Quota in Agricultural Positive Mathematical Programming Models

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Abstract

In Belgium, an agricultural sector model for ex ante policy analysis is developed. The model, called SEPALE, uses an adapted version of Positive Mathematical Programming allowing for simultaneous modelling of individual farms. SEPALE applies farm level calibrated cost functions to the sample of the Farm Accountancy Data Network to account for the large variability among farms. Due to the recent discussion on the Sugar Common Market Organization (CMO) reform, the need raises for an appropriate methodology to cope with quota in positive programming models. Modelling quota at farm level implies three important challenges: i) estimation of the marginal cost or the quota rent, ii) simulating over- or undersupply and iii) quota exchange. Present paper describes a methodology dealing with the three quota issues. Simulations of sugar beet policy options draw on the proposed approach. The paper also demonstrates that other types of quota could benefit as well.

Keywords: Quota, Sugar Reform, Positive mathematical programming.

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Introduction

Policy instruments make often use of quota or production permits. Quotas enable policy makers to internalise national resource constraints at farm level. Quota or production permits exist in both agricultural policies, such as the CAP (Common Agricultural Policy), as in environmental policies. Examples of production quota in agricultural policies are the quota for milk, suckler cows, sheep and sugar beet. Supply within quota limits ensures suppliers a high guaranteed price for milk and sugar or subsidies for sheep and suckler cows. These quotas allow for better control of the total budget for price or subsidy support, which is here the national resource constraint. Manure quota in Flanders is an example of quotas in environmental policies.

Adequate modelling of the agricultural sector requires that the model deals with the specificities of quota. In farm-level calibrated programming models, quotas put three major challenges to modellers.

One of the problems of quota representation is that the marginal cost - price equilibrium is often not satisfied anymore. The first challenge is therefore to estimate the correct marginal costs or the rent of quota, which is the difference between the price and the marginal cost.

The second challenge is to incorporate the possibility of oversupply, i.e. supply higher than the quota limit, or undersupply, i.e. supply lower than the quota limit. If there is a large penalty for oversupply (e.g. for environmental production permits) the producers tend to supply less. If there is a penalty for undersupply, farms oversupply (e.g. for sugar beet). Over- or undersupply depend on the level of the penalty, the variability of production, the possibilities to adapt supply and the profitability of supply both within as outside quota.

The third challenge is to model the transfer of quota among farms. In case of a market for quota, observations of the price and the transfers exist in most cases, as for example for dairy quota in the Netherlands. This is, however, often not the case. For sugar beet, Bureau et al. (1996) mention strong rigidities and transfer costs in the quota market for sugar beet.

This paper describes an approach to cope with the three major challenges of quota modelling. The approach, currently applied to sugar beet supply, could be useful for different types of quota. The basic model is a Positive Mathematical Programming (PMP) – based model of the Belgian Agricultural sector (called SEPALE). SEPALE simulates at farm level using Farm Accountancy Data Network (FADN) data. Results allow for aggregation per region, farm type or farm size. Buysse et al. (2004) and Henry de Frahan et al. (2004) are other applications of SEPALE.

1. The Basic SEPALE Model

SEPALE is the result of a project, initially financed by the Belgian ministries of Agriculture, later on taken over by the regional Flemish and Walloon governments. The project aims at developing a decision support system to analyze the impact of policy decisions on the agricultural sector.

SEPALE relies, for the moment, on a modified version of the standard PMP calibration method, which skips the first step of the standard approach (Howitt, 1995) for two reasons. The first argument for not using the first step of PMP is the availability of data on limiting resources. The second motivation is the bias in the estimation of the dual of the resource constraints as demonstrated by Heckelei and Wolff (2003). Standard PMP (Howitt, 1995) always assigns the highest possible value for the dual of the resource constraint.

