

Impact of the "Everything but Arms" initiative on the EU sugar sub-sector

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Abstract: This paper analyses the impact of "Everything but Arms" (EBA) initiative on the European Union (EU) sugar production, trade and agricultural income using the regionalised agricultural sector modelling system "CAPRI". The CAPRI model distinguishes a supply and a spatial multi-commodity market module that interact iteratively. The supply module contains 200 non-linear regional programming models, each representing production patterns of 30 crop and 15 animal activities at NUTS II level. Trade flows in the market module between 13 world regions and the EU are endogenously determined. The impact analysis shows that the EU welfare and agricultural income is negatively but moderately affected by the EBA initiative due to the small relative importance of sugar beet in agriculture as a whole. EU sugar supply, trade and regional distribution of sugar production are significantly affected while EU sugar demand remains unchanged. As expected EU sugar imports increase from the LDCs while EU sugar exports decrease. The quota and duty free access for LDCs plays a major role for the captured products.

1 Introduction

Protection of the sugar sector against imports has a long tradition in Europe, going back to the blockage of imports into the Napoleonian Europe. Export subsidies were granted to German sugar beet growers already in the 1870s in indirect form and collusion has been recognised among German producers of the 1890s, supported by the first quota regime in 1896 (Teichmann 1955: 331-346). Despite intermediate periods of relative liberalisation, the sugar sub-sector evolved to be arguably the most protected agricultural sub-sector in Germany in the 1960s when decisions on the European Union (EU) sugar Common Market Organisation (CMO) were made. Quota systems of various forms were operated in the other five EU founder members as well, but some of these countries, in particular France, were more competitive than Germany and had vested interests in their exports. The EU sugar CMO of 1967 resulted from a compromise among the different interests of the first six EU Member States (Bujard 1974). The compromise combined exceptionally high internal intervention prices for sugar closed to the former German level with a production quota system protecting

less efficient producers such as those in Italy and Germany at the time, while offering export possibilities to more competitive producers such as those in France. The quota system distinguishes an "A" quota receiving full price support through the intervention price which is, however, discounted by a 2% producer levy, and a "B" quota receiving substantially lower price support due to a maximum of 39.5% producer levy being charged on the intervention price. Any quantities sold beyond the combined A and B quotas and called "C" sugar have to be exported at international prices without refund (see details in Commission of the European Communities 2003a).

The first implication of this quota system is that, apart from C sugar production, market shares of the EU Member States which actually resulted from a delicate political compromise, may considerably deviate from those that would prevent from comparative advantage (Linde *et al.* 2000, Chapter 15). The second implication is that, because of their resulting granted monopsonic position, sugar refineries are likely to exercise market power towards beet growers as well as sugar users at the regional level. Third, the conjecture of C sugar production being cross-subsidised from the quota system and, hence, induced trade distortions are likely to be suspected as recently shown by the current dispute settlement panel launched by Australia, Brazil and Thailand at the World Trade Organisation (WTO). Fourth, one political driving force to reform is missing. Because A and B levies finance most of the sugar export refunds to dispose sugar surpluses on third markets and, hence, make the sugar CMO self-financing, budget constraints are not likely to motivate reform in this sub-sector unlike in the other heavily subsidised sub-sectors.

High EU support prices require an accompanying tariff protection which has been consistently prohibitive apart for imports of raw sugar from the African, Caribbean and Pacific (ACP) countries and India to which a preferential access at zero (or very low) tariffs has been renewed under the Sugar Protocol of the Cotonou Convention and the India Agreement. For many years, these preferential imports have been re-exported with export subsidies financed not through the producer levies but the EU budget. Despite the budgetary costs of these re-exports, reform proposals aimed at aligning the high EU internal prices to the world level are generally opposed with the claim that it would deprive exports from these developing countries of high EU internal prices.

Effective lobbying from the part of beet grower and sugar refinery professional organisations facilitated by the concentration of business interests on a relative small sub-sector was successful to thwart any significant reforms of the sugar CMO since its inception. Sugar price

fluctuations on the world market may have, moreover, lent some credibility to keep EU internal prices disconnected from outside. Without considering additional reasons, we may simply observe that the sugar CMO largely withstood the 1992 Common Agricultural Policy (CAP) reform, the General Agreement on Tariffs and Trade (GATT) Uruguay round agreement on agriculture, the 1998 Agenda 2000 decisions and, finally, the June 2003 Luxembourg agreement on revising Agenda 2000.

However, two recent developments in trade relations have opened the possibility of fundamental reform. The first development lays in the 2001 “Everything But Arms” (EBA) concession of the EU to the 48 least developed countries (LDC) allowing free and unlimited imports from the beneficiary countries, after a transition period ending in 2009 for banana, rice and sugar. If the currently negotiated “Economic Partnership Agreements” (EPA) with ACP countries includes equivalent concessions, additional sugar imports into the EU might also be triggered. These concessions are likely to stimulate a considerable surge in imports requiring equivalent cuts in EU quotas to comply with the Uruguay round agreement commitments on export subsidises. The second driving force is the likely current WTO panel ruling that may enforce a major reform of the sugar CMO. In addition, the current WTO round is likely to impose additional EU commitments on the conventional themes of internal support, market access and export subsidies. Another driving force might have been the decade-long criticism of the sugar CMO for its various inefficiencies from external studies (e.g., Bujard 1974, Linde *et al.* 2000) but also for its alleged impediments to competitiveness against the principle of the single market from the European Court of Auditors (1991, 2001).

In addition to these recent external pressures, internal pressures to reform the sugar CMO are accelerating too. With the 2003 Luxembourg agreement fundamentally switching to a single direct payment to support most of the agricultural sub-sectors in the near future, the sugar sub-sector is one important sub-sector left without reform, still benefiting from high internal prices, import barriers and export subsidies and, hence, increasingly seen as a relic of the old CAP in conflict with the Sustainable Development Strategy expressed by the EU. European non-governmental organisations which generally enjoy a favourable opinion for their stances in favour to poor countries, increasingly voice against the absurdities of the EU sugar subsidies showing in particular how the sugar regime enriches a small group of European farmers and large sugar refiners at the expense of the world's poorest (Oxfam, 2004).

As a result of these mounting pressures funnelling from different origins and supported by several well-documented academic studies, the Commission of the European Communities

(2003b) has proposed in September 2003 three options to reform the sugar regime.¹ The first option called "status-quo" consists in preserving the current sugar CMO but adjusting its system of trade barriers, domestic sugar prices and production quotas according to the various EU international commitments already agreed or agreed in the future. The second option called "price cut" consists in, first, lowering the domestic sugar price and the non-preferential import tariffs and, then, eliminating progressively the production quotas. European beet growers would be compensated from the beet price cut by a direct payment that would be partly or entirely integrated into the Luxembourg agreement's single farm payment while it is not clear how the least competitive sugar producing developing countries benefiting from high European sugar prices due to their preferential access would be treated. The third option called "liberalisation" consists in eliminating the current system of price support and production quotas of the sugar CMO and compensating the European beet growers with a decoupled direct farm payment.

Within the background of the upcoming implementation of the Luxembourg agreement, this paper analyses the impact of the EBA agreement reflecting the EC's "status-quo" option that triggers a certain reduction of production quotas to cope with expectable additional imports. We further mimic the elimination of export subsidies for sugar by reducing production quotas additionally. This analysis relies on simulations performed with the regionalised agricultural sector modelling system "CAPRI" that is adjusted to deal with these different scenarios.²

The following second section reminds the major features of the EU sugar industry to derive in particular internal price linkages between the EU beet and sugar markets. Section 3 focuses on the trade instruments of the EU sugar CMO to derive their modelling. Section 4 reviews in more detail various hypotheses to explain sugar beet farmers' behaviour. Section 5 specifies the simulation scenarios, enlightens key results, compares them with those from other studies and draws implications for the EU sugar sub-sector and trading partners. Section 6 provides conclusions and limitations of the study.

¹ An option called "fixed quota" of maintaining the current system of production quota and implementing tariff rate quotas (TRQ) for developing countries covered by the ACP and EBA concessions was removed from the last European Commission's proposal (see Commission of the European Communities 2003c). However, this option might return on the table again.

² A short description of the CAPRI model is given in the Annex.

