Bridging Micro- and Macro-Analyses of the EU Sugar Program: Methods and Insights

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Invited paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

Introduction

Several authors have recently investigated the effects of changes in sugar policies. Studies have focused on multilateral trade liberalization, either on the effect of an extension of preferential regimes (e.g. the EBA), or on the effect of domestic reforms. Perplexingly, the different studies provide results that are largely inconsistent, even for rather similar scenarios. Some authors find that market liberalization will result in large welfare gains and significant changes in international trade. Others believe that the overall gains will actually be limited, due to inelastic demand (i.e. small initial Harberger triangles on the consumer side), persistence of supply control (production quotas) and because large rents need to be reduced before reforms actually become binding and affect output.

The degree of incoherence in the quantitative results that have been published is troublesome. The inconsistencies exceed what is normally observed between different modeling approaches (general *vs* partial equilibrium) in the agricultural sector. Here, the effects of trade liberalization are sometimes contradictory and the magnitude of the differences in, say, world price variations or change in welfare is striking. While there are several explanations for the diverging results regarding the effects of reforms on the world market, the changes in EU sugar net trade appear to be of particular importance. There is a large degree of uncertainty as to the level of EU sugar supply under different policy conditions. Because producers have been largely isolated from world market signals for decades, there is little statistical variability to exploit, and the "guesstimates" of supply elasticities and production costs rely on thin evidence. We also believe that not enough attention has been paid to some specific characteristics of EU production, and in particular to the determinants of the supply of "C" sugar, i.e. sugar produced outside production quotas (C sugar is bound to disappear within the next years, due to the EU reform and the 2005 ruling of the WTO dispute settlement body).

A first objective of this paper is to model EU sugar supply, accounting for specific aspects such as a potential cross-subsidy between production quota sugar and C sugar, and the existence of rents in both the farm and processing sectors. Another objective is to provide estimates of the effects of *i/* the recent EU sugar reform (still to be implemented); *ii/* the elimination of EU export subsidies by 2013, a decision adopted (with some side conditions) in the framework of the WTO.

We first provide a brief survey of the various studies assessing the impact of liberalization of the sugar sector. The specification of the EU supply response seems to be a major determinant of the world market equilibrium. We then investigate some specific aspects of EU sugar production, in particular those that might result in a cross-subsidy between in-quota and C sugar. We propose a way to model the sugar market that includes these specific aspects of EU producer and processor behavior. We then estimate econometrically the parameters that allow us to account for this cross subsidization and to calibrate production costs. Finally, we integrate this representation of the sugar sector in a general equilibrium (GE) model of the EU economy in order to assess the effect of the November 2005 sugar reform and the effect of future international discipline under the WTO.

1. The effects of liberalizing sugar markets

Some ambiguous results. Recent studies have provided some information about the effects of sugar market liberalization. Clearly, the scenarios vary according to authors, but the variation in the findings can hardly be explained by differences in the policy changes that are modeled. Some authors find that even a partial liberalization in the sugar market will generate a very large increase in world prices. El Obeid and Beghin 's results illustrate such findings (El Obeid and Beghin, 2005). Using a partial equilibrium model to simulate the removal of trade distortions, they find a large increase in the world price, especially when domestic support is reduced, in spite of a large drop in demand that follows the removal of consumption subsidies in some countries. One explanation is the considerable decrease in the production of sugar in the EU, i.e. a fall of 61% under multilateral liberalization. As a result, the EU becomes a net importer of some 8 million tons of sugar.

Other models that rely on a relatively similar structure (partial equilibrium model, non spatial, etc.) lead to different results. For a similar increase in the world price, Wohlgenant (1999) finds that EU production increases by 2% and that the EU remains a net exporter of 2.5 million tons. Poonyth et al (2000) also find that EU production is barely affected by the reduction in intervention price required to export without subsidies, and that, overall, EU exports would remain relatively stable. The OECD (2005) finds that EU production would decrease by some 60% under their trade liberalization scenario. Adenäuer et al (2004) find that exports would decrease significantly if export subsidies were phased out. Witzke and Kuhn (2003) find a significant decrease in the production of C sugar for a 30% decrease in sugar price.

The various general equilibrium approaches also lead to different, although perhaps less contrasted, results. Under a reform that liberalizes the sugar market, Frandsen et al (2003) show mainly an erosion of rents. They find that production is only marginally affected by a strong reduction of the intervention price in France, Germany, Austria and the United Kingdom. Bouët et al (2005) find that the reduction in EU supply is significant if tariffs are cut by 60% and export subsidies removed, but the resulting increase in world market price is minimal. Van der Mensbrugghe et al (2003) find that the EU becomes a very large importer of sugar under a multilateral liberalization of the world market.

Why do the results differ so much? There are many explanations for these discrepancies across studies. Some refer to the model specification.[1] Different assumptions about some key factors such as

[1] The sensitivity to the assumption of a homogenous *vs* differentiated good à la Armington is shown by Van der Mensbrugghe et al (2003). Models that include an endogenous supply of land in Brazil (such as Van der Mensbrugghe et al, 2003 or Bouët et al, 2005) tend to show smaller increase in the world price. Partial equilibrium models often provide larger price effects than the GE ones.

the supply response in LDCs and Brazil also have a significant impact on the world price. The way some upstream, downstream and side-sectors (energy) are treated also plays a role, because the effect of sugar reforms also depends on the behavior of the processing sector and on the linkage with the ethanol market. However, a major explanation of the differences across models lies in the different response of EU supply to a particular policy shock. The EU is the second largest exporter of sugar, principally due to its support policy, and the fourth largest importer, mainly because of its development aid policy. Changes in the EU net trade position have a significant impact on the world market equilibrium.

Inferring the effect of the 2005 sugar reform (yet to be implemented), and, *a fortiori*, the effect of multilateral trade liberalization on EU supply is cumbersome. The present EU sugar policy is complex and it is understandable that modelers have taken different routes to cope with the difficulty of representing adequately all the components of the Common Market Organization (CMO) for sugar: two types of production quotas ("A" and "B") facing different supported prices, high specific tariffs, preferential access under import quotas, a safeguard clause, the possibility of producing out-of-quota sugar for the world market, levies for funding exports of in-quota sugar, etc (see Van der Linde et al, 2000, for a complete description of the sector, or Frandsen et al, 2003, for a briefer one). It is difficult to assess EU production costs and rents. Producers expect significant changes in prices and quota allocation and some hope for some compensation. That is, information on costs is often subject to strategic behavior and can hardly be trusted. Production quotas have been in place for more than 30 years and the administrative price has shown little variability. This makes it difficult to infer the effect of changes that would induce large variations away from the present equilibrium. Because of the two-tier production quotas, it is unclear how the quantity produced would respond to price changes. The problem is made worse by the interaction between the agricultural and processing sector. Indeed, there is evidence that part of the support to the beet sector is retained by the processing sector, which will be also affected by reforms. Because of high fixed costs and the need to find suppliers of beet within limited distances, strategies of processing firms are likely to interact with those of the farm sector and affect the overall EU supply response, in a way largely unknown to modelers.

In brief, the uncertainty about EU supply response under different policies is a particular problem, and assumptions in this area appear crucial in explaining the outcome of any given model. Two issues appear particularly important: the level of costs and rents under production quotas; and the modeling of the supply of C sugar. By driving the EU supply response, assumptions regarding these two issues play a large role in the results obtained by the different authors working on market liberalization and policy reform in the sugar sector.