SEPALE operates at farm level using an FADN sample of Belgian farms. The model employs a farm level profit function with a quadratic functional form for its cost component. In matrix notation, this gives:

$$Z_n = \mathbf{p_n' x_n - x_n' Q_n \ x_n /2 - d_n' x_n + a_n' Subs_n x_n} \qquad (1)$$

with

$\mathbf{p}_n$: a (j x 1) vector of output prices,
$\mathbf{x}_n$: a (j x 1) vector of production quantities with j production activities,
$\mathbf{Q}_n$: a (j x j) diagonal matrix of quadratic cost function parameters,
$\mathbf{d}_n$: a (j x 1) vector of linear cost function parameters,
$\mathbf{a}_n$: a (j x 1) vector of technical coefficients determining how much land is needed for x_n,
$\mathbf{Subs}_n$: a (j x j) diagonal matrix of subsidies per activity unit,
n: index for farms.

Output prices and subsidies are exogenously to the model. Two equations calibrate the parameters of the matrix Q_n and the vector d_n. The first equation is the marginal cost equation and sets the first derivative to x_{no} of the profit function (1) to zero:

$$\mathbf{p_{no} + \ Subs_{no} \ a_n = Q_n x_{no} + d_n} \qquad (2)$$

The second equation employs the observed average as follows:

$$\mathbf{c_{no} = Q_n x_{no}/2 + d_n} \qquad (3)$$

with c_{no} the vector of observed average variable costs per activity.

The observed variable costs from the FADN include seeds, fertilizers, pesticides, contract work and land.

These two equations can calibrate the diagonal matrix Q and the vector H for each farm in the sample as follows:

$$\mathbf{Q_n} = 2\,(\mathbf{p_{no}}\,\mathbf{x_{no}}' + \mathbf{Subs_n}\,\mathbf{a_n}\,\mathbf{x_{no}}' - \mathbf{c_n}\,\mathbf{x_{no}}')\,(\mathbf{x_{no}}\,\mathbf{x_{no}}')^{-1} \tag{4}$$
$$\mathbf{d_n} = \mathbf{p_{no}} + \mathbf{Subs_n}\,\mathbf{a_n} - 2\,(\mathbf{p_{no}}\,\mathbf{x_{no}}' + \mathbf{Subs_n}\,\mathbf{a_n}\,\mathbf{x_{no}}' - \mathbf{c_n}\,\mathbf{x_{no}}')\,(\mathbf{x_{no}}\,\mathbf{x_{no}}')^{-1}\,\mathbf{x_{no}} \tag{5}$$

The final step of PMP concerns simulation and optimizes therefore the calibrated profit function (1) added with the following land constraint defined over all *n* farms:

$$\Sigma\,\mathbf{a_n}'\,\mathbf{x_n} = \text{total available land in the region.} \tag{6}$$

Because one land constraint applies to the *n* farms in the sample, the model allows for competition and transaction of land among farms. Furthermore, the model assumes that farms cannot start activities not recorded during the base period. As a result, each farm can either re-allocate land among base period activities or trade land to other farms included in the sample. The cost function comprises the costs of land of the reference period. Therefore, the dual of the land constraint is zero for observed data.

2. Sugar Quota Modelling

Under the sugar Common Market Organisation (CMO), the EU imposes a quota system for sugar supply of sugar factories. The sugar factories distribute the delivery rights to the sugar beet growers. Through the CMO, supply within "A" quota receives full price support, only discounted by a 2% producer levy. Supply within "B" quota receives lower price support due to a maximum of 39.5% producer levy charged on the intervention price. Sugar beet supplied beyond the combined A and B quotas is called "C" sugar beet and has to be exported at international prices without refund (see details in Commission of the European Communities, 2003).

While factories in most Member States apply the classical A, B, C quota system, sugar factories in Belgium offer pooled A and B prices for all quota beets to beet growers. Also in the last Commission proposal, (Commission of the European Communities, 2004) merging A and B quotas into one single quota simplifies the quota arrangements. Consequently, in this paper, index A applied to sugar beet quantities and prices refers to the pooled price or quantity.

2.1 Quota Rent

The first challenge in modelling sugar beet is the calculation of the marginal costs. The basic modelling approach of previous section is not sufficient because the marginal cost – price equilibrium is not satisfied for sugar beet. The quota constraint holds sugar beet growers back from supplying sugar beet up to the point where marginal cost equals the price.

The quota rent, which is the difference between the price and the real marginal cost, can however not be directly observed. Therefore, the model employs the differences between the observed gross margin of sugar beet and the second best alternative crop as approximation for the quota rent. During calibration, SEPALE uses the average rent of five years. Winter wheat, potatoes and chicory are in most cases the second best alternative activity. Observed prices and the approximated quota rents allow for calibration to the real marginal costs.