2 Key features of the EU sugar industry

The first key feature of the EU sugar sub-sector lays in its strong dependence on administrative prices, export subsidies, import tariffs and production quotas. Because export subsidies are specified according to the sugar intervention price, they tend to set a price floor for EU sugar markets. In turn, applied import tariffs define the upper ceiling for EU sugar prices. The quota system limits the options to sell or export at high EU prices. A minimum sugar beet price is derived from the sugar intervention price allowing for notional processing margins. This minimum beet price provides a price floor for refinery contracts with beet growers. Actual refinery margins are, however, frequently higher than notional margins because EU market prices exceed intervention prices by some 10% and actual processing costs are not as high as assumed in the defined processing margins. This strong dependence on policy decisions implies, first, that rent seeking is highly rewarding for the industry. Together with the oligopolistic structure of sugar markets, see below, it also implies that it might be undesirable for the sugar industry to publicly reveal unbiased data on processing costs or sugar prices. Even though highly relevant for modelling, this information is difficult to come by. The lack of statistical information on wholesale sugar prices is symptomatic for our knowledge of this sector. Instead, we have to rely on survey information from industrial sugar users, reproduced in Linde *et al.* (2000), which may be considered the best available for modelling purposes, even though the sugar users might be affected by interests opposite to those of the sugar industry.

The second key feature is the quota system that severely limits competition of sugar refineries for beet growers and sugar buyers (Blume *et al.* 2002). With respect to growers, sugar refineries may be considered as regional monopsonists (Schmidt 2003). National markets are usually served by one to three refineries, which frequently have their main operating regions. The above mentioned price differential between the intervention and market prices is usually attributed to collusion among refineries, which agree not to interfere outside their designated markets. Using illustrative simulations based on UK data, McCorrison (2002: 366) finds that price transmission of a 30% farm level price cut in the sugar sector would be reduced to about 80% and welfare benefits to consumers to 60-70% of the perfect competition case.

Third, a number of studies of the EU sugar industry have included an analysis of the primal technology and cost function, notably those relying on programming models (Walkenhorst 2001, Mahler 1994, Render 1989) but also others (Schmidt 2003). The upshot of these studies is that fixed capital is an important cost element, amounting to about 65% of processing cost and leading to strongly decreasing average costs up to a capacity of about 10,000 tons beyond

which the average cost curve tends to become fairly flat. If variable cost only amounts to some 35% of total processing cost, it is frequently profitable to sugar factories to use its capacity completely, at least in the short run when capital cost may be considered sunk cost. However, when deciding on reinvestment of old equipment, say every 15 years, more complete cost coverage is required for continued operation of the plant. These technological features explain why the sugar industry, made up of hundreds of sugar refineries, is likely to adjust slowly to a drop in sugar prices and why seemingly unprofitable processing, for instance of C sugar, may be continued for a long time. On the other hand, the number of sugar refineries in EU-15 has declined from 209 to 143 in a decade from 1992 to 2002 (Bartens, Mosolff 2003: 30) with moderate pressure on the sugar industry to increase efficiency, indicating that the sunk cost impediment to adjustment should not be overrated.

Fourth, the sugar industry has to cope with uncertainty on sugar yields and international sugar prices. The carry forward possibilities for C sugar allowed by the sugar CMO may help smooth out yield fluctuations which would, otherwise, threaten the entire use of the quota for both the beet growers and the sugar refineries. Because yield fluctuations are, however, more relevant at the farm level whose beet production is bound to a specific single location than at the refinery level, beet growers may have precautionary motives to produce some C sugar beets if storage costs are born by the refinery.

These features also explain the considerable heterogeneity found in the inter-professional relationships between the sugar industry and beet grower organisations across the Member States. Inter-professional relationships are specified partly in the "inter-trade agreements", partly in individual contracts although they may also be of a purely informal nature. When beet growers hold shares of the sugar company (e.g., Südzucker), relationships are quite different too. First of all, payment schemes for beets differ across Member States. Apparently, refineries in only six Member States (Germany, Austria, France, Denmark, Sweden and Finland) apply the classical A, B, C discriminatory system whereas refineries in the other Member States offer to beet growers pooled prices at least for all quota beets, including in them even a part of C beet in the Netherlands. A pooled price system increases the incentive to fill entirely the farm level quota and, consequently, sugar production in these countries (Combette *et al.* 1997: 5). Refineries in Germany and Austria have introduced a third allotment so called "C₁" that represents 5 to 10% of the A quota and receives prices between those of the B allotment and those of the so called "C₂" allotment, which receives very low prices (Schmidt 2003: 14). This additional kink in the farm level demand function for beets triggers some C

beet production from beet growers who would not produce for C₂ prices. Finally, sugar refineries apparently distribute a volume of beet delivery rights to farmers that is greater than the one corresponding to their own sugar quota (Schmidt 2002: 32), a strategy which again tends to increase sugar production. The exceeding volumes of these delivery rights are unknown.

Although the derivation of the minimum A and B beet prices from the sugar intervention price are specified by the sugar CMO, the prevalence of various premiums for quality, payments for pulp, allowances for transport cost, etc. leads to consider the total beet price, inclusive of all supplements, to be a choice variable for refineries. For modelling purpose, a monopsony or oligopsony approach (Lotze 1998, Chapter 6) is recommended. However, the tight political constraints imposed on refinery choices over prices and quantities in the sugar CMO would add considerable complexity to this approach. Other studies have relied on explicit assumptions on the behaviour of beet prices, which is then included in the scenario definitions (Walkenhorst 2001: 67, Schmidt 2002: 58-59, Frandsen *et al.* 2003: 6).

In this paper, the linkage between each sugar beet price and market sugar price is based on a reduced form equation linking the farm-gate price of a type of sugar to the relevant derived revenue from sugar and molasses, taking into account the applicable levy. The parameters are calibrated to reproduce estimated differences between the farm-gate A, B and C beet prices and market sugar price observed in the base period while being consistent with an average beet price derived from the Eurostat Economic Agricultural Accounts (EAA).

Two other aspects of the sugar industry behaviour are now addressed. Depending on the inter-trade agreement between beet growers and sugar refineries, delivery rights to growers may be cut down after successive under-deliveries not due to "force majeure". In Ireland, for example, the shortfall clause is stricter (Irish Farmers Journal 2003) whereas, in Germany, no such clause usually exists (Schmidt 2003: 18). Even without an equivalent clause in the inter-trade agreement, a beet grower may fear the risk of permanently losing, for example, 10% of his delivery quota once the inter-trade agreement is renewed the following year. Such fear may evidently contribute to explain the widespread production of C sugar in almost all Member States. The modelling of such risk as well as some other risks is addressed in Section 4.

A second issue is the transferability of delivery rights among beet growers. Usually, such transfers are possible within the same delivery basin but require the approval of the refinery. Sometimes, the transfers need to be accompanied with land or company shares. Limits

imposed on quota trade induce well-documented efficiency loss (Bureau *et al.* 1997) and have implications for appropriate modelling that is addressed in Section 4.

3 Characteristics and modelling of sugar trade

Trade in sugar is arguably one of the most distorted of all commodities with many countries applying policy instruments designed to directly impact on trade. As a result of these widespread interventions, the international sugar market is often said to have a “residual” character with high volatility that serves in turn as an argument for continued policy intervention. However, volatility and policy interventions apparently eased since the beginning of the 80s, mainly as a result of the recession in the share of highly distorted trade flows (Borrell, Pearce 1999: 10-11). Uruguay round commitments contributed little so far to discipline interventionist policies.

An important exception for the EU is the limit on the value of export subsidies that is increasingly constraining EU policy (Meijl, Tongeren 2002: 461). EU protection against imports stays prohibitive at almost any international sugar price due to a very high trigger price being notified to the WTO for application of the safeguard clause. However, in 2000/02, about 1.7 million tons of preferential imports, mostly from ACP countries, entered the EU at zero or very low tariffs. In addition, the above mentioned EBA initiative will grant preferential access to a second country group up to their entire domestic production potential. Because bilateral tariff rate quotas (TRQs) constitute an important policy instrument for the EU, they need to be explicitly represented if far reaching policy options, such as dismantling of the EU sugar CMO, are to be considered. While such explicit treatment was achieved with the general equilibrium GTAP framework in Frandsen *et al.* (2003), this study uses a version of the CAPRI model with a spatial multi-commodity market module to cover bilateral trade flows and associated TRQs. The discontinuity implied by a TRQ regime is approximated with a smooth non-linear function characterised by a strong curvature (Liapis, Britz 2001). In addition, sugar is considered imperfectly substitutable between domestic and foreign origins through an Armington approach as in Frandsen *et al.* (2003).

The standard CAPRI market module is, however, not adequately suited to simulate the impact of the EBA initiative because the country group of the 48 Least Developed Countries (LDCs) that benefit from the EU trade concessions is not explicitly modelled as one regional aggregate in contrast to Henrichsmeyer *et al.* (2003a). Most LDCs are spread across the regional ACP country aggregate, the regional free trade developing country (CAD) aggregate and the rest of

the world (ROW) aggregate. Because the aggregation of the 48 LDCs in one regional aggregate in the market module was not feasible within the scope of this paper, we proceed as following.

