial p_b}\Pi(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,Q_a,Q_b) = Y_b(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,Q_a,Q_b) \\
&= \int_{i_b}^{i_{\underline{a}}} \left(\tilde{y}(\mathbf{w},\mathbf{p}_{-s},p_b,i) - \alpha(i)Q_a\right) f(i)\, di \\
&+ \int_{i_{\underline{b}}}^{i_b} \alpha(i)Q_b\; f(i)\, di \\
&+ \int_{1}^{i_{\underline{b}}} \alpha(i)Q_b\; f(i)\, di
\end{aligned}
\tag{19}
$$

and

$$
\begin{aligned}
&\frac{\partial}{\partial p_c}\Pi(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,Q_a,Q_b) = Y_c(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,Q_a,Q_b) \\
&= \int_{1}^{i_{\underline{b}}} \left(\tilde{y}(\mathbf{w},\mathbf{p}_{-s},p_c,i) - \alpha(i)(Q_a + Q_b)\right) f(i)\, di
\end{aligned}
\tag{20}
$$

In the same manner we might derive the production of non sugar outputs $Y_{-s}(.)$ from the derivative of $\Pi(.)$ wrt p_{-s} . This is omitted here because the result that total output is the integral of farm level output over all farms is not very surprising. Given the objective of this paper it is more interesting to investigate how total sugar production $Y_a(.) + Y_b(.) + Y_c(.)$ reacts to changes in prices and quotas.

2.3 Supply Response to Changing Prices and Quota Quantities

Given the limited length of the paper, it is impossible to present and explain all derivatives of the sugar supply function with respect to prices and quotas. Instead, the following table shall give an indication of the direction of change when changing exogenous variables in our context:[5]

Table 1 : Marginal Effects of Exogenous Variables on Sugar Beet Production:

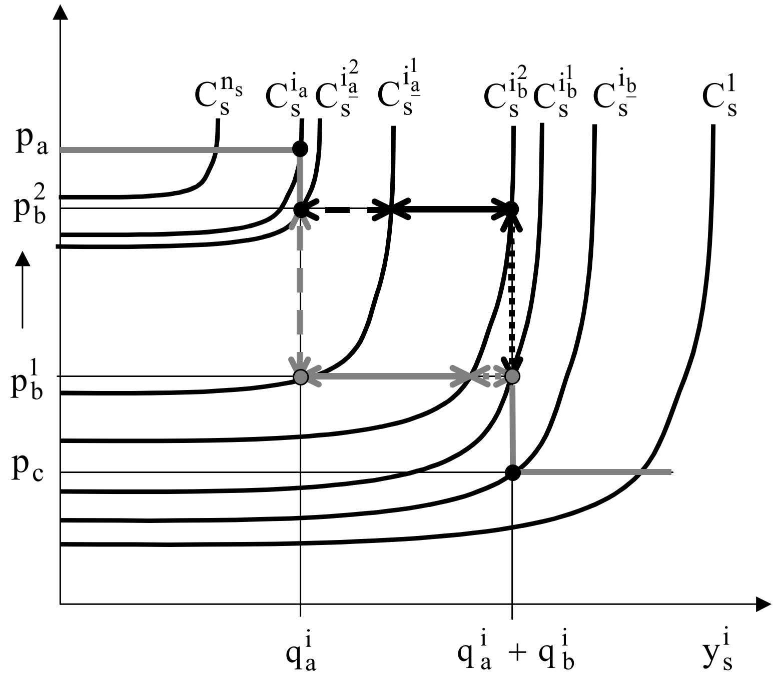
exogenous / endogenous	**w**	$\mathbf{p}_{-s}$	p_a	p_b	p_c	Q_a	Q_b
Y_a	–	–	+	0	0	0<x<1	0
Y_b	–	–	0	+	0	–	0<x<1
Y_c	–	–	0	0	+	–	–
Y_s	–	–	+	+	+	0<x<1	0<x<1

With respect to the formal background of table 1 it shall be reported that the marginal response of average supply with respect to prices follows only from the integration of farm level responses, because all effects of sugar beet prices on the borders of farm types drop out at the margin. One consequence of this is that the aggregate profit function inherits convexity in prices from farm level profit functions, because integrals of convex function are also convex. The production of A-sugar beet is independent from the prices of B- or C-sugar beet and vice versa. Increased production quotas cause increases in the respective quantities but decreased production of lower valued quantities.