Figure 1 illustrates the distribution of the average estimated quota rents of the Belgian sugar beet farm sample. Such a broad distribution in quota rents results from transaction costs in the quota transfers as reported in Bureau et al. (1996).

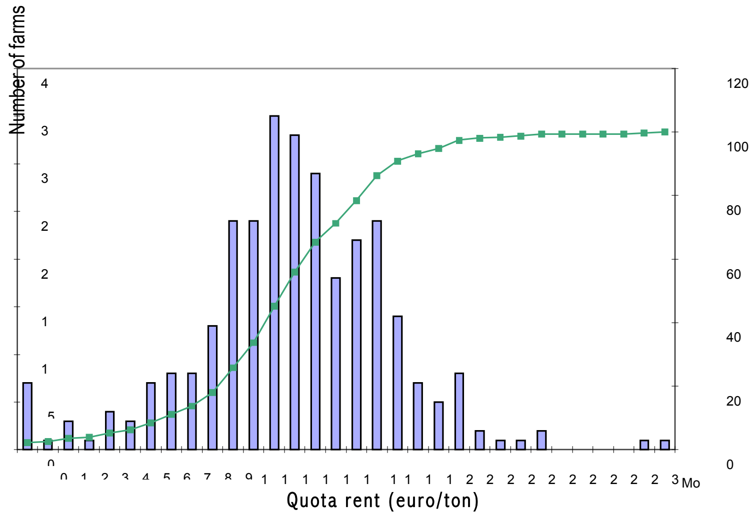

Figure 1. Distribution of the calculated average quota rents for sugar beets over the Belgian FADN sample (1996-2000)

2.2 C Sugar Beet Supply

The second challenge for sugar beet modelling is dealing with the supply of C sugar beet. Each sugar beet grower in the Belgian FADN sample supplies a certain amount of C sugar beet, which means that the quota constraint is binding at each farm. On the other hand, experts indicate that sugar beet supply at world market price is not profitable in Belgium. The observed supply of C sugar beet has several, difficult to measure, motivations.

A first reason is the loss of profit from undersupply in one particular year. Sugar beet growers consider quota as opportunity costs that remain constant even for undersupply. Consequently, they try to use each year their quota at its maximum potential, resulting in a significant amount of C sugar beet supply in a good harvest year.

A second reason for C sugar beet supply is the precautionary behaviour to avoid persistent supply lower than A and B sugar beet quota delivery right. In that case, the sugar beet grower loses a part of his delivery right to the sugar factory.

Yield uncertainty can explain both mentioned motivations. While modelling explicitly the undersupply and the resulting loss of profit related to yield uncertainty is possible (Adenauer et al., 2004), modelling explicitly the need for persistent supply to avoid a quota cut involves dynamic adjustments and is therefore be very complicated.

Additional explanations for C sugar beet supply are the land allocation discontinuity and fixed costs (Adenauer et al., 2005).

Buysse et al. (2004) deal with C sugar beet supply by the introduction of a fixed precaution coefficient, by assuming that the supply between 100% and 110% is motivated by precautionary behaviour. Not only this threshold of 10% is quite arbitrary chosen, it also remains constant during simulation. Frandsen et al. (2003) assume that farmers overshoot their quota by an amount corresponding to two times the standard deviation of variation in total production for their country. Frandsen et al. (2003) also do not take the changes in precautionary behaviour resulting from price or quota reductions into account. Adenauer et al. (2004) apply a stochastic approach considering explicitly the yield variation. The authors indicate however that optimizing of expected utility alone does not explain the C sugar beet supply. To overcome this problem Adenauer et al. (2004) add virtual quota.