In a first step, we feign that EBA is granted to the three regional ACP, CAD and ROW aggregates that include, in particular, the 48 LDCs. Because of the resulting EU sugar import over-estimation, EU sugar imports from each regional aggregate are, then, corrected by subtracting from them the increase in imports whose origin is allegedly attributed to non LDCs belonging to the regional aggregate, as illustrated in the following equation for the ACP aggregate:

$$\text{IMP}_{\text{EU-ACP}} = \text{IMP}_{\text{EU-ACP}}^1 - s_{\text{nonLDCinACP}}^0 \left(\text{IMP}_{\text{EU-ACP}}^1 - \text{IMP}_{\text{EU-ACP}}^0 \right)$$

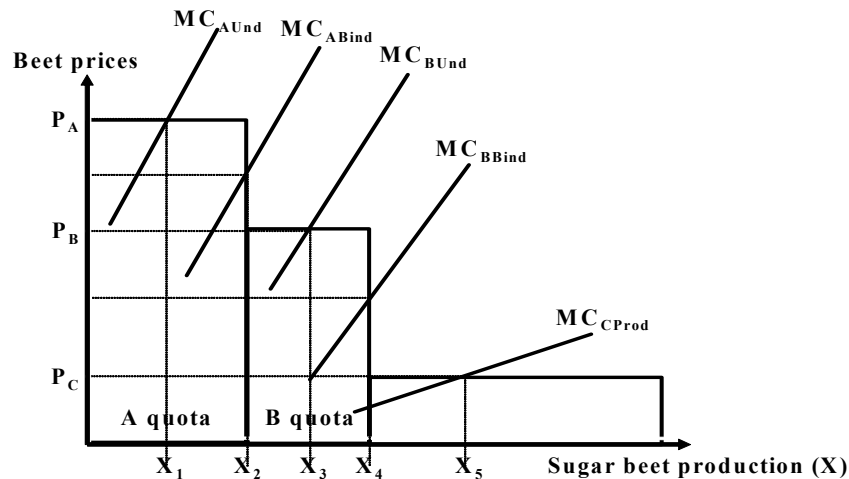
$\text{IMP}_{\text{EU-ACP}}$ is the corrected import volume of sugar from ACP countries to the EU taking into account that some of them benefited from the EBA initiative. The index 1 stands for the result of the 1st step and the index 0 for the base period of 1998-2001. The share $s_{\text{nonLDCinACP}}^0$ is the share of exports of non-LDCs included in the ACP aggregate in exports of all countries included in the ACP aggregate, all destinations included, for the base period. A similar treatment is performed for exports of non-LDCs included in the CAD and ROW aggregates. This approximation of sugar exports of regional aggregates that include LDCs has several implicit hypotheses. First, supply elasticities of LDCs within an aggregate are assumed to be the same as the supply elasticities of non-LDCs within the same aggregate. Second, export shares of non-LDCs in exports of all countries belonging to the same aggregate are assumed to be the same in the base period whatever the destination. Third, exports of non-LDCs to the EU are prevented to vary in the simulation scenarios, implying no room for diversion effect in detriment to non-LDCs.

In a second step, we impose for those three aggregates a TRQ, amounting the so calculated imports with preferential tariffs equal to zero and prohibitive out quota tariffs. Then, the market module is solved again to make sure that the market equilibrium correctly reflects the implementation of the EBA initiative solely granted to the LDCs and not to all the countries of the aggregates.

4 Representing sugar beet grower supply behaviour

The standard microeconomic assumption on farmer behaviour is profit maximisation. Frandsen *et al.* (2003) show the implication of profit maximisation under the current sugar CMO that Figure 1 illustrates.

Figure 1 Five different farm types in view of the EU sugar CMO



Source: Own calculations

Principally, one can imagine five different producer types defined according to their marginal cost (MC) curve. The first type of A quota under-fillers (*Aund*) has marginal costs equal to the A beet price. The second type of A quota binders (*Abind*) has marginal costs that lie in between the A and B beet prices. The third type of B quota under-fillers (*Bund*) produces at marginal costs equal to the B beet price and the fourth type of A and B binders (*Bbind*) at marginal costs in between B and C beet prices. Finally, the fifth type of C producers (*Cprod*) is assumed to produce at marginal costs equal to the C beet price.

Frandsen *et al.* (2003) allocate each EU Member State to one of these five producer groups. This procedure, however, neglects the possibility that more than one producer type exists at the country level although it is likely that at least the last three producer types have members in each country.

Estimations of the share of producer types show that a major part of all EU sugar beet farms belongs to the C producer type (*Cprod*). Relying on profit maximisation alone would have two troublesome implications:

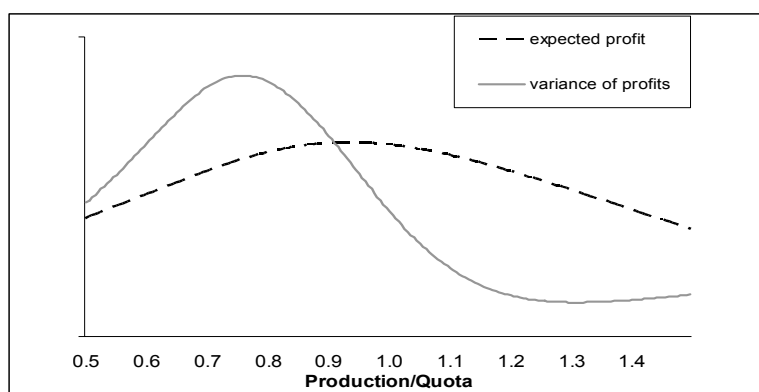
1. Marginal costs including opportunity cost of land of many supposedly efficient beet farms would have to be very low compared to expectations by farm management specialists.
2. The vast majority of C beet producing farms would hardly respond to changes in the prices for quota beets, or to changes in quota endowments since the only relevant variable at the margin would be the C beet price.

This further implies to consider behavioural hypotheses that go beyond the simple profit maximisation hypothesis.

1. To reconcile the low C beet price with observed C beet supply, it is frequently alleged that fixed costs are born by quota beets alone while C beet supply only covers variable cost (Schmidt 2003). While this is a plausible explanation for the short run, beet growers should be inclined to reduce their farm capacity in the long run if the C beet price permanently falls short of full cost coverage.
2. The simple profit maximisation problem should also be modified to account for the discontinuity in land allocation to reflect the incentive to grow single plots entirely with a single crop. In the case of sugar beet, this incentive is likely to be important because suppliers of harvesting services charge a lower price per ha the larger the plot size is to the point that they refuse to harvest plots of very small size.
3. An alternative explanation to this puzzle incorporates yield uncertainty in the expected marginal revenue function of sugar beet. Whereas the deterministic marginal revenue function has two single sharp kinks, the calculation of an expected marginal revenue amounts to smooth out these kinks since neighbouring values of a given production are incorporated according to their probability weight in the estimation of the expected marginal revenue of that particular production. This boils down to explain growing C beet as an insurance strategy against revenues foregone in case of poor harvests. By the same token, it reduces the implausible unresponsiveness of C beet growers to quota beet prices and endowments mentioned above. Nonetheless, some questions remain. Beet farms with high production levels would still be very insensitive to quota beet prices unless they calculate with extremely high yield variation. For the beet farms whose C beet production exceeds by 20% their quota, yield uncertainty is not an entirely convincing explanation for C beet production. Furthermore, beet farms have still some possibilities to shift their quota use across years using the carry forward mechanism.

4. Given yield uncertainty and the consequent expected profit uncertainty from sugar beet production, it is natural to consider now “true” risk aversion, placing an additional value on the stability of profits in addition to their expected value. If stability is measured in terms of a low variance, these two objectives may be depicted as in Figure 2 (compare Schmidt 2003) based on a normal distribution of yields.³

Figure 2: Expected profit and variance as a function of sugar beet production relative to quota endowment



Source: Own calculations

The variance is first increasing because yields are multiplied with an increasing area at high (quota) revenues. At a certain point, C beet production occurs and reduces the variance because higher production is associated with lower prices. This variance reducing effect is dominated by the variance increasing effect of an increasing beet area at a certain point. Given some degree of risk aversion, optimal behaviour is located between the maximum of the expected profit function and the minimum of the variance. Consequently, true risk aversion may explain C beet production beyond the maximum of expected profit. However, to explain high C beet production in a number of Member States (e.g., in France, Germany, United Kingdom and Austria), the variance of profits at the observed production is very close to its minimum, implying an implausibly high degree of risk aversion.⁴