EU production costs. A major problem in modeling EU sugar supply is to assess which prices and costs actually drive production. The EU CMO sets an intervention price for sugar, from which a base price for beets is derived, but market prices may be different from regulated prices (Swedish

Competition Authority, 2002). Moreover, the actual price received by producers depends on local agreements and there are no reliable statistics on the price of beets within the A and the B quotas. Van der Linde et al (2000), Eurocare (2003), LMC (2004) compiled some information on costs of production. Estimates relying on budget generators and engineering data suggest that costs of production are close to the intervention price for sugar and the administrative ("base") price for beets (i.e. roughly 47 €/ton of beet until the implementation of the 2005 reform). However, econometric or linear programming- based estimates of marginal costs or "opportunity costs" (i.e. the cost of producing one unit of beet instead of alternative crops) are much lower (Bureau et al., 1997). Recent estimates for France suggest that they were below 18 €/ton of beet before the June 2003 CAP reform (see Rozakis and Sourie, 2005).

The EU production of C sugar has been significant over the last decade, representing 4 to 13% of the 18 to 20 million tons of sugar now produced in the EU-25, depending on the year. It is therefore tempting to believe that, at least in the most efficient regions, producers respond to the world price. However, an indirect implication of this assumption is that the resulting EU supply curve is such that a fall in the intervention price would mainly erode rents, but not affect production. Even though this seems consistent with the existence of production of C sugar for the world market, the assumption that aggregate EU production responds to the marginal costs of the most efficient producers might lead to an underestimation of the impact of reforms on EU output.

2. The microeconomics of EU sugar supply behavior

Cross-subsidization of out-of quota C sugar by A and B sugar is sometimes seen as driving C sugar production. Three possible effects can be identified.

- Some authors, and obviously the members of the WTO panel, consider that the high supported price for the production under A and B quotas covers fixed costs. This would allow production of C sugar at low prices, given the need to recover only variable cost (Van der Linde et al, 2000; Schmidt, 2003). If this is the case, it is not only marginal (variable) costs that drive EU sugar production. A change in the in-quota price will affect the possibility of recovering fixed costs (Chau and de Gorter, 2005).
- During the recent period, world prices of sugar have been very low. There is some empirical evidence that this price hardly covers the cost of even variable inputs, such as intermediate consumption (Rozakis and Sourie, 2005). This suggests that some producers, if not all, lose money on some of the C sugar quantities they produce. A possible explanation is that some producers grow C sugar beets as an insurance strategy against in-quota sugar revenues foregone when there are poor harvests. Again, if it is the case, one cannot model EU supply as a function of marginal cost only. It is necessary to work out more carefully the interaction

between the supply of C sugar and the level of the rent drawn from the production of in-quota sugar.

- Finally, another possibility is that C sugar was produced so as to build references when producers expected that the ongoing reforms would result in a particular allocation of future production rights, premium rights or compensation. Again, if it is the case, this feature must be included in the modeling of EU sugar supply.

These points may result in interactions between in-quota sugar and C sugar, and could play a role in the response of EU sugar production to price changes. This may occur both at the beet production level and at the refined sugar production level. In the next section, we address these three possible cases in a more analytical way.

Cross subsidization through fixed costs. The potential cross-subsidization between in-quota and C sugar can be modeled using a simple short run comparative static framework. The short run profit maximizing problem of the beet producer in the presence of quasi-fixed factors can be written as (1).

$$\underset{y_1, y_2}{Max}\, \pi = p_1 y_1 + p_2 y_2 - C^{SR}(y_1 + y_2; w; z) - p_z.z \qquad (1),$$

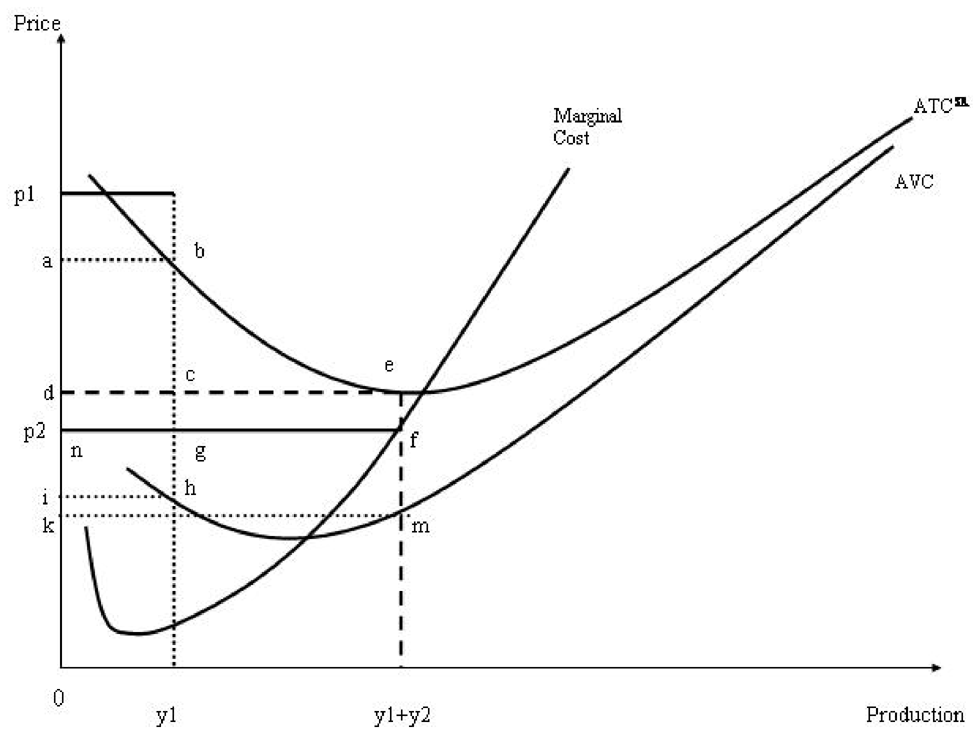
subject to $y_1 \leq Quota$,

where z denotes an aggregate of quasi-fixed primary factors (capital, self-employed labor and land owned or subject to long term leases) whose (exogenous) price is p_z. The variable w denotes the price of variable inputs; p_1 denotes the price of in-quota sugar beets; p_2 the price of out-of-quota beets; y_1 the quantity produced in the quota; and y_2 the quantity produced out of the quota (quantities of beets are expressed in sugar equivalent, so as to adjust for the sugar content). C^{SR} denotes the restricted or short run cost function.

For certain levels of the marginal cost function, of the quota and of the price of C beets, the existence of quasi-fixed inputs may result in a cross-subsidy between in-quota and C beets. This happens when p_2 and y_1 are such that the production of C sugar induces a lower average cost due to a larger production scale. In such a situation profit maximization may result in a larger output than if the quantity y_1 was not subsidized, i.e. if there was only one sugar price p_2. This situation is well described by Kopp and de Gorter (2005). Figure 1 shows a special case where the price of C sugar is higher than the marginal (variable) cost *AVC* of producing at y_1, explaining that a quantity y_2 of C sugar is produced, while the price of C sugar does not cover its production cost (p_2 lies below the short run average cost curve ATC^{SR}). The fixed costs are covered by the in-quota sugar. The production of C sugar is positive provided that the area *abcd* is larger than the area *cefg* in Figure 1. In that case, the gains resulting from the economies of scale exceed the loss resulting from selling the extra quantities at p_2. As pointed out by Kopp and de Gorter, *abcd* is always larger than *cefg* because the fixed costs at y_1 (*abhi*) equal the fixed costs at y_1+y_2 (*demk*), meaning that *abcd* is equal to *cefg* + *ihgfmk* > *cefg*.