In the conclusion, Buysse et al. (2004) suggests to use a variable precaution threshold. The mentioned motivations indicate that C supply is most likely a function of the quota amount, the quota rent and farm characteristics. These farm characteristics can include the managers risk adverse behaviour, under delivery penalty perception, production variability and plot size. The presentation of the precautionary supply function is then as follows:

$$x_c = f(\text{rent}, x_a, \text{farm dependent coefficient}) \quad (7)$$

The precautionary supply function should satisfy two properties. First, when the rent or the supply within A and B sugar quota becomes zero, C sugar beet supply should also equal zero. Secondly, C sugar beet supply should be increasing with quota and the rent. The simplest relationship satisfying these two necessary properties (10) extends following farm level sugar beet profit function (8) in algebraic notation:

$$\prod = p_a\, x_a + p_c\, x_c - q/2\, (x_a + x_c)^2 - d\, (x_a + x_c) - l\, a\, (x_a + x_c) \quad (8)$$

subject to:

$$x_a \leq m \quad (9)$$

$$x_c = s\ r\ x_a \quad (10)$$

with

p_a: the pooled price of A and B sugar beet,
p_c: the price of C sugar beet,
x_a: the supply of A and B sugar beets,
x_c: the supply of C sugar beets,
q: the quadratic cost function parameter,
d: the linear cost function parameter,
l: dual from the global land constraint reflecting changes in land price,
a: inverse of yield,
s: farm dependent precaution coefficient,
r: rent on A and B quota
m: A and B sugar beet quota
$x_a \geq 0$; $x_c \geq 0$; $r \geq 0$

Note that the two variables x_a and x_c are introduced in a single quadratic cost function because they depend on the same activity.

The precautionary supply function (7) could have other functional forms than (10). A better option is to choose a more flexible form including quadratic terms. However, as this requires also better estimation techniques and more data for calibration, SEPALE retains currently the simplest representation.

Due to constraint (10), the model (8)-(10) cannot be optimized directly because the rent parameter in the second constraint (10) of the primal model should equal the dual variable of the first constraint (9). Rewriting the model in its complementary slackness conditions can overcome the problem of the primal optimisation approach. Subsequently, during optimization, the dual of the quota constraint equates the rent parameter. Following equations are the complementary slackness conditions for the sugar beet profit function:

$$[p_a + p_c\, s\, r - q\,(1 + s\, r)^2\, x_a - d\,(1 + s\, r) - l\, a\,(1 + s\, r)]\, x_a = 0 \qquad (11)$$
$$(m - x_a)\, r = 0 \qquad (12)$$

Calibration determines the farm dependent parameters q, h and f. The price parameters p_a and p_c are available for the base year and are externally determined for simulation. x_a, x_c, r and c are variable during simulation.

The model calibrates as follows. First, the parameter f is calculated using following equation.

$$s = x_{co} / (r_o\, x_{ao}) \qquad (13)$$

x_{co}: observed C sugar beet supply
x_{ao}: observed A and B sugar beet supply
r_o: estimated rent

The average cost and marginal cost equations calibrate similarly as for other activities the parameters q and d. The marginal cost equation sets the first derivative to x_a of the sugar beet profit function to zero as follows:

$$p_a + p_c\ s\ \ r\ - q\ (1 + s\ \ r)^2\ x_a - d\ (1 + s\ \ r) = 0 \qquad (14)$$

The second equation equates the implied averages costs in the simulation model to the observed average costs as follows:

$$q/2\ (1 + s\ \ r)^2\ x_a - d\ (1 + s\ \ r) = c_{sugar\ beet} \qquad (15)$$

with $c_{sugar\ beet}$ the observed average variable costs for sugar beet.

Note that the dual of the land constraint is zero for observed data and therefore does not appear in equation (14) and (15).

The simulations of section 3 of this paper use calibrated equations (11) and (12) combined with all other calibrated equations into their complementary slackness representation. This gives following final simulation model with a dummy objective function:

$$[p_{na} + p_{nc}\ s_n\ \ r_n\ - q_n\ (1 + s_n\ \ r_n)^2\ x_{na} - d_n\ (1 + s_n\ \ r_n) - l\ a_n\ (1 + s_n\ \ r_n)]\ x_{na}\ = 0 \qquad (16)$$

$$(m_n - x_{na})\ r_n = 0 \qquad (17)$$

$$[\mathbf{p_{no}} + \mathbf{Subs_{no}}\ \mathbf{a_n} - \mathbf{Q_n}\ \mathbf{x_n} - \mathbf{d_n} - l\ \mathbf{a_n}]\ \mathbf{i}\ \mathbf{x_n} = \mathbf{o} \qquad (18)$$

$$\Sigma_n\ \mathbf{a_n}'\ \ \mathbf{x_n} = \Sigma_n\ \mathbf{a_{no}}'\ \ \mathbf{x_{no}} \qquad (19)$$

with
i: (j x 1) a unit vector
o: (j x 1) vector of zeros

If, for some reason, the complementary slackness representation is not possible an alternative approach exists. A function of all other variables in the model, obtained for the partial derivative to x_a of the Langrangean of the sugar beet profit function, can determine the rent of the sugar beet quota as well, as illustrated in equation (20).