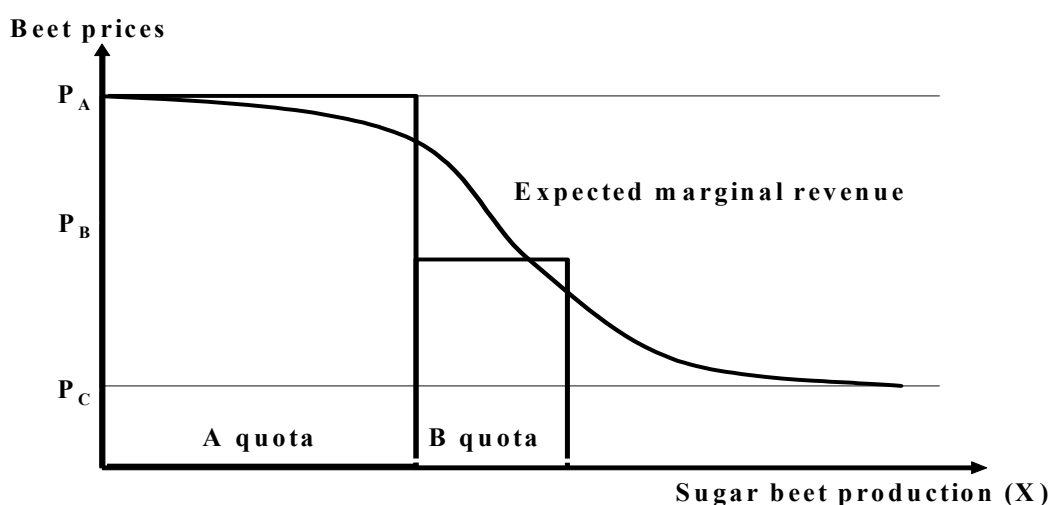
³ As we do not want to draw quantitative conclusions, we leave the ordinate axis without units. Quantitative results, not the shapes of the functions, strongly depend on the quota endowments, beet prices, expected sugar yields and their coefficients of variation. Expected profits additionally depend on the farm specific cost function for sugar beets. In Figure 2, constant marginal costs are assumed. Note that uncertainty in C beet prices is not included therein.

⁴ This explanation holds even more with the inclusion of price uncertainty for C beets, an inclusion which would move the minimum of the variance to the left.

5. As already mentioned in Section 2, it is known from some Member States (e.g., from Germany) that sugar refineries often distribute somewhat higher beet delivery rights to beet growers than corresponding to their own quotas. In this case, the aggregate C beet production as perceived from the growers' perspective is smaller than the quantity inferred from national statistics. Unfortunately, the relevance of this practice in the EU countries is difficult to assess.
6. An additional motive to produce C beet lays in the expectation that future farm level quota cuts may be smaller if C beet production is high, an expectation which might be encouraged by the sugar industry as mentioned in Section 2. Conversely, beet growers may even hope to receive additional quota rights from the sugar industry if some delivery rights are redistributed among beet farms. Both of these considerations imply that a ton of C beet may include a speculative value for beet farms on the top of the market price for C beet.

Looking at those different explanations of a C beet supply greater than expected under simple profit maximisation, it becomes apparent that the effects of each motive are difficult to anticipate quantitatively. Beneath the distinction of producer types, yield uncertainty is explicitly included in the CAPRI supply module by replacing the profit function for sugar beet by an expected profit function based on normally distributed yields with estimated standard deviations. The first order condition for sugar beet supply is a marginal cost that is no longer equal to a respective price but equal to expected marginal revenue. Figure 3 provides an illustration.

Figure 3 Expected marginal revenue function of beet production under yield uncertainty

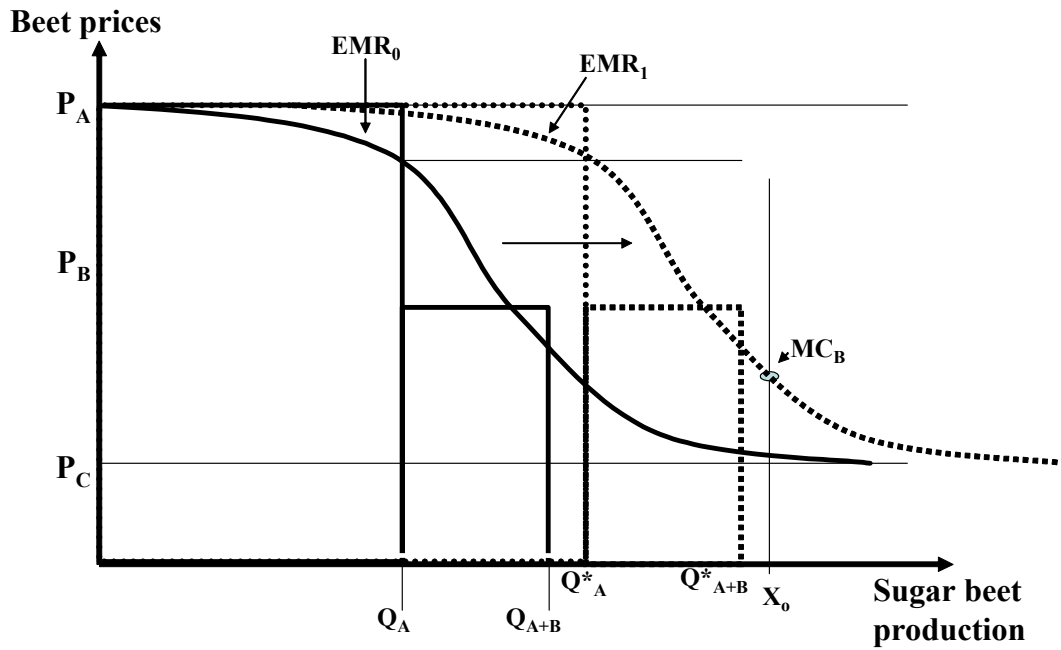


Source: Own calculations

The expected marginal revenue equals the A beet price if production is only a fraction of the A quota and reaches the C beet price if production is considerable above the A and B quotas. In between these two extreme values, there is a smooth transition in expected marginal revenue. The shape of the transition curve depends on quota endowments, yield and its variation, and beet prices. The use of expected profits in the CAPRI supply module makes quota restrictions superfluous because they are implicitly included.

As mentioned above, many beet growers are found with an expected marginal revenue and, in turn, a marginal cost almost equal to the C beet price at the observed supply volume. A comparison of marginal costs implied by this procedure with some estimates of opportunity costs from Bureau *et al.* (1997) also confirms that expected profit maximisation solely as well as simple profit maximisation imply marginal costs of a very low level at least for the *Cprod* producer type. To reflect that marginal costs are probably higher due to the above mentioned motive to produce additional amounts of sugar beets, a *virtual quota mark up* is defined such that the expected marginal revenue function equals the opportunity cost of sugar beet production estimated by Bureau *et al.* (1997) at the observed supply level. As shown in Figure 4, the expected marginal revenue (EMR) function is simply moved to the right (EMR₀ to EMR₁). The virtual quota mark up is defined relative to the actual quota and is tackled as a constant value. The quota rent of this mark up can be interpreted similarly as an insurance that beet growers pay for the motive explained above. The marginal cost MC_B corresponds to the opportunity cost estimated by Bureau *et al.* (1997) for beet supply which is assumed to be the correct one at the observed supply X₀. While the actual quota endowment is at Q_{A+B}, we envisage that the beet grower behaves as if his quota endowment is at Q*_{A+B}. This procedure guarantees that the EMR function is relatively steep at the observed supply level, which in turn leads to a stronger response to quota and price changes. This procedure is repeated for every NUTS 2 region where sugar beets are grown for each producer type existing there. Unfortunately, Bureau *et al.* (1997) do not provide estimates for all sugar producing NUTS 2 regions in the EU and neither do they distinguish different producer types. How gaps are filled in and how marginal costs are determined for the different technologies are explained in the Annex.

Figure 4 Determination of virtual quota mark ups



Source: Own calculations

To allow for possible transfers of delivery rights among regions of the same Member State when these rights are not filled at the regional level, and avoid an awkward simulation outcome where some Member States end up supplying C sugar without fulfilling their A and B quotas, the sugar module includes an accounting balance at the national level that counts sugar supply first as sugar quotas A and B and then as C sugar.

5 Empirical analysis of Reform Options

Besides the reference scenario, two reform scenarios are assessed in this study: (1) the "*Everything But Arms*" (EBA) initiative, and (2) the EBA initiative with progressive reduction of production quota to phase out export subsidies. These scenarios are implemented for the year 2009 at constant 2001 prices.

Following a brief presentation of their main features, the impact of these scenarios on supply, demand, trade and prices within the EU are shown and discussed. The results from scenario 2 are compared to those from scenario 1, which are compared in turn to those from the reference scenario.

5.1 *Layout and implementation of the scenarios*

Reference scenario

This section briefly presents the most important features of the reference scenario, referred as "2003 CAP reform". This reference scenario reflects the new CAP reform of 26 June 2003. The stated objectives of this reform include distribution of agricultural income, promotion of good agricultural practices in marginal agricultural areas, simplification of the CAP operation, facilitation of the process of eastward enlargement of the EU and defence of the CAP in the WTO negotiation (CEC, 2002b).