Because of the relevance in our context, we want to pay more attention to non-marginal changes of beet prices and quotas. They are best calculated as the differences of two supply quantities. It will be more interesting to investigate the effect of a non-marginal change in the B sugar beet price p_b (Figure 2), because the effect of price p_a will be negligible in practice given that type 1 producers are very rare in most regions.

[5] Formal derivations can be obtained from the authors upon request.

Figure 2: Increase of B sugar beet price with farm heterogeneity



Based on figure 2 and the B-sugar supply function (19), the increase in production of sugar beet may be calculated as follows:

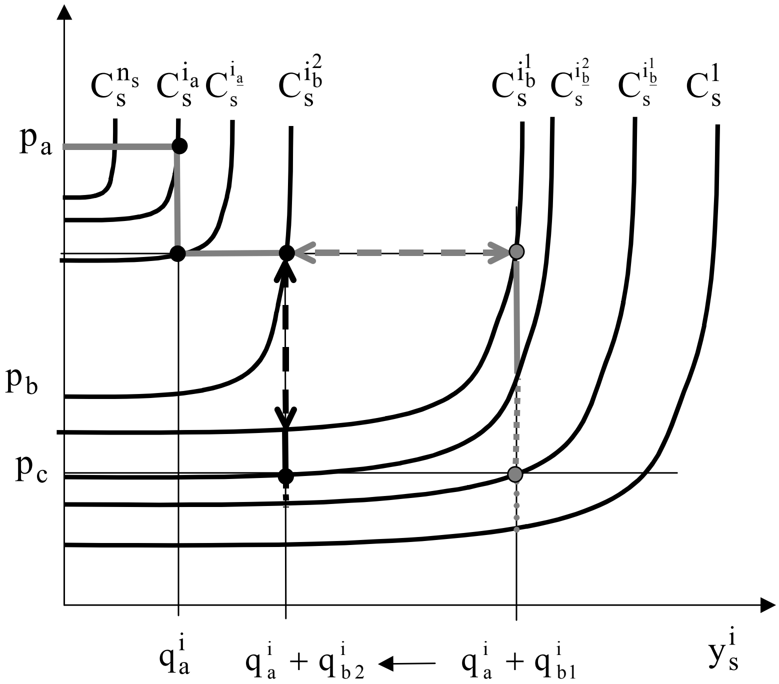
$$
\begin{aligned}
& Y_b^2(\mathbf{w},\mathbf{p}_{-s},p_a,p_b^2,p_c,Q_a,Q_b) - Y_b^1(\mathbf{w},\mathbf{p}_{-s},p_a,p_b^1,p_c,Q_a,Q_b) \\
& = \int_{i_{\underline{a}}^1}^{i_{\underline{a}}^2} \left(\tilde{y}(\mathbf{w},p_{-s},p_b^2,i) - \alpha(i)Q_a\right) f(i)\, di \\
& + \int_{i_b^2}^{i_{\underline{a}}^1} \left(\tilde{y}(\mathbf{w},\mathbf{p}_{-s},p_b^2,i) - \tilde{y}(\mathbf{w},\mathbf{p}_{-s},p_b^1,i)\right) f(i)\, di \\
& + \int_{i_b^1}^{i_b^2} \left(\alpha(i)Q_b - \tilde{y}(\mathbf{w},\mathbf{p}_{-s},p_b^1,i)\right) f(i)\, di
\end{aligned}
\tag{21}
$$

For the case of a price increase, $i_{\underline{b}}^2 > i_{\underline{b}}^1$, because some farms who did not make any use of their B-quota will use it partially and thus move from type 4 to type 3 (dotted lines in figure 2). The first integral gives this new production of B-quota beets. The second integral gives the additional production of B-quota beets on farms belonging to type 3 both before and after the price change (solid lines in figure 2). Finally a price increase will imply $i_b^2 > i_b^1$, because some farms who did not before will fully exploit their B quota now, that is they will move from type 3 to type 2 (dashed lines in figure 2). The "old" set of type 2 producers and the type 1 producers will make full use of their B quota at both prices and hence do not contribute to the impact of the change in p_b. Furthermore, type 5 farmers and a part of type 4 farmers will not change their status for moderate but non-marginal changes. Hence the production of A-sugar beet and C-sugar beet will not respond at all to moderate price changes of B sugar beet, just as is case for marginal changes.