Lagrangean = $p_a\ x_a + p_c\ s\ \ r\ \ x_a - q/2\ (x_a + s\ \ r\ \ x_a)^2 - d\ (x_a + s\ \ r\ \ x_a) - l\ A\ (x_a + s\ \ r\ \ x_a) - r\ x_a + r\ m$

$$\partial L\ /\ \partial\ x_a = 0$$
$$\Rightarrow$$
$$r = p_a + p_c\ s\ r - q\ (1 + s\ r)^2\ x_a - d\ (1 + s\ \ r) - l\ A\ (1 + s\ r)$$
$$\Rightarrow$$
$$r = p_a + p_c\ s\ r - q\ (1 + 2\ s\ r + s^2\ r^2)\ x_a - d\ (1 + s\ r) - l\ A\ (1 + s\ r)$$
$$\Rightarrow$$
$$q\ x_a\ s^2\ r^2 + (1 - p_c\ s + 2\ s\ q\ x_a + d\ s + l\ A\ s)\ r - p_a + d + q\ x_a + l\ A = 0$$

$$\Rightarrow$$

$$r = [-(1 - p_c\, s + 2\, s\, q\, x_a + h\, s + l\, A\, s) + ((1 - p_c\, s + 2\, s\, q\, x_a + d\, s + l\, A\, s)^2 - 4\,(q\, x_a\, s^2)(q\, x_a + d + l\, A - p_a))^{1/2}] / (2\, q\, x_a\, s^2) \quad (20)$$

The rent equation (20) extends model (8)-(10) as an additional constraint. Equation (20) ensures that during optimization the rent in constraint (10) is always equal to the dual of the quota constraint (9). As the rent still depends on the change of land price, it is necessary to delete the land constraint (6) and replace this constraint with a loop over the optimisation model. The loop adapts the land price until all available land is used.

2.3 Quota Transfers

The third challenge is modelling the quota transfers. Sugar factories in Belgium, that distribute the delivery rights, intervene and transfer delivery rights when a sugar beet grower supplies consistently less than his A and B sugar beet quota.

The model simulates these transfers controlled by sugar factories. The quota exchange mechanism works in such a way that when some beet farms do not use the complete sugar quota, the unfilled quota shift to other beet farms. A loop in the model performs this redistribution process.

Each iteration of the loop optimizes the simulation model (16-19). The loop of optimisations ends when the supply of A and B sugar beets equals the total available A and B sugar beet quota for the region. During that exchange, sugar beet quota goes from beet farms with a lower margin on sugar beet to beet farms with a higher margin on sugar beet.

3. Impact Analysis

An impact analysis of possible sugar reforms uses the approach presented in section 2. The analysis employs a FADN sub-sample of 51 Belgian farms specialised in arable crops, retaining only farms with more than 80% of their output from arable crops. The average farm size is 53 ha and the most important crops in land use are cereals and sugar beet. Note that due to the limited sample size, extrapolation to the Belgian agricultural sector is not possible. Simulation results can however give more insight in the mechanisms behind the sugar quota modelling approach from section 2. Therefore, the application analyses the effect of quota reductions, price cuts and combined quota and price reductions with or without coupled or decoupled subsidies.

The base period is year 2000 and the reference scenario is the mid-term review (MTR) of Agenda 2000 as applied in 2009. The MTR in Belgium implies total decoupling of subsidies for arable crops. Table 1 summarizes the observed supply levels in the 2000 base year and the simulated supply levels in the 2009 reference scenario. As expected, decoupling of direct subsidies leads to a supply reduction of subsidized crops such as cereals, pulses and oilseeds and a supply increase of most other crops. The precautionary C sugar beet supply also increases due to the enlarged quota rent. A and B sugar beet supply remain limited by quota and stay therefore constant with respect to the base year.