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 by beginning in 2005 of a 'single payment per farm' for the different direct payments or premium currently received. 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 not depend anymore 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. Table 1 shows the likely options of the 2003 CAP reform envisaged by each Member State, which are taken into account in the reference and subsequent EBA simulation scenarios. A detailed description of the calculation of the decoupled premium can be found in Britz *et al.* (2002).

Table 1 Shares of the direct payments remaining coupled in the reference and EBA simulation scenarios by Member State

	COP	Durum wheat	Suckler cow	Bovine slaughter	Special male	Sheep & goat
Belgium, Luxemburg Austria	Maximum decoupling		100 %	40 %	Maximum decoupling	
Denmark, Finland	Maximum decoupling				75 %	50 %
Spain Greece	Maximum decoupling	40 %	100 %	40 %	Maximum decoupling	50 %
France	25 %	Maximum decoupling	100 %	40 %		50 %
Sweden	Maximum decoupling				75%	50 %
Portugal	Maximum decoupling	40 %	100 %	40 %	Maximum decoupling	50 %
Italy		40 %		100 %		50 %
Germany Netherlands, Ireland United Kingdom	Maximum decoupling					

Source: CAPRI modelling system

In terms of trade policy, the reference scenario takes into account some preferential arrangements, particularly the ACP-EC Partnership Agreements of the Cotonou convention, the Agreement with India and Balkan countries and the full membership of the former accession countries. For the sugar regime, the reference scenario includes the Regulation no. 1260/2001 of 19 June 2001 on the sugar CMO (OJL 178, 30.6.2001: p.1)

The EBA simulation scenarios

Scenario 1: implementation of quota and duty free access to the 48 Least Developed Countries (LDCs) as defined by the "Everything But Arms" (EBA) initiative. The principal aim of this first EBA simulation scenario, which reflects the EC's "status quo" option in the September 2003 European Commission proposal, is to isolate the impact of this EBA initiative on EU supply, demand, trade and prices. To cope with additional sugar imports triggered by EBA, EU A and B sugar quotas are also reduced. The distribution of this reduction in quotas among Member States follows the declassification key defined in the sugar CMO (EC regulation N° 2038/1993). This declassification key implies that Member States with a high share of B quota

in total quota (e.g., Germany and France) see their quota reduced more proportionally than Member States with a low share of B quota (e.g., Spain and United Kingdom).

Scenario 2: implementation of the EBA initiative combined with a reduction of A and B sugar quotas to phase out export subsidies. In addition to the implementation of the EBA initiative, this second EBA simulation scenario requires to cut A and B sugar quota until only C sugar is exported and all export subsidies are avoided. The quota reduction is again distributed among Member States following the declassification key explained above.

Table 2 Definition of the reference and EBA simulation scenarios

	Reference (2009) "2003 CAP reform"	Scenario 1 "EBA"	Scenario 2 "EBA without export subsidies"
CAP reform	Member State MTR likely implementation - Further decrease in administrative prices Modulation implementation		
Production quotas	14592 T	20% cut to reference	42% cut to reference
Tariffs and TRQ for LDCs	Current WTO commitments	Duty and quota free access for LDCs	
Export Subsidies	Current WTO commitments		Elimination

Scenario 1: EBA initiative (2009)

Scenario 2: EBA and quota cut to phase out export subsidies (2009)

5.2 Results

Table 3 shows how agricultural area for some selected crops is reallocated in the reference and EBA simulation scenarios. It is apparent that the area of sugar beets, cereals and oilseeds decreases in the reference scenario compared to the base year, while the area of potatoes, fodder crops, set aside and fallow land increases. The reduction in the area of the first three crop activities is mainly driven by increasing yields. The increase in the area of potatoes, fodder crops and fallow land can be partly explained by the implementation of the new scheme of the single farm payment that decouples crop premiums. Because these activities can now be included in the eligible area for the single farm payment, they become more valuable. This positive effect surely accounts also for the sugar beet area that is also eligible for the single farm payment. However, this positive effect on sugar beet area is counter-balanced by (i) the quota constraint associated with a positive yield trend between 2001 and 2009 due to technical progress and (ii) the drop in real sugar prices as shown in Table 4 (whereas nominal sugar prices are basically constant – only slightly decreasing). Furthermore, the EBA simulation scenarios barely affect the area allocation among the selected crops, except sugar beets whose acreage drops by 13 and 24% respectively in favour of a slight increase in the area of the other crops.

Table 3 Impact of the reference and EBA simulation scenarios on EU crop area

Scenario	Base year (2001)	Reference (2009) "2003 - CAP reform"		"EBA"		"EBA" without export subsidies	
	1000 ha	1000 ha	% change to base	1000 ha	% change to ref	1000 ha	% change to "EBA"
Sugar beet	1870	1773	-5.2	1545	-12.9	1167	-24.5
Cereals	37473	34045	-9.1	34114	0.2	34225	0.3
Oilseeds	5319	4971	-6.5	4988	0.3	5018	0.6
Potatoes	1279	1296	1.3	1298	0.2	1302	0.3
Fodder crops	59914	63011	5.2	63092	0.1	63228	0.2
Set aside and fallow land	10001	11109	11.1	11158	0.4	11240	0.7

Source: CAPRI modelling system

Table 4 summarises the impacts of the reference and EBA simulation scenarios on the most important figures concerning sugar and sugar beets. The EU sugar price decreases under the reference scenario in real terms compared to the base year. In contrast, the EU sugar price does not change much as a result of the EBA simulation scenarios because EU net sugar supply (supply plus imports minus exports) and, consequently, EU sugar demand do not vary. The world market price for sugar slightly decreases under the reference scenario, as well, while it increases under the EBA simulation scenarios as a result of a lower world market supply under the first EBA scenario and lower EU sugar exports under the second EBA simulation scenario.

Producer sugar beet prices at the Member State level are linked to the EU and world sugar prices as explained in Section 2. The direction of the relative change in the EU producer A, B and C sugar beet prices from the base to the reference scenarios corresponds to the change in the EU and world sugar prices, as the producer levies are not changing significantly. Despite the drop in EU producer sugar beet prices, sugar beet supply increases. This can be explained by (1) the eligibility of the sugar beet area to the single payment that tends to dampen the fall in sugar beet area in response to the drop in the producer sugar beet prices and (2) the yield trend between 2001 and 2009. The EU sugar beet supply response in the two EBA simulation scenarios is affected by two elements: the changes in sugar beet prices and the changes in sugar beet delivery rights. Although sugar beet supply varies according to quota changes, the aggregate sugar beet supply deviates from these quota changes because the sugar module allows for different producer types from different regions to vary their quota fill rates. The producer price for A sugar beets now equals the one for B sugar beets because no B sugar is exported anymore and, hence, no B levy is needed anymore since the EU supply of sugar under quotas A and B is lower than the EU demand for sugar. C sugar beet supply increases under the first EBA simulation scenario compared to the reference because of the increase in the C beet price opening the possibility of some sugar beet production previously supplied under the sugar quota constraint being supplied as C sugar beets. Under the second EBA simulation scenario compared to the first EBA simulation scenario, C sugar beet supply, however, decreases despite the increase in producer sugar beet prices as a result of the further reduction in quotas as discussed in Section 4.

Changes in the EU sugar supply directly follow changes in the EU sugar beet supply and, hence, show the same variations. Generally, the reduction in sugar supply is lower than the reduction in sugar quotas.

The impacts of quota cuts on sugar beet supply vary among Member States because of the differences in production costs and price transmissions and the declassification key. At a first look, it is surprising to observe that Member States that are known to be more competitive in sugar beet production like France, Germany and Austria, show the largest relative drop in sugar beet supply of all Member States. The main reason lays in the declassification key enforced in the distribution of the quota reduction among Member States. This key imposes above average reductions on Member States with high B quotas.

The sugar quota cuts result from the EBA agreement for the first EBA simulation scenario and the elimination of exports subsidies in the second EBA simulation scenario. Both quota cuts impose a reduction in the EU sugar supply. As expected, the simulation of the EBA initiative only leads to an increase in EU sugar imports of 2.5 Mio tons compared to the reference scenario, which originate from LDCs. Coupling the EBA initiative with an elimination of EU export subsidies further increase those EU sugar imports because of a slight increase in the EU sugar price. In the reference and first EBA simulation scenarios, the increases in sugar exports are linked to the increases in C sugar supply because the only outlet for C sugar is the world market. In the second EBA simulation scenario, the elimination of EU export subsidies further decreases sugar exports and all EU sugar exports correspond to C sugar here. The further reduction in sugar quota in the second EBA simulation scenario has almost no impact on EU sugar demand compared to the first EBA simulation scenario since the EU sugar price hardly varies.