Note, that typical aggregate models would not correctly capture the response to changes in the price of B-sugar beet. If the region were modeled as if it had a marginal cost curve index of $i<i_b^1$, and hence remain in a type 1 or 2 situation, the aggregate response would incorrectly predicted to be zero. A zero response would also result if the region were taken to operate as a pure type 4 or 5 farm with farm index $i>i_{\underline{a}}^2$. If the region were finally modeled as if it had a farm index of $i_b^1<i< i_{\underline{a}}^2$ the aggregate response would be overestimated. An improved approach might be to distinguish farm types 1-5 and model their behavior separately. While being an improvement over a simple representative agent approach it would miss the endogenous regrouping of farms, which tends to limit the aggregate response. This is because the type-switching farmers (see the dashed lines in figure 2) are constrained in their response to a change in p_b.

Because a change in the B-quota is a relevant policy option, we will investigate it for non-marginal changes as well:

Figure 3: Decrease of B-Sugar Beet Quota with Farm Heterogeneity



Based on figure 3 and the B-Sugar Supply function (19), the effect on the production of B sugar beet Y_b may be calculated as follows:

$$Y_b^2(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,Q_a,Q_b^2) - Y_b^1(\mathbf{w},\mathbf{p}_{-s},p_a,p_b,p_c,Q_a,Q_b^1)$$

(22) $$= \int_{i_b^1}^{i_b^2} \Big(\alpha(i)Q_b^2 - \big(\tilde{y}(\mathbf{w},\mathbf{p}_{-s},p_b,i) - \alpha(i)Q_a\big)\Big)\, f(i)\, di$$

$$+ \int_{i_{\underline{b}}^2}^{i_b^1} \alpha(i)\big(Q_b^2 - Q_b^1\big)\, f(i)\, di + \int_{i_{\underline{b}}^1}^{i_{\underline{b}}^2} \alpha(i)\big(Q_b^2 - Q_b^1\big)\, f(i)\, di + \int_{1}^{i_{\underline{b}}^1} \alpha(i)\big(Q_b^2 - Q_b^1\big)\, f(i)\, di$$

With a decrease in the B-quota, both indices for the borders between types 2 and 3 and between types 1 and 2 will increase. For the graphical presentation we assume that some farms are of type 2 both before and after the change, i.e. $i_{\underline{b}}^1 < i_{\underline{b}}^2 < i_b^1 < i_b^2$. Some former type 3 farmers will become constrained type 2 farmers such that their cut in B-sugar beet production is less than their quota cut (first integral in (19)). Farms of type 1 will completely substitute an increase in C sugar beet for former B-sugar beet, whereas some type 2 producers will do so partially. Consequently the decrease in total sugar production will be clearly less than the cut in the B-quota.

In order to lead over to the simulation exercise presented below, we want to collect the relevant findings of our theoretical considerations in this respect:

- The profit maximization model of the sugar beet producing farm in the EU shows that each farm operates at one out of 5 possible cases depending on the marginal cost at the allocated A and B quota levels.
- Ordering farms according to their marginal cost at quota levels and incorporating the farm index as an argument leads to regular profit and derived supply functions for the average or aggregate farm.
- Derived aggregate behavioral functions depend on the separate prices for A-, B, and C-sugar with distinct effects on other endogenous model variables. This allows (and requires) treating the corresponding sugar beet quantities in an aggregate analysis as separate products.
- The theoretical analysis provides quantitative ranges for the supply response to changes in aggregate quota levels (without change in relative allocation across farms).
- The behavioral functions depend on an exogenous allocation of sugar beet quotas to farms. Any change in this allocation implies different quantitative responses to marginal and discrete variations in exogenous variables.