Table 1. Changes in the supply for the sample as a result of the mid-term review

	Observed land use	Simulated land use in the reference scenario	Difference (%)
Cereals	1101	1019	-7
A and B sugar beet	586	586	0
C sugar beet	70	95	36
Potatoes	448	478	7
Industrial crops	173	198	15
Summer cereals	142	131	-8
Other crops	127	120	-5
Wet pulses	66	88	32
Maize	28	31	12
Oil seeds	17	15	-11
Pulses	13	10	-25

3.1 Impact Analysis of Quota Reductions

Figure 2 and Figure 3 illustrate the impact of a sole quota reduction on the sugar beet quota rent and on the sugar beet supply. A quota reduction induces an increase of the sugar beet quota rent. The supply of C sugar beet responds positively to the quota rent increase and negatively to the A and B sugar beet quota reduction. Figure 3 shows that the effect of the quota rent is larger than the quota reduction, implying an increase of the precautionary C supply. The C supply increase can however not compensate completely the supply reduction of A and B sugar beet and therefore total sugar beet supply declines.

The total sugar beet supply reduction in Figure 3 is stronger than the supply reduction induced by a quota reduction in Buysse et al. (2004) where a fixed precaution coefficient is applied. Current approach allows each sugar beet grower to increase the precautionary C sugar beet supply, while in Buysse et al. (2004) only the sugar beet growers with observed supply of more than 110% of their quota increases the C sugar beet supply. The results demonstrate that the response of sugar beet growers assumed to have very low marginal costs is much larger than the precautionary C sugar beet supply.

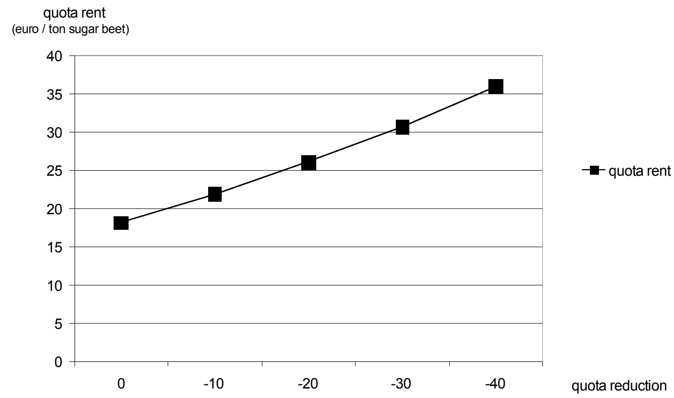

Figure 2. Impact of quota reductions on the average quota rent

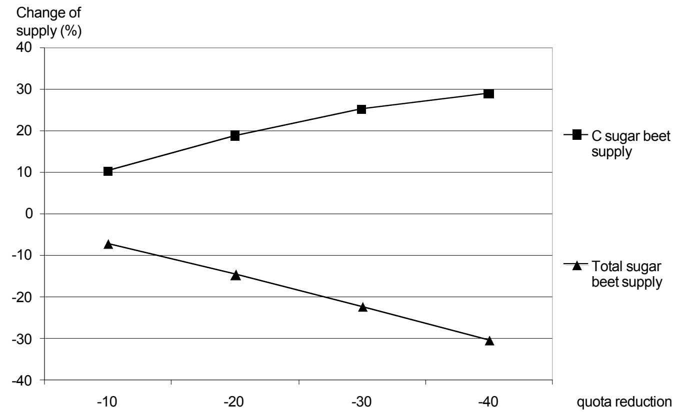

Figure 3. Impact of quota reductions on the C and total sugar beet supply

3.2 Impact Analysis of Price Reductions

Figure 4 shows the declining quota rents as a consequence of pooled A and B sugar beet price reductions. The average quota rent remains positive for an A and B sugar beet price reduction of 40%. For the price cut of 40%, only 3 of the 51 sugar beet growers have a zero rent on their quota and a part of their quota is transferred to other sugar beet growers. For a pooled A and B sugar beet price reduction of 50% the average quota rent is still positive, but 18 of the 51 sugar beet growers in the sample do not fill their quota any more.