Table 4 Impacts of the reference and EBA simulation scenarios on the EU sugar sector

			Base year (2001)	Reference (2009) "2003 - CAP reform"		"EBA"		"EBA without export subsidies"	
		Unit ^a	value	value	% change to base	value	% change to ref	value	% change to "EBA"
Sugar beet	A sugar beet								
	producer price	€/t	51.45	48.86	-5.0	51.02	4.4	51.12	0.2
	production	1000t	78010	78308	0.4	63404	-19.0	46492	-26.7
	B sugar beet								
	producer price	€/t	42.45	39.16	-7.8	51.02	30.3	51.12	0.2
	production	1000t	15473	16012	3.5	12928	-19.3	8978	-30.6
Sugar beet total	C sugar beet								
	producer price	€/t	15.94	14.33	-10.1	15.31	6.8	15.6	1.9
	production	1000t	13470	15365	14.1	18903	23.0	15823	-16.3
	average price	€/t	46.05	39.24	-14.8	37.69	-4.0	37.15	-1.4
	production	1000t	106953	109685	2.6	95235	-13.2	71293	-25.1
Sugar	EU price	€/t	696	667	-4.2	671	0.6	672	0.2
	World market price	€/t	204	194	-5.2	204	5.5	208	1.9
	Quota	1000t	14592	14592	0.0	11688	-19.9	8450	-27.7
	Domestic supply	1000t	15917	16312	2.5	14145	-13.3	10561	-25.3
	Belgium	1000t	895	910	1.7	770	-15.4	601	-21.9
	Denmark	1000t	517	525	1.7	443	-15.7	305	-31.2
	Germany	1000t	4219	4226	0.2	3492	-17.4	2293	-34.3
	Greece	1000t	327	328	0.3	312	-5.0	270	-13.6
	Spain	1000t	1028	1045	1.7	991	-5.2	908	-8.3
	France	1000t	4141	4330	4.6	3733	-13.8	2625	-29.7
	Ireland	1000t	211	213	1.0	194	-9.0	166	-14.1
	Italy	1000t	1376	1480	7.6	1316	-11.1	1037	-21.2
	Netherlands	1000t	830	840	1.3	695	-17.4	494	-28.9
	Austria	1000t	437	444	1.6	388	-12.7	289	-25.6
	Portugal	1000t	78	77	-1.2	74	-4.7	65	-11.5
	Sweden	1000t	418	424	1.5	396	-6.6	342	-13.7
	Finland	1000t	146	151	3.4	143	-5.3	124	-13.4
	United Kingdom	1000t	1295	1317	1.7	1199	-8.9	1044	-13.0
	Imports	1000t	1734	1755	1.2	4239	141.6	4457	5.1
	ACP ^b	1000t	989	999	1.0	999	0.0	999	0.0
	LDCs	1000t	646	652	1.0	3137	381.0	3354	6.9
	India	1000t	16	20	26.7	20	-1.7	20	0.3
Other regions ^b	1000t	83	83	0.9	83	0.0	83	0.0	
Total supply	1000t	17651	18067	2.4	18384	1.8	15017	-18.3	
Domestic demand	1000t	12947	12954	0.0	12952	0.0	12922	-0.2	
Exports	1000t	4704	5113	8.7	5348	4.6	2111	-60.5	
Total demand	1000t	17651	18067	2.4	18301	1.3	15033	-17.9	

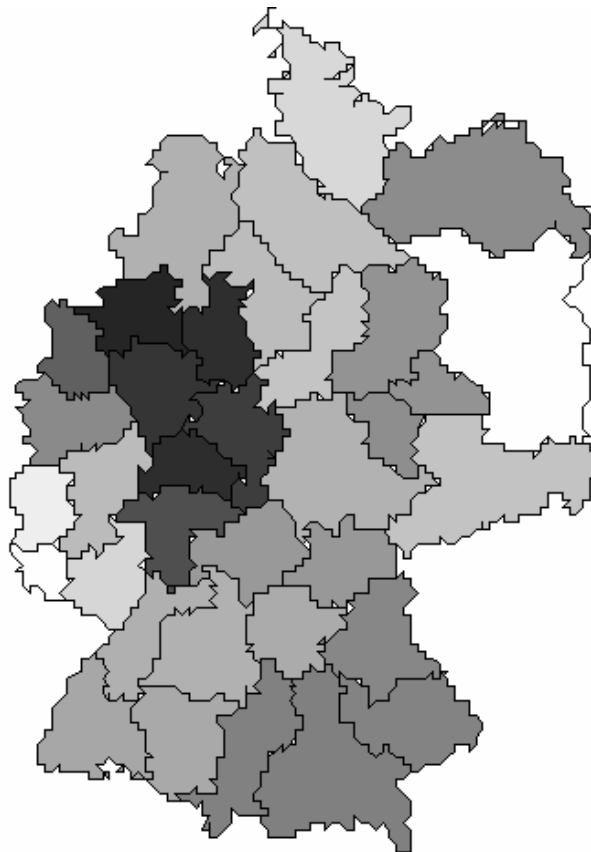
(a) Monetary values for 2009 are deflated to be expressed in constant 2001 prices.

(b) Not including LDC countries belonging to that aggregate.

Source: CAPRI modelling system

Regional differences in supply changes among Member States reflect differences in competitiveness which can be apparent from their marginal costs and differences in C sugar share in total sugar supply as well. These regional differences are illustrated in Figure 5 for Germany from the results of the first EBA simulation scenario compared to the reference scenario.

Figure 5 Relative changes in regional sugar beet supply from the ‘EBA’ initiative for Germany (%)



Source: Capri modelling system

The darker the region is shaded, the greater is the relative reduction in sugar beet supply. The scale ranges from -16% (bright) to -20% (dark). The relative quota cut is the same for all regions within a Member State and amounts to 37% for Germany. According to these results, regions in Southern and Eastern Germany show the lowest reduction in sugar beet supply while the Middle Western part of Germany is more affected. These differences largely depend on the assumed marginal costs for beet supply in those regions that are derived from Bureau *et al.* (1997). The results are hence in line with those from Bureau *et al.* (1997) and Mahler (1994) as well. Regional differences are observed across all Member States in all scenarios and can mostly be explained by differences in marginal costs given in Table A1 of the Annex.

Impact of the reference and simulation scenarios on EU welfare and the FEOGA budget

Compared to the base year, the "2003 CAP reform" of the reference scenario leads, as shown in Table 5, to (i) a decrease of 17% in real budget outlays under the so-called first pillar of the CAP, (ii) an increase of 4% in consumer surplus due to the decrease in import and consumer prices of major products such as meat, cereals, sugar and milk products, (iii) a decrease of 7% in real agricultural income owing to the long-term price trends and administrative price adjustments, and (vi) an increase of 4% in EU welfare, as consumer gain is greater than producer loss. The fall in the real budget outlays stems from a drop in real administrative prices and export subsidies. In nominal terms, the budget outlays stay, however, almost constant.

Table 5 Impact of reference and EBA simulation scenarios on EU welfare (Mio Euro) ^a

	Base year	Reference (2009)		"EBA"		"EBA without export subsidies"	
	(2001)	"2003 - CAP reform"					
	Mio €	Mio €	% change to base	Mio €	% change to ref	Mio €	% change to "EBA"
EU Budgeted	37793	31301	-17.2	31822	1.7	31492	-1.0
Consumer Surplus	4519175	4703412	4.1	4703489	0.0	4703008	0.0
Agricultural Income	147522	137354	-6.9	136799	-0.4	136087	-0.5
from sugar beets	3365	3232	-3.9	2630	-18.6	1911	-27.3
EU Welfare	4685971	4868164	3.9	4867163	0.0	4866305	0.0

(a) Monetary values for 2009 are deflated to be expressed in constant 2001 prices..

Source: CAPRI modelling system

As shown in Table 5, both EBA simulation scenarios lead to a very low welfare loss for the EU compared to the reference scenario. Agricultural income is negatively but moderately affected due to the modest contribution of sugar beets to agricultural income as a whole. The additional quota cut of 28% of the second EBA simulation scenario appears to be clearly unfavourable for sugar beet growers since it induces a additional income loss of 27%. Consumer surplus remains almost unchanged because the demand and the consumer prices of the major products are practically not affected by the changes in the sugar CMO resulting from the EBA simulation scenarios. The very small increase in the EU sugar price and the small decreases in

EU prices for the other products turn to cancel out almost completely. Budget outlays slightly increase under the first EBA simulation scenario because subsidised sugar exports are now completely financed by the FEOGA, not by the levy mechanism anymore, and they decrease in the second EBA simulation scenario because export subsidies are no longer used. In sum, both EBA simulation scenarios lead to minor changes for EU agriculture as a whole. But, agricultural incomes from sugar beets, including quota rents, considerably drop, particularly under the second EBA simulation scenario.