That is, if the out-of quota price is lower than the average total cost in the short run and the out-of-quota price is greater than the average variable cost (a plausible case in C sugar producing regions), then there is cross-subsidization driving the production of out-of-quota sugar.

Figure 1: A case of cross-subsidy between A&B and C sugar due to fixed costs



Kopp and de Gorter (2005) also point out another possible case of cross subsidization when the out-of-quota price p_2 is lower than AVC and the in quota price p_1 is greater than ATC in y_1. In such a case, there will be production of y_2 if the costs saving due to returns to scale exceed the losses on the out-of quota market

The analytical derivation of the optimal conditions is cumbersome, because of the discontinuity in the supply response introduced by the quota regime. The maximization program is such that one cannot assume that the equality between the marginal cost and the out-of-quota price drives production in a general case. The level of quota must be large enough to ensure that the short run profit (profit less fixed costs) is positive. Supply is then determined by the combination of two conditions: *i/* that p_2 equals marginal cost ; and *ii/* that $p_1y_1+p_2y_2-C(y_1+y_2,w,z)>0$ (break even point).

The considerations above suggest that the coverage of fixed costs by the rent provided to the in-quota production is a possible determinant of the supply of C sugar. This idea was central in the decision of the WTO panel that EU exports of C sugar should be considered as subsidized. However, such a cross-subsidization cannot hold in the long run. If quasi-fixed factors can adjust to their optimal level for production y_1, then there is no point producing C sugar at loss as in Figure 1, for example. The simple expression of the long run producer's profit maximization problem (3) and Hotelling's lemma shows that such a cross-subsidy is not optimal.

$$\begin{aligned} \underset{Y}{Max}\, \pi &= p_1 y_1 + p_2 y_2 - C^{LR}\left(y_1 + y_2; w; p_z\right) \\ &= p_1 y_1 + p_2 y_2 - CV\left(y_1 + y_2; w; z^*\right) - p_z . z^* \end{aligned} \qquad (3),$$

with $z^* \equiv z^*(y_1 + y_2) = Arg \dfrac{\partial \pi}{\partial p_z}$

Because z can freely adjust, there will be no production of y_2. The reason is that there is no cost saving due to increasing returns to scale (caused by a non-optimal level of fixed cost at y_1 in the short run) that can offset a loss in the out-of-quota market. Obviously, there might be production of C sugar in efficient firms where the long run marginal cost is lower than p_2 at the production level y_1, but in such cases, the difference between p_1 and p_2 is a simple rent, and there is arguably no cross subsidy.

As pointed out by Witzke and Kuhn (2003), the quota regime has been in place for many decades almost without modification, and it is difficult to believe that the situation that has been taking place during the last years is merely a short run equilibrium. Major non-convexities (indivisible inputs) could prevent firms from adjusting their production structure to the optimal input level corresponding to the quota as in (3). However, in the beet sector, there are many opportunities to share machinery, to buy second hand machinery, and to purchase contract work. Contract harvesting or planting costs are only slightly decreasing with the size of operation. The fixed component in the cost of contract work is not large enough to provide a significant incentive for producing C beets so as to spread this fixed cost on a larger output. Overall, the argument that the fixed costs of C sugar are covered by the quota, and that this explains the production of C sugar in the EU is not compelling.

However, a recurrent problem in production economics is to define how long is the "long run". In Europe, there is evidence that some equipment has a long service life (Ball et al, 1993). In addition, in the processing sector, some equipment might be less divisible, or less easily adjustable than in agriculture, and fixed costs in refineries could be a reason for sugar processors to encourage farmers to produce C sugar. For this reason, we keep open the possibility that the production of C sugar benefits from the high price of in-quota sugar, i.e. that there is some form of cross-subsidy, when we model the EU sugar sector.

Quota overshooting as insurance. Because of the high price received for in-quota sugar beets, producers may overshoot so as to make sure that they will capture the rent in case of poor harvests. A rational beet producer will accept losses on the C sugar, or on a share of the C sugar, in order to maximize expected profit. The non-linearity in prices caused by the quota and the asymmetry between gains and losses caused by the dual price system result in kinked marginal returns, showing similarities with the classical concavity of the expected utility function. In such a case, even a risk neutral producer will overshoot as prevention.

A defendable assumption is that all costs are experienced by the time of harvesting. In such a case, if the output harvested is one unit lower than the target quantity y_1, the loss is p_1. If it is one unit larger, the extra profit is p_2. Let us call q the subjective probability that the actual yield exceeds the expected one by one unit. The expected profit of the producer targeting a production y_1 is $p_1.y_1\text{-}C(y_1)\text{-}q.p_1\text{+}(1\text{-}q).p_2$. Here, C denotes the long run cost function (rather similar behavior can be derived with a restricted cost function) and Cm denotes the marginal cost. The expected profit of a producer targeting one unit of production above y_1 (i.e. overshooting) is $p_1.y_1\text{+}p_2\text{-}C(y_1\text{+}1)\text{+}(1\text{-}q).p_2\text{-}q.p_2$, with $C(y_1+1)-C(y_1)\approx Cm(y_1)$). That is, overshooting is rational provided that $Cm(y_1) - p_2 < q(p_1 - p_2)$. The higher the difference between the two prices, the more likely the overshooting.

More formally, the introduction of an "insurance" behavior modifies the standard marginal conditions that characterize optimal production. Following Roumasset (1977), the producer's expected profit maximization problem takes the form of a discontinuous function as in equation (4), where δ denotes the Kronecker symbol, and μ_r is the expected yield (unit sugar content times quantity of beets per hectare), under the assumption that variable costs are experienced before climatic conditions affect the final yields. L denotes the quantity of land (acreage), r denotes the actual yield and the bar over y_1 denotes the quantity under quota.

$$\underset{L}{Max}\, E\left(p_2\,.\left(r.L-\overline{y_1}\right)+p_1.\overline{y_1}-C\left(\mu_r.L;w\right)-\delta_{rL\le\overline{Y1}}\left(p_2-p_1\right).\left(r.L-\overline{y_1}\right)\right) \qquad (4),$$

or

$$\underset{L}{Max}\, p_2.\left(\mu_r.L-\overline{y_1}\right)+p_1.\overline{y_1}-C\left(\mu_r.L;w\right)-\left(p_2-p_1\right).\mathrm{Prob}\left[rL\le\overline{y_1}\right].E(r.L-\overline{y_1}\,;r.L-\overline{y_1}\le 0)$$

The first order conditions involve

$$p_2.\mu_r-\mu_r Cmg(\mu_r.L;w)=\left(p_2-p_1\right).\left\{\begin{array}{l}\dfrac{\partial \mathrm{Prob}\left[rL\le\overline{y_1}\right]}{\partial L}.E(r.L-\overline{y_1}\,;r.L-\overline{y_1}\le 0)\\ +\mathrm{Prob}\left[rL\le\overline{y_1}\right].\dfrac{\partial E(r.L-\overline{y_1};r.L-\overline{y_1}\le 0)}{\partial L}\end{array}\right\}. \qquad (5).$$

Three conclusions can be drawn from equation (5) and from the fact that the bracketed term is positive, and therefore the right hand side of (5) is negative. First, producers will overshoot and produce C sugar, since the determination of the optimal supply behavior responds to the condition that marginal costs equals the price p_2 plus a positive term. Second, this term depends positively on the probability of a bad harvest. Third, this positive term depends positively on the difference (p_1-p_2). This point is important because it shows that, under such an "insurance" behavior, there is a cross-subsidy between in-quota and C sugar even in the long run, without the fixed cost effect described above. Indeed, the higher p_1, the more it becomes profitable to produce C sugar for insurance. Note that this cross-subsidy is obviously linked to the fact that the quota is binding, otherwise equation (5) would collapse into the traditional condition $Cm=p_1$.