3 The CAPSIM Model

3.1 Objectives and Overview

The common agricultural policy simulation model (CAPSIM) is being developed to serve as a speedy and user-friendly policy information system for the European Commission. It is the successor of the medium-term forecasting and simulation model (MFSS, see Witzke, Verhoog and Zintl 2001).[6] The main objectives of the modeling system are

- detailed coverage of products and CAP policies
- results for the major variables of political interest: agricultural income, market balances and trade, consumer and budgetary impacts
- reliability of results an member state level
- user friendliness through ease and speed of operation as well as transparency

The enumeration of these objectives might already make clear that CAPSIM is not a typical academic tool of analysis. It is designed for quick, repeated policy analysis, requiring sufficient transparency to allow discussion of model assumptions and scenario specification with EU officials. Together with the need for a rather disaggregated product list, those characteristics require some trade-offs that limit the theoretical complexity of the system. The choices made in model design, however, try to compromise little on the reliability of results.

As the development of CAPSIM from the predecessor MFSS is still incomplete, the following explanations refer to the intermediate version used for the simulations in this paper. CAPSIM is currently a comparative static modeling system, driven by a set of synthetic elasticities. The behavioral functions are based on profit and utility maximization. They are completed by a set of accounting identities to form a complete set of market balances for agricultural products as covered by the Economic Accounts for Agriculture (EAA). Market clearing is either obtained by endogenous trade volumes and policy intervention or through endogenous prices depending on policy and market characteristics relevant for the specific commodity. The database mainly integrates different data domains of the Statistical Office of the European Communities (Eurostat) which comprise market balances, production statistics

[6] The description of the modelling system has to be general and informal here for space limitations. For further detailed information see to Witzke, Verhoog, and Zintl (2001), which has been published before the name change to CAPSIM and is the most current available description of the system.

and the EAA. Due to missing data and inconsistencies, the database compilation has been handled by a separate modeling activity (Britz, Wieck, Janson 2002).

3.2 Supply Specification

The supply specification explicitly distinguishes between activity levels and yields of about 30 production activities. However, yields are taken exogenous to simplify the model both from a theoretical and practical point of view. It appears that variations in intensity add little to the aggregate supply response (FAPRI 2000, p. 55).

The underlying profit maximization model endogenously determines activity levels and input demands. Further characteristics include a feed technology separable from crop activity levels and the explicit incorporation of land and calves balances. With the exception of feed demand, input prices and revenues per activity unit drive behavioral functions. The latter are calculated based upon market prices, price supports, and yields as well as hectare or livestock premiums. Feed demand functions are conceptually derived from a cost function and include animal activity levels and feed prices as determining factors.

The underlying optimization model provides an explicit framework for the calibration of activity and input demand elasticities based on a Maximum Entropy procedure observing microeconomic conditions in the base year situation. In the intermediate version of CAPSIM most behavioral functions are expressed in double log form.

3.3 Demand Specification and Market Clearing

The modeling of food demand is modeled based on a utility maximization model subject to a budget constraint. Consumer prices, total private expenditure, and population determine derived demands. Again, standard microeconomic conditions are imposed including full curvature. The specification is derived from a Generalized Leontief cost function (see Witzke, 2002).

For most products, processing and price linkages between producer and consumer prices are not explicitly modeled. A fixed "marketing margin" applies in these cases. For the case of oilseeds, potatoes, olives, and "other cereals", milk, and sugar beet, an explicit processing model at the EU-level is included. With the exception of the last two products, processing quantities are determined based upon a behavioral function derived from a profit maximization hypothesis subject to fixed processing coefficients. Due to the absence of significant raw product trade in milk and sugar beet, it may be assumed for these products that basically the complete usable production is also processed. For sugar beet, this is combined with a constant return to scale assumption for the processing technology leading to a fixed processing cost.