Figure 5 illustrates the reductions of both total sugar beet supply as the C sugar beet supply due to pooled A and B price reductions. Precautionary C sugar beet supply declines sharply. There is only a moderate total sugar beet supply decline because the main sugar beet supply depends on A and B quota. While in Buysse et al. (2004) supply reduction induced by price reductions is only the result of quota transfers, in current approach the decline in precautionary C sugar beet supply causes the drop in total sugar beet supply. Quota rents decline sharperly when there are quota transfers. Therefore, in current approach, quota transfers merely enlarge the decline of precautionary C sugar beet supply.

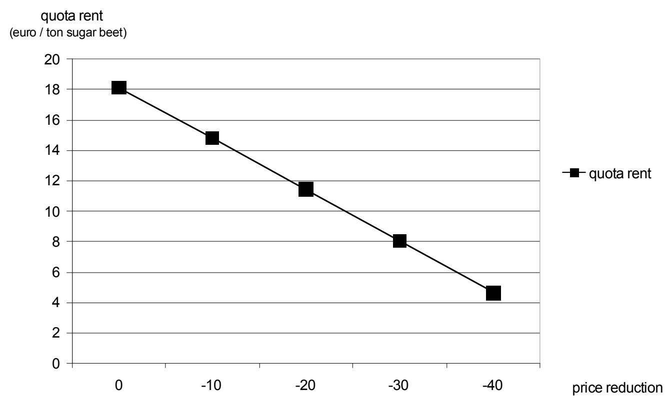

Figure 4. Impact of price reductions on the average quota rent

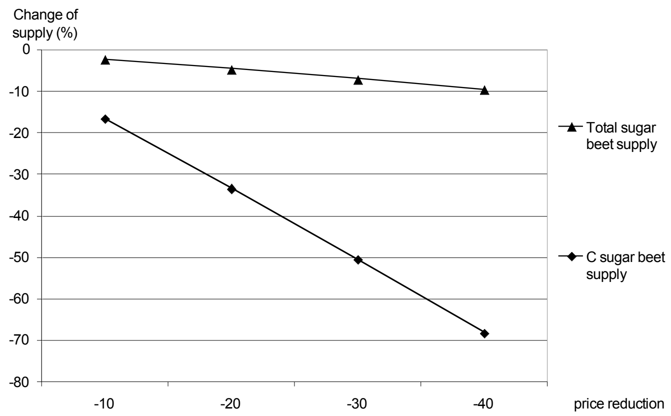

Figure 5. Impact of price reductions on the C and total sugar beet supply

The main conclusion of the comparison of price and quota reductions is that quota reductions induce a larger decline in supply than pooled A and B sugar beet price cuts, which sounds logical by comparing the change in marginal revenue of both types of policy decisions. A 1% reduction in the A and B pooled price results in a 1% decline in marginal revenue while a 1% reduction in quota results in a more than 60% decline in marginal revenue. With a 1% pooled price reduction, the price of the last unit supplied declines from 50 euro to 49.5 euro, while with a 1% quota reduction the price of the last unit supplied decreases from 50 euro to less than 20 euro.

3.3 Impact Analysis of Combined Quota and Price Reductions

The third impact analysis deals with a combination of equal price cuts and quota reductions. The results for the quota rent are illustrated in Figure 6 and supply effects are illustrated in Figure 7. Pooled A and B sugar beet price reductions cause a quota rent decline while quota reductions induce a quota rent increase. The net result, illustrated in Figure 6, is a small quota rent increase. Due to the rent increase, no transfers of quota are observed, even for a price and quota reduction of 40%.

Both the quota and the quota rent influence the precautionary C sugar beet supply. Because the quota rent increase is relatively smaller than the reduction of the A and B sugar beet quota, the precautionary C sugar beet supply decreases. Total sugar beet supply also declines but less than the quota reduction and less than the sum of the effects of the single price cuts and quota reductions.