This relation does not prove that C sugar is formally cross-subsidized in the EU. The incentive to overshoot is mitigated by the possibility of "carrying over" sugar quotas rights from one year to another, a feature of the EU CMO. This possibility reduces significantly the cross-subsidy resulting from (5). Some sugar processors also have private arrangements giving flexibility to beet suppliers to smooth the supply over several years, so as to prevent overshooting. In addition, empirical evidence suggests that the insurance behavior is unlikely to explain all the C sugar production in the EU15 (Adenäuer et al, 2004). Indeed, the level of EU15 production is only consistent with expectations on yields that would be unrealistic. However, the "overshooting" factor may explain a share of the C sugar production, and we believe that the resulting implicit cross-subsidy needs to be included in the modeling of EU supply response behavior.

Expectations. Projects for a reform of the EU CMO have circulated for decades before 2005. It is possible that farmers have produced beyond the (static) optimum level, expecting that historical references will be used in the future. Indeed, in the past reforms of the CAP, many quota allocations, premium rights or compensations have been given on the basis of historical references. A precautionary behavior so as to "build up" potential references would be rational under particular expectations by producers and/or processors regarding future reforms. Assume that producers expect that future quota mobility across the EU will result in closing sugar plants in some regions. This assumption is realistic, since some sugar processors closed profitable plants in anticipation of the reform in 2005 (e.g. in Ireland). Consider an efficient producer who expects that, in his area, local processors will manage to increase their sugar quota, and that the level of present production of C sugar will be used as a variable in allocating the new quota between individual beet producers. (Other patterns of expectation are possible, but it is likely that farmers will end up with the idea that the more they produce C sugar beet, the more they will be eligible for extra compensation, or future reference values). Let us use a subscript t+1 to denote expected prices and quantities in future period, a subscript t for the present period, and the variable τ to represent a discount factor. The profit maximization problem of a producer like the one described above is:

$$\begin{aligned} Max\pi = {} & p_{1,t}.y_{1,t} + p_{2,t}.y_{2,t} - C\left(y_{1,t} + y_{2,t}; w_t; z\right) + \\ & \tau\left(p_{1,t+1}.y_{1,t+1} + p_{2,t+1}.y_{2,t+1} - C\left(y_{1,t+1} + y_{2,t+1}; w_{t+1}; z\right)\right) \end{aligned} \quad (6),$$

subject to $y_{1,t} < \bar{y}_{1_t}$ and $y_{1,t+1} < \bar{y}_{1_t} + \lambda y_{2,t}$, where λ represents the degree to which the producer estimates that future quotas will be based on the present production of C sugar. Maximization in y_{2t} leads to a first order condition stating that $Cm_t = p_{2t} + \tau\ \lambda(p_{1,t+1} - Cm(y_{t+1}))$. That is, the optimal production of C sugar verifies the condition that $Cmg = p_2$ plus a positive term. This term depends on future rents, i.e. on future in-quota prices. While it is likely that producers expect future in-quota prices to be lower than the present ones, the prospect that these prices will remain higher than the world price may explain present production of C sugar.

Does this show that the C sugar is cross-subsidized? Formally, there is no direct linkage between the in-quota sugar price and the supply of out-of-quota sugar, since the production of C sugar depends on future in-quota prices, and not on present in-quota prices. However, if the "reference building" behavior does not introduce a formal cross-subsidy, it may be one of the explanations for the relatively high levels of C sugar produced during the recent years in the EU15, in spite of low world prices.

3. Econometric identification of production costs

Rents and production costs. The three cases presented above suggest that modeling of EU production under the usual assumption, that producers maximize profit so that marginal revenue equals marginal costs, may incorrectly represent EU supply response. If one calibrates the supply curve assuming such a relation in a simulation model, and then uses the prices observed to infer marginal costs, this may lead to construct an EU supply curve which lies below the actual one. The fall in EU production that would take place under market liberalization could therefore be underestimated. Overall, this might have a significant impact on the results obtained for world prices and trade.

Several authors have acknowledged that the different effects above should lead to a modification in the traditional modeling of supply. Adenäuer et al (2004) introduce shifts in the supply curve in order to account for some of the phenomena described above. They identify the problem as being the representative agent assumption. They account for the diversity of situations by using a larger number of representative farms. Within their framework, the "insurance effect" described above affects differently two producers with different levels of marginal costs. Once these individual behaviors are aggregated, the resulting supply curve is such that beet growers behave like if their quota endowments were higher than the actual ones.

The existence of a gap between marginal revenue and marginal costs for the aggregate producer is central in our approach. A common feature of the three effects described above (fixed costs, uncertainty on future yields and the asymmetry of gains/losses, expectation on future references) is that the producer's behavior leads to conditions between the marginal cost Cm and the out-of-quota price p_2 of the type $Cm = p_2 + \theta$, where θ is a positive function of p_1, a negative function of p_2 and a positive function of the quota.

We have little information on the value of θ. In order to characterize θ , we estimate econometrically the linkage between the decision to plant L hectares in sugar beet in one hand, and sugar prices and quotas on the other hand. We assume that Cm is a linear (increasing) function of L and we include a trend t to account for technical change, i.e. Cm=W(a+brL+ct), where a, b and c are coefficients to be estimated and W is a price index of inputs. The variable θ is also assumed to depend in a linear way on the in-quota and out-of quota sugar prices, i.e. $\theta = d+eQ+f(p_1-p_2)$, with Q being the level of quota, d, e, f being coefficients to be estimated. Combining the expressions of Cm and θ , a synthetic representation of the land acreage decision is therefore:

$$L = \frac{1}{Wr}\left(\frac{d}{b} - \frac{a}{b}W - cWt + \frac{1}{b}p_2 + \frac{f}{b}(p_1 - p_2) + \frac{e}{b}Q\right) \qquad (7),$$

Econometric estimation of the coefficients of (7) makes it possible to estimate the cross subsidy between in-quota sugar and C sugar, the production costs and the supply elasticities. In order to do so we add an error term to equation (7), reflecting all other variables omitted in this specification.[2] We use a Generalized Maximum Entropy (GME) estimation technique. This technique is robust for small samples. It is also useful for integrating inequality constraints that are consistent with the theory (such as b>0; θ ≥0, see the appendix). In addition, GME allows estimation of non linear functions, which makes it possible to perform specification tests on a larger range of functional forms. The method used is described in Golan et al (2001). We test the significance of estimates by the ratio of entropy (Golan et al., 1999).

There is barely any literature on the properties of GME estimators under inequality constraints, but there is little reason to believe the GME method solves the spurious regression problem if series are non stationary and non cointegrated. We thus test for stationarity using three common tests. Results are reported in the appendix. Because the EU sugar market organization has not changed over the last years, there is only a limited variability in some of the observations. Even though the goodness of fit looks satisfactory, the different stationarity tests are often inconsistent (see the appendix). That is, econometric estimates are rather fragile. This is a limitation of the study, since the parameters d, e and f play a role in the computation of production costs and rents. In each of the six countries producing C sugar where (7) was estimated, at least one parameter entering in the expression of θ, i.e. f, and e, is significantly different from zero. This suggests that there is indeed some form of cross subsidy between C sugar production and the quota rent. The costs of production presented in Table 1 are derived from the parameters estimates of equation (7). Estimates suggest low production costs in Belgium, Germany and France, and high production costs in Italy and Spain. This is in line with the

[2] The specification as in equation (7) performs poorly in the case of Italy. An alternative specification is used $\theta=d+eQ+f(p_1- p_2)Q$. In that case, *e* and *f* are not constrained.

findings of the EC Commission (2004). The low costs in the Netherlands and the UK are perhaps more surprising. But they are in line with Van der Linde et al, and could be explained by the scale of the plants in the processing sector (see Van der Linde, et al 2000, Figure 14.2). We also estimate the supply elasticity to a change in the net in-quota price. These estimates are rather low for Northern EU countries and larger for Southern countries. The weighted average elasticity is 0.23, in line with previous estimates (Bureau et al 1997).