3.4 Policy Representation

Overall the most important support instrument of the current CAP is the system of premiums for crop and livestock activities. These premiums have been constrained by ceilings, again reflecting the overriding importance of budgetary considerations in the EU. An obligatory set aside rate accompanies the system of premiums. To account for the counteracting response of voluntary set aside to a change in the obligatory set aside rate, the latter translates less than proportionally to the effective set aside area in the model. The milk quota regime is implemented in a standard way. This leads to a divergence of market revenues and shadow revenues, the latter of which have been specified in view of results in Barkaoui, Butault, and Guyomard 1997.

Most interesting for this paper is the implementation of sugar policies. According to section 2.3, A-, B-, and C-sugar beet are treated as separate products with strong supply response to changes in the respective quotas. Those may be considered as fixed factors in formal terms. The crucial elasticities will be specified based on an analysis of FADN data, which is not yet finished. To obtain the operational intermediate version we relied on the following assumptions on some of the required elasticities:

Table 2: Preliminary Specification of Sugar Beet Elasticities:

exogenous / endogenous	p_a	p_b	p_c	Q_a	Q_b
Y_a	0.005	0	0	0.99	0
Y_b	0	0.1	0	–0.2	0.9
Y_c	0	0	0.5	–0.2	–0.04

The self-financing character of the sugar market organization has been incorporated in CAPSIM. Consequently the levies on B-sugar have to finance the export subsidies for A+B-sugar which are not covered by the basic levy. This accounts for the increase in the producer price of B-sugar beet after an increase in the world market price of sugar or a decrease in the sugar quota. As long as they are below international prices, EU market prices proportionally follow any change in the EU intervention price. Consequently, it is assumed that EU authorities adjust export subsidies exactly by the amount necessary to bring about this parallel movement which has been observed in the past even though market prices are usually somewhat higher than intervention prices.

4 Scenario Specification and Results

4.1 Scenario specification

The chosen simulation year is 2011. The Reference run implies the full implementation of the Agenda 2000 package (see European Commission 2000 or Witzke, Verhoog, Zintl 2001 for details).

- Administered *prices* for *cereals, beef and raw milk* reduction in accordance with Agenda 2000.
- Per-hectare *premiums* for cereals rise to compensate for the decline in prices, with little change on the durum wheat premium. Premiums for pulses and oilseeds,

however, decline to more or less complete the equalization of payments with those for cereals. Cattle premiums rise to partly compensate for the drop in intervention prices.

- The obligatory *set-aside* rate is set to 10 %.
- Milk *quotas* rise in line with the Berlin summit decisions.
- For sugar we assume one million tons of additional imports into the EU from EBA beneficiaries which effectively reduces the maximum quantity of subsidized exports stemming from EU A- and B- sugar beet.

In view of the Commission's call for proposals we specified the following policy options:

- Option 1: Uniform reduction of all sugar quotas (A+B) by 13%. This turned out sufficient to not only avoid any intervention purchases but also to dispense with subsidized exports in spite of the new EBA imports.
- Option 2: Reduction of the intervention price from 630 Euro/t to 340 Euro/t. Even though the resulting intervention price is basically equal to the assumed world market price (339 Euro), the price decline proved insufficient in this modeling exercise to make subsidized exports or intervention unnecessary.

4.2 Results

The results are illustrative for the theoretical developments of section 3.

Table 3 : Results on Area Use

	Base 1997/99	Reference 2011	Low quota 2011	Low quota - Reference	Low price 2011	Low price - Reference
Soft wheat revenue	*1034*	*1251*	*1250*	*-0.1%*	*1250*	*0.0%*
Soft wheat area	13865	14267	14310	0.3%	14265	0.0%
Sugar beet area	2080	2099	1906	-9.2%	2029	-3.3%
A sugar beet revenue	*3056*	*3054*	*3172*	*3.9%*	*488*	*-84.0%*
A sugar beet area	1457	1473	1295	-12.0%	1456	-1.1%
B sugar beet revenue	*2136*	*3020*	*3195*	*5.8%*	*492*	*-83.7%*
B sugar beet area	311	323	297	-7.9%	269	-16.5%
C sugar beet revenue	*270*	*293*	*293*	*0.0%*	*293*	*0.0%*
C sugar beet area	312	303	314	3.4%	303	0.0%

Given the small share of sugar beet in crop area (about 2.5%) the effects on other crops are almost negligible in the two policy scenarios as is visible on the example of soft wheat which is reproduced in the table. The different responses of sugar beet areas to changes in quotas or revenues are evidently related to our elasticity assumptions.