Comparison with results from other studies

The results from this study are now compared to results from other similar studies. Because most of these available studies do not take into account the EBA initiative, we compare the percentage changes in key variables induced by the quota cut of the second EBA simulation scenario with respect to the first EBA simulation scenario, to the percentage changes induced by quota cuts reported in these other studies. Because the policy context of this study is different from the policy context of these other studies, the comparison is fragile.

Table 6: Impact of quota cut on the EU sugar market in selected studies

	Δ Quota cut (%)	Δ supply (%)	Δ demand (%)	Δ net trade [mio T]	Δ World price (%)
Sheales <i>et al.</i> 1999	- 8.2	-2.8	0.0	-0.5	3.67
Poonyth <i>et al.</i> 2000	- 9.6	-3.2	0.0	-0.55	9.10
Frandsen <i>et al.</i> 2003^a	- 13.1	-1.2	0.0	-0.21	0.47
Adenäuer <i>et al.</i> 2004	-28.0	-25.0	-0.20	-2.35	1.90

(a) Net trade effects estimated from percentage changes in trade values applied to 1997 FAO trade quantity data. World price change is the average price change in Australia, Thailand and Brazil.

Key results on the market impact of the second EBA simulation scenario are assembled in Table 6 together with the results from other recent and comparable studies. Results from these studies show that at most one third of a given quota cut is transmitted into a decline in sugar supply, implying that C sugar supply rises correspondingly. Nonetheless, results from this study show a stronger response in sugar supply from a quota cut than the other studies. This stronger supply response in this study reflects the representation of additional motives in the sugar beet grower's behaviour to supply sugar beets explained in Section 4 and modelled by a *virtual quota mark* up. From all studies, demand for sugar is consistently very unresponsive to

quota cut since consumer prices do hardly not change. The increase in world market price associated with policy curbing net exports from the EU is at the lower end of the range spanned by the other available studies. Because of the differences between these reported studies in terms of modelling, assumptions and data, in particular with respect to the determination of the sugar marginal cost in each Member State, the comparison of the results of this study with the other available studies should be considered tentative.

6 Conclusions

This study contributes in several aspects to the understanding of the EU sugar regime and the impacts of reforming it. First of all, the study shows that farm heterogeneity cannot be neglected given the limited tradability of quotas. This heterogeneity helps explain the size of the aggregate C sugar supply and the responsiveness of this aggregate sugar beet supply to quota and price variations. Second, several hypotheses about production indivisibility and uncertainty are brought together implying that C sugar supply is economically stimulated by support given to the quota sugar. As this also applies to joint production in general, we may leave apart the question whether this is a case of cross subsidisation or not.

Both farm level heterogeneity and behaviour are used to focus the analysis on two scenarios: 1) implementation of the EBA initiative and 2) implementation of the EBA initiative with a progressive reduction in production quotas to phase out sugar export subsidies. The impact analysis shows that both policy reform scenarios affect the EU welfare and overall agricultural income only slightly but the EU agricultural income from sugar beets more significantly. EU sugar supply, trade and regional supply distribution are mainly affected while EU sugar demand remains unchanged. EU sugar imports increase, particularly from LDCs, while EU sugar exports decrease. The quota and duty free access for LDCs plays a major role in trade of the products that are considered in the model.

The treatment of the sugar and food industry in the sugar module involves several simplifications pointing to possible areas for future research. First of all, it was impossible to collect sufficient information on all relevant aspects of the sugar industry conduct (e.g., in terms of delivery right management, sugar beet price negotiation, cost control and sale strategy). The price linkage between beet and sugar prices at the wholesale and consumer level is, therefore, not derived from an explicit optimisation framework. This also implies that the regional supply programming models do not optimise the regional distribution of the

processing capacity to the extent that regional impacts of a quota cut might lead to a complete retreat of sugar beet supply in some regions in favour of others.

Addressing these simplifications is likely to become more relevant in the long run which points to another limitation of the analysis. Impacts are estimated for 2009 but the adjustment process is likely to be dynamic. In the long run, investment decisions in EU agriculture and sugar industry, in preferentially treated LDCs and other regions are likely to lead to additional adjustment possibilities. The initial EU quota cut policy would not be sustainable without additional quota cuts over time because the eventual sugar yield growth in EBA beneficiary countries is most likely to increase further EU preferential imports in the longer run.

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8 Annex

8.1 The CAPRI simulation model: an overview

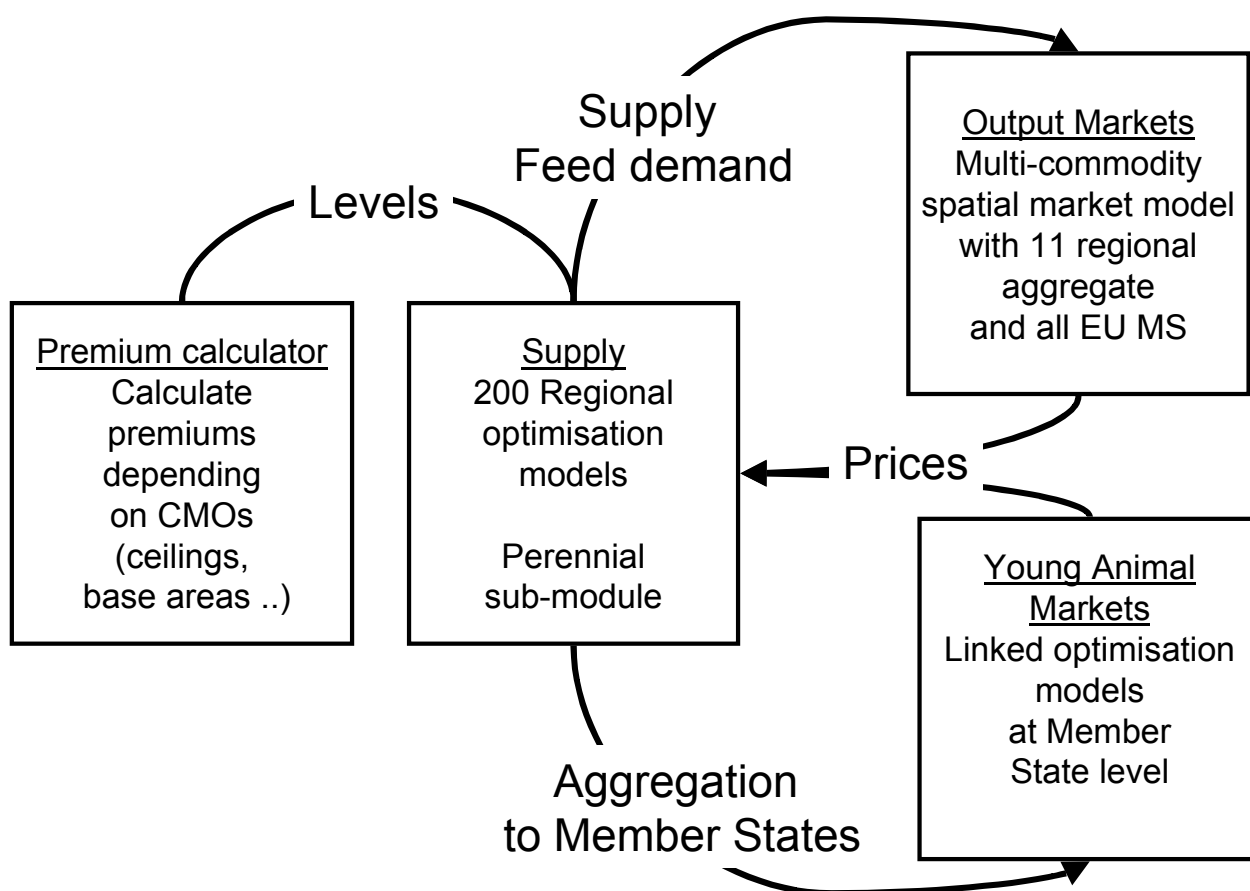
The regionalised agricultural sector modelling system "CAPRI" is designed as a projection and simulation tool for the European agricultural sector based on:

1. A **physical consistency framework**, covering balances for agricultural area, young animals and feed requirements for animals as well as nutrient requirement for crops, realised as constraints in the regional supply models.
2. **Economic accounting principles** according to the definition of the Economic Accounts for Agriculture (EAA). The model covers all outputs and inputs included in the national EAAs for the 15 Member States, and the revenues and costs are broken down consistently to NUTS 2 regions and production activities.
3. A **detailed policy description**, capturing all relevant payment schemes with their respective ceilings on the supply side and covering tariffs, intervention purchases and subsidised exports on the market side. The policy of non-EU world regions is based on OECD PSE/CSE data bank.
4. **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.