Table 1. Production costs and aggregate supply response estimates

	Costs (€/T)	Supply elasticity estimate with respect to P1	Fit, i.e. R^2 of equation (7)
Netherlands	355	0.33	0.83
United Kingdom	388	0.11	0.60
Belgium	407	0.06	0.82
France	397	0.14	0.78
Germany	424	0.22	0.96
Spain	527	0.14	0.87
Italy	551	0.90	0.45

4. The simulation framework

The GE model. The modeling of EU sugar sector is included in a larger GE framework in order to assess the effect of trade liberalization and policy reforms on the EU economy. At first glance, this may seem an "overkill" strategy, since the sugar sector is unlikely to be large enough to have significant macroeconomic effects. However, there is no serious obstacle to including a more detailed sector within a broader framework. The GE framework is appropriate for modeling multi-output production, consistent with the fact that sugar is always produced in combination with other crops. In addition, proper modeling of the EU sugar response to policy changes requires that one takes into account the interaction of the farm sector with both the processing sector (refineries) and the food sector that uses sugar, an issue better dealt with in a GE framework. GE also makes it possible to assess some particular effects of reforms, such as the impact on employment. Welfare effects are also more easily addressed within a GE framework in the case of second best equilibria (see Gohin and Moschini, 2006). Finally, GE approaches impose an internal coherence because of accounting equalities. This, for example, makes production costs more consistent with prices and rents than in many partial equilibrium approaches (Hertel, 2002). Because production costs play a significant role in the characterization of sugar supply, a proper endogenization of returns to primary factors accounting for intersectoral linkages is an asset.

The model focuses on the agricultural and food processing sectors of the EU. Other countries and sectors are treated in a much less detailed way. The model used this paper is static, with perfect competition in most sectors and a neo-classical closure. Investment is savings driven and balance of payments equilibrium is ensured by financial flows. A Social Accounting Matrix (SAM) was constructed for the EU, using original data for the year 1995. The sectoral coverage distinguishes 75 products, including 18 products in the arable crops sector, 29 products in the animal sector. There are three primary factors (capital, labor and land), whose quantities remain constant, but which are mobile across sectors. The EU is a large country whose trade affects other regions' exports prices through a series of export supply and demand functions. The model has four main original features, which are: i) the use of flexible forms which globally satisfy regularity conditions for production technology, household preferences and factor mobility ii) a detailed disaggregation of the agricultural sector; iii) a detailed representation of all instruments of the CAP; iv/ the use of Mixed Complementarity Programming (MCP) methods in order to represent changes in regimes such as production shifts under a quota. The specification used to represent preferences, technologies and factor mobility makes use of latent separability. The model is described in Gohin and Latruffe (2006).

The modeling of the sugar sector. The sugar sector includes the sugar beet activity which supplies "A&B beets", i.e. in-quota beets, "C beets" and the sugar processing sector which offers "A&B sugar", "C sugar", "pulps", "molasses". The in-quota and out-of-quota beets (respectively sugar) are distinct products, but perfect substitutes. They differ in terms of prices, levies and constraints. Isoglucose is modeled as a substitute for sugar. Sugar beets are assumed to be nontradable. Sugar is modeled as an homogenous product. Accordingly, a net trade (rather than an Armington) specification is used so that the difference between EU sugar exports (A&B and C sugar) minus preferential imports meets a net export demand function from non-EU countries. EU imports are limited by tariff quotas, which generate rents, assumed to be retained by the exporting countries. The processing sector is represented in the model. Raw sugar is the only type of sugar imported, while only white sugar is exported. The difference in price between raw and refined sugar is kept constant, so that the products behave like perfect substitutes. The modeling of the beet and processing sectors allows for a cross-subsidy between A&B and C productions at both stages. The A&B beet and sugar are linked through a Leontieff technology, and assumptions must be made regarding the share of the rent passed to the farm sector and retained by the processing sector. The convention that is adopted here is the one used by Frandsen et al (2003), with a constant proportion of price decrease between the two sectors as long as there remains some positive rents at the two stages.

The costs of production estimates presented in Table 1 characterize supply response at the national (country) level and as mentioned before, we only rely on the average in the EU model. Here, a full blown model of each EU country would be required in order to take into account the differences in domestic production costs. However, one may always argue that the heterogeneous sugar production conditions in the EU require a region specific model, or even a farm level model (Mahler, 1994; Revoredo, 2005). Here, we need to combine country specific information on supply and an EU-wide

GE model. In order to do so, the GE model is first used to simulate the 2010 baseline, using average figures obtained from our econometric estimations.[3] National supply curves are then used to calculate country-level supply and production costs under the baseline and the reform scenarios. The fall in domestic production caused by the reform is then introduced into the GE model which is used for simulating the overall impact of the corresponding scenario. This iterative technique makes it possible to include the information on supply in the different EU countries while taking advantage of the GE model.

The model focuses on the EU. In practice, there are also large variations in production costs among countries exporting sugar with the EU. That is, exports of third countries to the EU, including those under preferential agreements, might be affected by the change in EU prices. Information on production costs provided by Garside et al (2004), LMC (2004) show that some countries that export to the EU, such as Guyana, St Kitts and Nevis, Barbados or Trinidad and Tobago are unlikely to produce for the EU market after a large cut in EU intervention price. Their present production is driven by the high internal EU price. However, since we do not consider the possible outcome of a revision of the Cotonou regime, we assume that import quotas for ACP countries will remained unchanged. We assume that a country benefiting from a duty free tariff quota will export sugar (possibly purchased on the world market) to the EU market, as long as EU domestic price for raw sugar is higher than the world price. In-quota imports with a positive tariff (i.e. imports under the Traditional supply needs and Special preferential sugar provisions) will continue as long as the gap between the EU domestic price for raw sugar and the world price exceed the tariff.