The next table reveals the implications of these scenarios for wheat and sugar markets.

Table 4 : Results on Market Impacts

		Base 1997/99	Reference 2011	Low quota 2011	Low quota - Reference	Low price 2011	Low price - Reference
soft wheat	*producer price*	*116*	*119*	*119*	*0.0%*	*119*	*0.0%*
	production	90384	111359	111716	0.3%	111348	0.0%
	total domestic use	76139	75691	75684	0.0%	75633	-0.1%
	excess supply	14245	35668	36032	1.0%	35714	0.1%
A sugar beet	*producer price*	*53*	*53*	*57*	*6.7%*	*9*	*-83.6%*
	production	83438	84302	74115	-12.1%	83346	-1.1%
B sugar beet	*producer price*	*37*	*52*	*55*	*7.2%*	*9*	*-83.5%*
	production	18206	18857	17361	-7.9%	15750	-16.5%
C sugar beet	*producer price*	*5*	*5*	*5*	*0.7%*	*5*	*0.8%*
	production	17865	18803	19442	3.4%	18802	0.0%
sugar beet	production	119509	121962	110918	-9.1%	117897	-3.3%
	total domestic use	118459	122282	111239	-9.0%	118218	-3.3%
	excess supply	1051	-320	-320	0.0%	-320	0.0%
sugar	*market price*						
	production	17149	17420	15773	-9.5%	16814	-3.5%
	total domestic use	12990	13934	13934	0.0%	14130	1.4%
	excess supply	4160	3486	1839	-47.3%	2683	-23.0%
	AB sugar exports	1603	1273	1	-99.9%	1	-99.9%
	C sugar exports	2557	2684	2779	3.6%	2684	0.0%
	EBA imports	0	1000	1000	0.0%	1000	0.0%
	intervention	0	529	59	-88.9%	999	88.9%

As is evident from the table, net trade (= excess supply) of sugar beet has been fixed exogenously. In the above experiments the quota reduction proved more effective in curbing net supply. For both policy scenarios it has been assumed that subsidized exports are basically forbidden so that intervention purchases would be used to clear the market. This might not be a realistic assumption (especially as the new US farm bill will most likely decrease the WTO pressure on the CAP), but it provides a convenient indicator of success or failure of the respective option and does not change other model outcomes. In this respect it is evident that a quota cut of around 13% would be sufficient to solve the trade related problems of the EU. This does not hold for the price reduction scenario.

However, in quantitative terms, the supply impact of the price decline does not seem very realistic. While it is perfectly plausible to assume a fairly low response of A-sugar beet to the own revenue at the current high prices, it may be questioned that this elasticity remains low for drastic price reductions such as those considered above. A different functional form with non-constant elasticities would have most likely changed the results in this respect. This issue will be addressed in the upcoming weeks, but could not be tackled at the moment.

After completion of the database revision on subsidies, a complete welfare analysis in terms of producer income, consumer welfare and budgetary (EAGGF) impacts will be added to the market results above. This will provide a more complete picture as the income effects and benefits to consumers are of course quite different.

5 Conclusions

This paper has made a number of contributions. In theoretical terms we have developed the implications of farm heterogeneity for aggregate supply modeling purposes under the EU quota regime. The derived behavioral characteristics have been implemented in the framework of the agricultural sector model CAPSIM, for the time being based on assumed parameters. Contingent upon those, simulation results for the year 2011 have shown that a moderate quota reduction of 12.5% allows avoiding subsidized exports and/or intervention purchases, whereas a drastic reduction of prices to world market level is not sufficient in this respect. Apart from uncertainties with respect to the parameter specification, the preferability of any one of these options cannot be concluded without consideration of welfare effects on all involved groups.

Research during the next months will concentrate on econometric estimation at farm level. This will not only provide firmer empirical ground for the parameter specification under the current quota regime, but also provide the opportunity to investigate changes in the aggregate supply response, if quotas were allowed to be traded between farms or regions – another reform option to be considered.

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