The model distinguishes a supply and market modules, which are iteratively coupled. The interplay of the modules is shown in Figure A.1. The supply module consists of aggregate programming models at NUTS 2 level, working with exogenous prices defined at Member State level during each iteration. 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 build with an identical structure as the NUTS II models are then calibrated to the aggregated results of the NUTS II models. Next, young animal prices are determined by linking together these Member State models. Afterwards, 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, drive the next iteration with the supply module. Equally, in between iterations, premiums for the activities are adjusted if ceilings are overshoot according to the results laid down in the Common Market Organisations (CMOs). More detailed information on the CAPRI system are available on the following web page:

http://www.agp.uni-bonn.de/agpo/rsrch/capri/capri_e.htm.

Figure A. 1. Linkages between the supply and the market modules of CAPRI



Source: CAPRI modelling system

8.2 Determination of sugar beet marginal costs per EU NUTS 2 region and producer type

A complete matrix of sugar beet marginal costs by NUTS 2 region and producer type is derived from marginal costs provided by Bureau *et al.* (1997) and Frandsen *et al.* (2003) using additional assumptions captured with a standard maximum entropy estimation. Bureau *et al.* (1997) provide opportunity costs for beet growing calculated for the most important producing regions of the EU-15, except for Austria, Finland, Ireland, Portugal and Sweden, but considering a single technology per region. Frandsen *et al.* (2003) provide marginal costs estimated for every entire Member State considering also a single technology per state. First, we need to determine a likely marginal cost for the missing regions and Member States. For the missing regions of Member States considered in Bureau *et al.* (1997), a national average value of marginal costs is used. For missing Austria, the average value of marginal costs of Germany is used. For missing Finland, Ireland, Portugal and Sweden, the marginal costs

estimated in Frandsen *et al.* (2003) for these four States are weighted by the average value from all the Bureau *et al.*'s estimates over the average value from all the Frandsen *et al.*'s estimates.

Then, a standard maximum entropy approach is used to derive the marginal cost of each producer type for every region or Member State of EU-15. For each producer type, two support points are defined according to Table A.1, following the intuitive assumptions that:

1. the marginal cost of producers supplying less than their allocated quota A (*Aund*) ranges between A beet price and the average of A and B beet prices,
2. the marginal cost of producers just supplying the allocated quota A (*Abind*) ranges between A and B beet prices,
3. the marginal cost of producers supplying less than their allocated quota A and B (*Bund*) ranges between the average of A and B beet prices and the average of B and C beet prices,
4. the marginal cost of producers just supplying the allocated quota A and B (*Bbind*) ranges between B and C beet prices,
5. the marginal cost of producers supplying more than their allocated quota A and B (*Cprod*) ranges between the average of A and B prices and C beet price.

Table A.1. Maximum entropy support points for marginal costs

	Support Point 1	Support Point 2
Aund	Pa	0.5(Pa +Pb)
Abind	Pa	Pb
Bund	0.5(Pa+Pb)	0.5(Pb+Pc)
Bbind	Pb	Pc
Cprod	0.5(Pb+Pc)	Pc

Restrictions to the maximum entropy problem include that the average of the marginal costs over producer types for one specific region or Member State equals the marginal cost determined for that region or Member State, and the following order of magnitude of marginal costs (MC) is respected for every region or Member State:

$$MC(Aund) > MC(Abind) > MC(Bund) > MC(Bbind) > MC(Cprod)$$

Final marginal costs per producer type for all NUTS 2 regions determined by this maximum entropy problem in combination with the application of an additional quota mark up as described in Section 4 are reported in Table A.2. Marginal costs are reported for regions when they differ from the national ones, and only for observed producer types.

Table A.2. Regional marginal costs of sugar beet production

	Qprod	Ebind	Bund	Abind	Aund		Qprod	Ebind	Bund	Abind	Aund
DANMARK	23.8	30.8	48.8			FRANCE	26.7	30.2	38.7		
DEUTSCHLAND	21.2	23.6	42.1			ILE DE FRANCE	25.9	30.3			
BRANDENBURG	20.0	22.2	37.4			NORD-PAS-DE-CALAIS	26.7	30.4			
MECKLENBURG-VORPOMMERN	21.0	24.3	54.4			CHAMPAGNE-ARDENNE	21.8	33.1	43.0		
SACHSEN	20.6	22.9	56.1			PICARDIE	29.9	33.2			
SCHLESWIG-HOLSTEIN	20.8	23.5	33.4			HAUTE-NORMANDIE	26.6	30.9			
THUERINGEN	20.9	24.5	41.9			CENTRE	25.8	30.2	33.6		
STUTT GART	21.0	24.2	50.6			BASSE-NORMANDIE	29.3	32.6			
KARLSRUHE	21.0	24.2	50.6			BOURGOGNE	25.9	31.4			
FREIBURG	21.0	24.2	50.6			LORRAINE	26.8				
TUEBINGEN	21.0	24.2	50.6			ALSACE	26.8	32.7			
OBERBAYERN	18.8	26.3	46.0			FRANCHE-COMTE		26.8			
NIEDERBAYERN	18.8	26.3	46.0			PAYS DE LA LOIRE	26.7	30.2	39.0		
OBERPFALZ	18.8	26.3	46.0			RHONE-ALPES	26.7	30.2	39.0		
OBERFRANKEN	18.8	26.3	46.0			AUVERGNE	23.2	31.1			
MITTELFRANKEN	18.8	26.3	46.0			IRELAND	32.4	42.0	55.0		
UNTERFRANKEN	18.8	26.3	46.0			ITALIA	27.3	39.4	43.8		
SCHWABEN	18.8	26.3	46.0			LOMBARDIA	27.8	39.4	43.8		
DARMSTADT	20.8	23.1	41.5			EMILIA-ROMAGNA	26.8	39.4	43.8		
GIESSEN	20.8	23.1	41.5			LAZIO		39.4			
KASSEL	20.8	23.1	41.5			CAMPANIA	27.3	39.4	43.8		
BRALNSCHWEIG	26.9	33.5	45.5			SARDEGNA	26.7	39.4	43.4		
HANNOVER	26.9	33.5	45.5			PIEMONTE	26.8	39.4			
LUENEBURG	26.9	33.5	45.5			VENETO	27.5	39.4	43.7		
WESER-EMIS	26.9	33.5	45.5			FRILUI-VENEZIA GIULIA	37.1	39.4	43.8		
DUESSELDORF	22.9	25.5	49.5			TOSCANA	26.9	39.4	43.8		
KOELN	22.9	25.5	49.5			UMBRIA	26.8	39.4	43.8		
MUENSTER	22.9	25.5	49.5			MARCHE	26.9	39.4	43.7		
DETMOLD	22.9	25.5	49.5			ABRUZZO	27.8	39.4	39.4		
ARNSBERG	22.9	25.5	49.5			MOLISE		39.4	39.5		
KOBLENZ	18.9	21.0	43.7			PUGLIA	39.4	39.4	43.8		
TRIER	18.9	21.0	43.7			BASILICATA	27.3	39.4	43.8		
RHEINHESSEN-PFALZ	18.9	21.0	43.7			CALABRIA	38.5	39.4			
DESSAU	20.4	22.8	36.8			NEDERLAND	28.0	36.2	49.6		
HALLE	20.4	22.8	36.8			OESTERREICH	23.7	28.4	41.9		
MAGDEBURG	20.4	22.8	36.8			PORTUGAL				56.7	61.9
ELLADA				32.0		SVERIGE	26.7	38.4		48.0	0.0
ESPAÑA	33.6	37.8	54.6			SUOMI/FINLAND		41.5		51.9	55.2
MADRID	33.5	37.9	55.3			UNITED KINGDOM	30.3	43.9			
PAIS VASCO		37.9	45.3			North West (including Merseyside)	29.6	50.8			
NAVARRA	33.5	37.9	55.3			Yorkshire and The Humber	29.6	50.8			
RIOJA	33.7	37.4	55.3			East Midlands	30.4	44.2			
ARAGON	33.5	37.9	55.3			West Midlands	31.3	57.9			
CASTILLA-LEON	32.6	36.3	50.7			Eastern	30.4	44.2			
CASTILLA-LA MANCHA	33.3	42.3	55.5			South East	30.4	44.2			
EXTREMADURA		38.5				South West	31.3	57.9			
ANDALUCIA		39.0	55.5			Wales	30.3	43.9			
MURCIA	33.5	37.9	55.3			BELGIQUE-BELGIE	28.0	32.7	53.2		

Source: Own estimations using Bureau *et al.* (1997) and Frandsen *et al.* (2003)