5. Policy changes simulations

The baseline. We first define a reference scenario or baseline which corresponds to the situation that will take place in 2010, assuming the full implementation of the Agenda 2000, the June 2003 CAP reform and the enlargement of the EU, i.e. without the 2005 reform of the sugar sector. The definition of this baseline is of particular importance, since the June 2003 reform might have, in the absence of other policy development, favored the production of C sugar in the most efficient regions. In the

[3] In order to calibrate the sugar sector in our CGE model, we first determine the gross margin of both beet productions (in and out-of-quota beets). We use input/output coefficients for a vector of intermediate inputs, and returns to land from various sources, including Eurostat SPEL and the Farm Accountancy Data Network. We assume that the sum of the margin of A&B and C beets is exhausted in returns to the labor and capital bundle and quota rents. The econometric estimates of (7) are used to calibrate the cross-subsidies between in-quota beets and C beets, assuming that the unitary implicit subsidy on C beets adjusts to satisfy budget neutrality (i.e., the total implicit tax on in-quota beets equals total implicit subsidy on C beets). This makes it possible to measure the value of the rent and the value of the returns to the capital and labor aggregate. For the refining sector, a similar calibration procedure is done, imposing that only A&B sugar beets are used to produce A&B sugar. Both A&B and C sugar processing produces molasses and pulps. Unit labor costs cannot adjust in the processing sector. Profit is exhausted in returns to capital and in quota rent. Again, econometric estimates of (7) are used to calculate the rent.

present version, the GE model is still calibrated for the year 1995 and we construct this baseline scenario as a pre-experiment simulation, updating the relevant data, but using the original structure of the matrix (input-output, etc.). Because the SAM does not include detailed information on the 10 new members of the EU, we present only the results for the EU15. The EU10 are treated as foreign countries within a free trade area. Some variables describing the macroeconomic environment are set exogenously, using data from different institutions, including the Food and Agricultural Policy Research Institute. Assumptions are also made about technical change in different sectors. We assume, for example that Hicks neutral technical change results in a 1% reduction in unit costs in the sugar sector, based on estimates for France (Sourie et al, 2005). Table 2 presents the baseline, given the calibration of the cross-subsidization presented above. In brief, in the "baseline" column of Table 2, the 2005 sugar reform is not implemented, export refunds are only limited by the Uruguay Round agreement framework, and we assume that the EU does not face any additional constraint due to the WTO dispute on export subsidies or to the Doha Round.

Table 2. EU15 sugar markets under the baseline, after the reform proposal and a ban of export subsidies

	Model calibration	Baseline (2010)	Impact of 2005 reform (Scenario 1)	Total ban of export subsidies (Scenario 2)	Scenario 2 / scenario 1
EU15 production of in quota beets	99.570 mt	102.629 mt	92. 080 mt *(-10%)*	83.651 mt *(-18%)*	-9%
EU15 production of C beets	11.961 mt	8811 mt	0 *(-100%)*	0 *(-100%)*	-
EU15 production of in-quota sugar	14.157 mt	14.592 mt	13. 092 *(-10%)*	11.894 *(-18%)*	-9%
EU15 production of C sugar	1.701 mt	1.293 mt	0 *(-100%)*	0 *(-100%)*	-
EU 15 imports of sugar*	1.950 mt	1.724 mt	1.724 mt *(0%)*	1724 mt *(0%)*	0%
EU15 exports of in quota sugar*	2.888 mt	2.919 mt	1.238 mt *(-44%)*	0 *(-100%)*	-100%
EU 15 consumption of sugar	12.863 mt	12.987 mt	13.171 mt *(+1%)*	13.213 mt *(+1%)*	0%
Domestic price of in quota beets	50 €/t	46 €/t	22 €/t *(-52%)*	16 €/t *(-65%)*	-27%
Domestic price of C beets	22 €/t	11 €/t	-	-	-
Domestic price of in quota sugar	687 €/t	632 €/t	404 €/t *(-36%)*	360 €/t *(-43%)*	-11%
Export price (white sugar)	306 €/t	221 €/t	261 €/t *(+18%)*	277€/t *(+25%)*	+6%
Export subsidies	1 311 mn€	1 200 mn€	178 mn€ *(-85%)*	0 (-100%)	-100%
Rents (sector)	1 749 mn € (beet) 1 119 mn (sugar)	2203 mn € (beet) 300 mn (sugar)	464 mn € (beet) 0 mn (sugar)	0 *(-100%)*	-100%
Cross subsidy (beets) (sugar)	55 mn € 128 mn €	63 mn € 141 mn €	-	-	-

** outside EU10.. Source: simulations by the authors.*

In the baseline, the EU produces and exports some 1.3 million tons of C sugar in addition to the 2.9 million tons of in-quota sugar exported. Note that production costs account for cumulative technical change up to 2010, which explains the ability of the EU to produce C sugar at a price of 221 € per ton. The quota rents amount to 2.6 billion euros, after deduction of a 798 million euros levy for the funding of B sugar exports. Production costs amount to 20 euros per ton of beet and 391 euros per ton of sugar, in particular because of the flexibility brought by the 2003 CAP reform.

Policy scenarios. The model is used for simulations of two scenarios that appear relevant in the present policy debate. These are:

- Scenario 1: the 2005 reform of the sugar sector is implemented, with no other adjustment coming from international pressures.
- Scenario 2: the ending of all export subsidies in the sugar sector (including ending of exports of C sugar), with no change in the ACP quotas, and without the implementation of the EBA.

The EU sugar reform. The 2005 sugar reform includes a 36 percent price cut over four years beginning in 2006/07; compensation to farmers at an average of 64.2 percent of the price cut as part of the CAP single farm payment. The "A" and "B" quotas are merged into a single production quota, with no quota cuts, unless market situation demands such a measure. The reform offers the possibility for member states to reduce production quotas. However, the reform allows coupled payments when production falls in excess of 50% of the historical quotas. In addition, some 1.1. million tons of sugar will be made available for countries which produced C sugar in the past (firms that overshot internal production quotas will be able to access extra quotas against a 730 euro per ton one off payment). Finally, some national aids persist, which could limit the fall in production in the least efficient regions.[4]

In Table 2, the "Scenario 1" column presents the outcome of the EU reform of the sugar sector. The figures between parentheses are variations in percentage compared to the baseline. Here, we assume that the compensation for the reform provided to the beet producers are decoupled payments, and has no impact on output (an assumption that we also use for the single farm payments in the baseline).

Our econometric estimates of national supply curves for seven countries, and those that we calibrated using EU Commission estimates of costs of production, suggest that several countries will not be able to economically produce all their quota at a price of 405 euros per ton. For example, in the case of Italy, we estimate that production could decrease by roughly 20% after the cut in intervention price, given the supply elasticities. According to our estimates, a significant share of the EU production seems to rely on production costs that exceed the 405 euros per ton. However, the possibility of coupled payments might limit the fall in production to 50% of the initial quota even in least efficient

[4] Note that at this stage, the reform was only adopted by the Council, and that we rely on a draft regulation.

Member states. If we assume that these (draft) provisions will maintain at least half of the national output, we find that the in-quota production would fall by 1.5 million tons relative to the baseline. This is this reduction that we introduce in the GE model.

The EU15 no longer produces C sugar after the reform. The decrease in intervention price reduces the incentive to "overshoot". Indeed, the asymmetric loss described in equation (4) between one unit below or over the targeted quantity is now reduced to a few euros per ton, an amount too small to justify overshooting. The overall simulation of the reform with the GE model suggests that the combination of the decrease in in-quota sugar and C sugar, EU production will fall by 2.7 million tons of white sugar. This estimate is likely to be an upper bound given the possibility left for national aids and for coupled payments in case of large fall in production, and the extra quota that could be purchased by most efficient regions (the draft regulation states that sugar undertakings that produced C sugar during the marketing year 2004/2005 may request from the Member State where they are established the allocation of an additional quota). Our estimates suggest that the decrease in EU production after the reform will be more limited than what has been forecasted by the Commission (EU Commission 2005). The Commission estimates rely on a proposal where coupled payments were not allowed, and where quota mobility between countries was allowed. Our figures are consistent with an average EU production cost of 370 euros per ton, a reference price of 404 euros per ton for white sugar and a world price of 261 euros per ton.

Figures in Table 2 show that the fall in beet prices is larger in percentage terms, than the fall in sugar price. Our figures are therefore inconsistent with the draft regulation that specifies that the minimum price for sugar beets will be reduced by 39.5% only. However, we find that the reform exhausts the rents to the processing sector. At some point, the adjustment will need to be borne by beet growers. Our finding is obviously linked to our assumption that some of the unit costs of the processing sector are difficult to reduce, such as energy and labor costs. However, we believe that, even under alternative assumptions on the sharing of the rents, processors are likely to put pressure on the farm sector, and that it is unlikely that the 36% decrease in the price of the final product can be compatible with a 39.5% decrease in the price of the beet input, given the low elasticity in the demand of other inputs.

The fall in prices only results in a slight expansion of consumption. The EU demand for sugar is very inelastic in our GE model. Such a low elasticity is questionable. However, it is noteworthy that opportunities for substituting sugar for sweeteners are limited: unlike the US one, the EU soft drink sector does not use large quantities of isoglucose that could be replaced by beet sugar even if the latter became much cheaper. Other studies also find little expansion of consumption following lower sugar prices (Eurocare 2003).

The reform provides a considerable degree of freedom for lowering EU tariff protection. Indeed, without the reform, we estimate that the minimal protection necessary to prevent sugar (outside tariff quotas) from flowing into the EU in 2010 is 412 euros per ton of white sugar. The non-preferential tariff is presently 339 euros per ton for raw sugar and 419 euros per ton of white sugar. After the reform, the gap between the domestic and world price for EU sugar would fall to 143 euro per ton of white sugar. That is, the EU community preference can be maintained with a significant decrease in MFN tariff. Clearly, the reform would be a major step towards compatibility with a WTO agreement under the Doha Round.

Our simulations for Scenario 1 suggest that the sugar reform will result in minor changes outside the sugar sector. In the EU15, 360 000 hectares will be reallocated to other enterprises, mainly grains, and in particular soft wheat. This will result in a limited decrease in the cost of feedstuffs with a small impact on livestock producers. The reform should also result in a limited increase in the production of vegetables. The reform should lead to 680 million euros of estimated welfare gains. However, this results from conflicting effects, since the loss for sugar beet producers is significant (1.7 billion euros). Given the estimated compensation paid to producers, their net losses should amount to some 550 million euros. The fall in production of refined sugar results in a decrease of some 1.2 billion euros in value added for the processing sector. The fall in employment is limited in the farm sector because of the reallocation of resources to other sectors (we find a decrease of 3000 jobs in the EU15 farm sector), but is larger in the processing sector (5500 jobs). EU taxpayers save roughly some 900 million euros of export subsidies.

Overall, the reform provides some degrees of freedom to the EU in terms of WTO commitments, including market access, domestic support and export competition. The reform brings export subsidies down to a level which is consistent with the conclusions of the 2005 WTO ruling. Nevertheless, this sugar reform alone hardly addresses longer terms constraints, unless trade liberalization in other countries, and in particular the US, results in a large increase in the world price, which seems unlikely (Bouët et al, 2005).

The elimination of export refunds. Following the WTO dispute and the panel requested by Brazil, Australia and Thailand, the 2005 ruling of the Appellate Body implies that EU subsidized exports have to be reduced (Both the re-exportation of ACP/India preferential imports and the sale of C sugar on the world market were found to be in violation of the maximum subsidized export commitments). However, the EU CMO faces other constraints in the longer run. Indeed, all subsidized exports must be eliminated by 2013, following the Ministerial meeting of the WTO in December 2005.

Scenario 2 includes the elimination of all subsidized exports, including the C sugar relative to the baseline (i.e. assuming that the 2005 sugar reform has not taken place). We also assume that the duty free quotas granted to ACP and India remain unchanged, and that the EBA agreement does not result in extra imports, an assumption that we discuss later.

The ending of export subsidies might be obtained by reducing the level of the sugar quota. However, here, we assume that the domestic price EU adjusts to clear the market. Results are presented in Table 2, column "Scenario 2". The figures in parentheses indicate the change relative to the baseline. The changes relative to the situation after the 2005 reform are provided in the right hand side column of Table 2.

With no possibility of using subsidies to dispose excess supply on the world market, a considerable decrease in sugar prices is needed to clear the EU market (43% relative to the baseline, i.e. a further 11% decrease after the implementation of the 2005 reform). The required fall in the price of sugar beets would even be larger because we assumed that wages and some input prices could not decrease in the processing sector. Even though the domestic price would still be 30% higher than the world price, all rents would disappear in the EU sector. Such a fall in EU domestic prices would make larger cuts in tariffs possible. That is, the WTO discipline on export competition (ban on export subsidies) seems more constraining that the WTO discipline on market access in the sugar sector.

The fall in domestic price required to eliminate export refunds would erode the rent for preferential imports of sugar under tariff rate quotas. The difference between domestic prices and world prices would barely be enough to sustain the present imports facing a positive tariff (the Traditional supply needs and the Special preferential sugar, whose future after 2009 is, anyway, uncertain due to the full implementation of the EBA). Indeed, the rent associated to the tariff quota would fall to almost zero for these two categories of imports under scenario 2.

Table 2 shows that the 2005 reform will not be sufficient to reach the objectives of the elimination of all export refunds, which would require a decrease of some 4 million tons of output, relative to the baseline. It is likely that, rather than a price decrease as the one assumed under Scenario 2, the level of quotas will be adjusted. Indeed, according to the draft regulation following the November 2005 Council decision, the Commission will be mandated to “withdraw” a percentage of quota sugar if the market situation demands it. Note, however, that the WTO negotiations on market access will interfere. Sugar tariffs will be in the highest band which is likely to face very large cuts (e.g. a 60% cut under the 2005 EU proposal and 80% under the 2005 US proposal). With such tariff cuts, competition from imports would force the EU to lower domestic price, in addition to adjusting the level of production quota. A reduction in domestic price in line with the one found in Scenario 2 could be required, even if the EU chose to fill WTO constraints with a tighter supply control.

Finally, the sector will face constraints which have not been included in the Scenario 2. This is particularly the case of the preferential imports under the EBA initiative. The EU sugar market will be entirely open to exports from LDCs in 2009. At this point, it is not totally clear whether quotas or rules of origin requirements will eventually limit the EBA concessions of full and unlimited access (Talks, 2005). In addition, uncertainty persists regarding the ability of LDCs to become major suppliers to the EU market due to the lower EU prices and supply side constraints. EBA sugar may also displace ACP imports. However, during the transition period, LDCs have shown that they were already making full use of their tariff rate quotas (74 185 tons of white-sugar equivalent in 2001/2002 supposed to aise to 197 355 tons in 2008/2009, July to June marketing year). This suggests that some significant imports could take place, perhaps some 2.2 million tons, after 2009 according to some estimates (EU Commission 2005). These imports would need to be offset by a corresponding reduction in EU production. Clearly, the 2005 reform would need, in that case, to be complemented by either a significant cut in quota, or a considerable cut in prices, that would bring the EU sugar prices much closer to the world price.

In brief, there is large uncertainty on whether LDCs would be able to export sugar if the EU domestic price decreased. There is also a considerable uncertainty regarding the possible non food utilization of sugar beets or cane, and the resulting world market price. However, unless the EU finds some WTO compatible ways to dispose surplus (which should exclude export subsidies), it is likely that further adjustment in domestic price or in quotas will be required after the 2005 reform.

6. Conclusion

The various assessments of the effects of a liberalization of world sugar markets are quite inconsistent. We believe that a significant explanation of the observed differences in results lies in the specification of the supply response of the EU, and in particular relates to the assumption regarding C sugar production. The supply of C sugar can be affected by the support provided to in-quota sugar through three channels: *i/* the existence of fixed costs covered by the in-quota sugar, that may explain that C sugar can be sold at prices that cover only marginal (variable) costs; *ii/* "overshooting" behavior, as insurance against poor yields; *iii/* the production of C sugar as "reference building" in view of expected reforms.

Microeconomic analysis of the determinants of EU sugar supply do not lead to conclude that the in quota sugar formally cross subsidizes the production of C sugar. Indeed, the fixed-costs effect cannot explain a cross-subsidy in the long run, and under the "reference building" effect, the supply of C sugar only responds to expected (future) in-quota prices. However, they are uncertainties about the time horizon and the divisibility of inputs in the processing sector. The "overshooting effect" may also make the supply of C sugar dependent on the level of the in-quota price. Overall, the positive impact of the quota rent and the quota level on the supply of C sugar deserves to be taken into account in the representation of the EU sugar supply. We introduce some interaction between the quota and the supply of marginal sugar production in our model. We calibrate the supply of C beets and sugar using econometric estimates. We then include such a specification in a GE model including a detailed representation of the sugar sector.

Our simulations suggest that the 2005 reform of the EU sugar sector will lead to the end of C sugar exports, and that the fall in prices will provide significant degree of freedom for coping with the need to reduce significantly the EU sugar tariffs under the WTO negotiations. The reform should also make it possible to cope with short run constraints imposed by the WTO panel such as the cut of refunds by an amount corresponding to the sum of ACP sugar imports and the C sugar. The losses for sugar beet producers and processors will be significant, although they are partially compensated. The reform should also result in savings for taxpayers and consumers. Overall, the reform should result in a higher welfare for the EU15, even though cheaper sugar might raises some public health issues that are not accounted for in the model. However, our simulations suggest that the 2005 reform is not sufficient to address longer term commitments such as a complete elimination of export subsidies. It is difficult to predict future world prices for sugar, in particular given the possible development of non food use of sugar cane and beets. However, it is likely that the extra pressure added by preferential imports under the EBA will make larger cuts in EU prices or/and in production quotas necessary.

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Appendix. Econometric procedures and estimates

Stationnary tests

The time series used in the econometric estimations were tested for stationarity using the augmented Dickey-Fuller (ADF) with drift as well as with the Kwiatkowski-Phillips-Schmidt-Shin (KPPSS) tests for stationarity (Kwiatkowski et al 1992). As it is well known, none of these tests is fully conclusive, especially when used on small samples. The ADF tests for the rejection of non stationarity. If the value of this statistic is lower than the critical value of –3.6, then this means that we can reject at 5% level of confidence the hypothesis of non-stationarity. KPSS test has stationarity as the null hypothesis and the unit root as the alternative. Again, if the value of this statistic is lower than the critical value of 0.146, we can not reject at the 5% level of confidence the hypothesis of stationarity.

Table A1 shows the values of these two tests for all variables estimated (sugar beet acreage by Member States) as well as for the prices entering the French equation. The number of lag in the ADF test is determined according to the Durbin Watson test. As it is often the case, these two tests are not always consistent. For instance, according to the ADF test, we can not reject the assumption that the UK sugar beet area variable is non stationary but according to the KPSS test, we can not reject the hypothesis of stationarity. It appears in Table A1 that for no series did we find the two tests in favor of non stationarity. With this fragile conclusion, we are only able to be cautious about the inferences on our econometric estimates.

Table A1. Augmented Dickey Fuller and KPSS tests

	ADF test (critical value <-3.60)	KPSS test (critical value <0.146)
Sugar beet areas in		
France	-4.50	0.113
UK	0.06	0.142
Belgium	-4.30	0.148
Spain	-2.77	0.096
Italy	-2.37	0.149
Netherland	-4.37	0.106
Germany (with dummy for 1991)	-9.45	0.127
Prices in the French equation:		
1/PW	-14.42	0.184
P2/PW	-4.43	0.121
(P1-P2)/PW	-2.86	0.114

Econometric estimation

The equation that is estimated corresponds to (7) in the paper. The series are annual data from 1981. Data sources include Eurostat for acreages and p_2 (spot sugar prices, London) is from the annual report of the Confédération Générale de la Betterave. Data for p_1 including various taxes are taken from van der Linde et al (2002) and from Confédération Générale de la Betterave. All prices were deflated by the GNP price using Eurostat data. Price and yields are expressed as an arithmetic average over the past three years. Various specifications with trends and lagged variables were tested, but the naïve expectation specification fit the data best.

The Generalized Maximum Entropy (GME) method allows us to consistently and efficiently estimate equations with with nonnegativity constraints and relatively few degrees of freedom without imposing restrictions on the error process. The GME estimates are robust even if errors are not normal and the exogenous variables are correlated. Entropy is used to measure the uncertainty (state of knowledge) we have about the occurrence of a collection of events. Given x a random variable with possible outcomes x_s, s=1,2,..,N, with probabilities π_s , the entropy of the distribution $\pi = (\pi_1, \dots \pi_N)$ is

$$S(\pi) = -\sum_1^N \pi_s \ln \pi_s, \quad with \quad \sum_1^N \pi_s = 1$$

S reaches a maximum when all the π_s are equal , and a minimum when one of the π_s is equal to one. In order to recover the unknown π_s that characterize M moments of a given dataset, one can maximize entropy subject to sample moment information. Using a sample of T draws of an identically and independently distributed random variable x that can take N values x_t with probabilities π_t,. The number of times x_s occurs, f_s, defines a vector of outcomes $(f_i,\dots f_N)$ such as $\Sigma_s f_s = T$. Maximization of entropy S relies on the idea of selecting the vector of outcomes that is most likely to be drawn. The frequency that maximizes entropy is an estimate of the true distribution which can be altered by extra (sample or non sample) information. The ME method picks the distribution consistent with the data which is closest to the uniform distribution. The GME approach uses each observation by treating moment conditions as stochastic restrictions. The parameters to be estimated are expressed as probabilities using a support space (i.e. a set of discrete points that are uniform intervals symmetric) and a vector of corresponding unknown weights. The GME estimator maximizes the joint entropy of all the probabilities representing the parameters to be estimated and the error terms subject to the data and the various constraints. The various desirable properties described by Golan et al (2001) include the ability to impose non linear and inequality constraints, and the efficiency of the estimator with small samples.

In practice, we set support values for parameters and residuals as triplets $\{-\alpha, 0, \alpha\}$. An initial value of the parameters to be estimated is set, and entropy is maximized under the constraints that the data matches equation (7) and the various constraints imposed: $b>0$; $0<f<1$; $\theta \geq 0$; $p_1 \geq \theta + p_2$.

Estimation results are provided in Table A2. The stars indicate estimators significantly different from zero, respectively at the 10% and 5% threshold. It is noteworthy that most of the parameters of interest, i.e. parameters b, f, e, are significantly different from zero (with the exception of Italy, the adjustment is satisfactory). This suggests that the specification adopted, where the usual marginal become $Cm=p_2+\theta$, θ is indeed a a positive function of p_1, a negative function of p_2 and a positive function of the quota.

Table A2. Estimation results

	R2	DW	b	e	f
Netherlands	0.83	1.92	1.09**	0.57*	0.69**
UK	0.60	2.08	3.97**	0.76**	0.99**
Belgium	0.82	1.95	3.74**	0.61*	0.38**
France	0.78	1.80	0.32**	0.45*	0.34*
Germany	0.96	1.89	0.36**	0	0.56*
Spain	0.87	1.76	2.82**	0	0.65**
Italy	0.45	1.72	0.67**	2.64**	0.001**