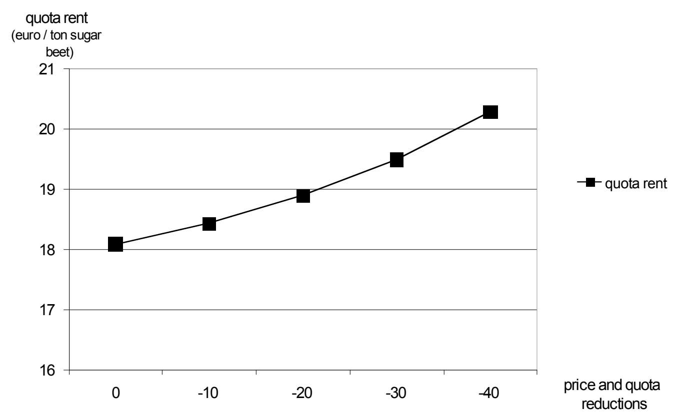

Figure 6. Impact of equal price and quota reductions on the average quota rent

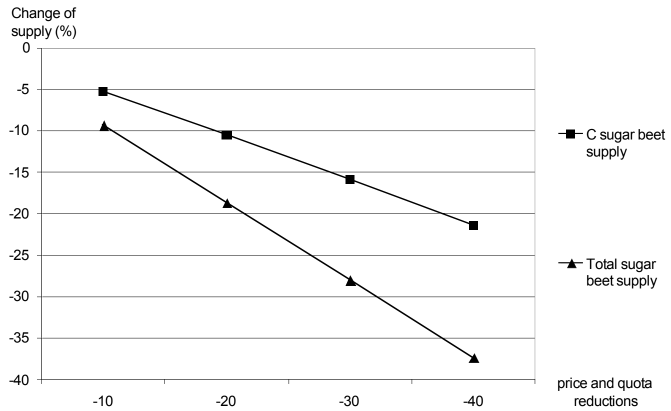

Figure 7. Impact of price and quota reductions on the C and total sugar beet supply

3.4 Impact Analysis of Coupled versus Decoupled Price Reduction Compensations

The fourth and last impact analysis involves coupled and decoupled compensations of pooled A and B sugar beet price reductions. This impact analysis employs a quota reduction of 16% and a pooled A and B sugar beet price cut of 37% as proposed by Commission of the European Communities (2004). Coupled or decoupled subsidies compensate 0-100% of the price cuts.

The sugar beet quota rent increases from 11.2 euro to 24.3 euro in case of a 100% coupled compensation and to 17.3 euro for a 100% decoupled compensation, as shown in Figure 8. The lower rent for decoupled compensations has two reasons. The most important reason is that subsidies directly linked with the sugar beet activity are higher with a coupled compensation. The second reason is that decoupled compensation increases decoupled subsidies for the other activities, resulting in a higher land price. The higher land price induces a decrease of the quota rent.

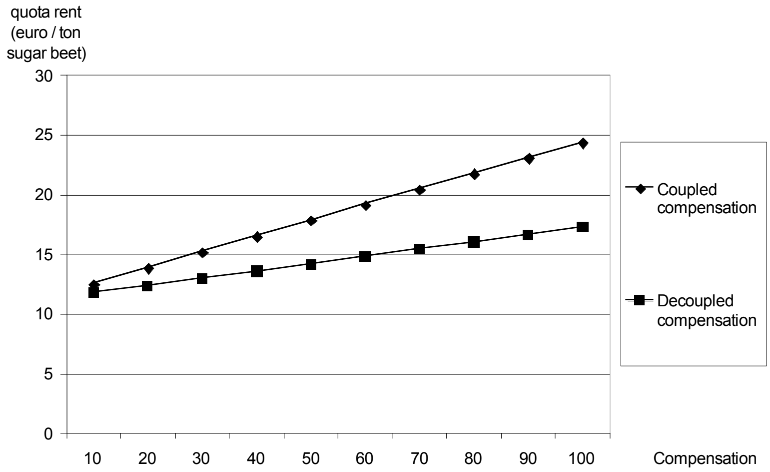

Figure 8. Impact of coupled or decoupled compensation on the average quota rent for a quota reduction of 16% and pooled A and B price reduction of 37%

Compensation leads through a higher quota rent also to a higher precautionary C sugar beet supply, as illustrated in Figure 9. The C sugar beet supply increase is higher for higher compensations and higher with a coupled compensation than with a decoupled compensation.

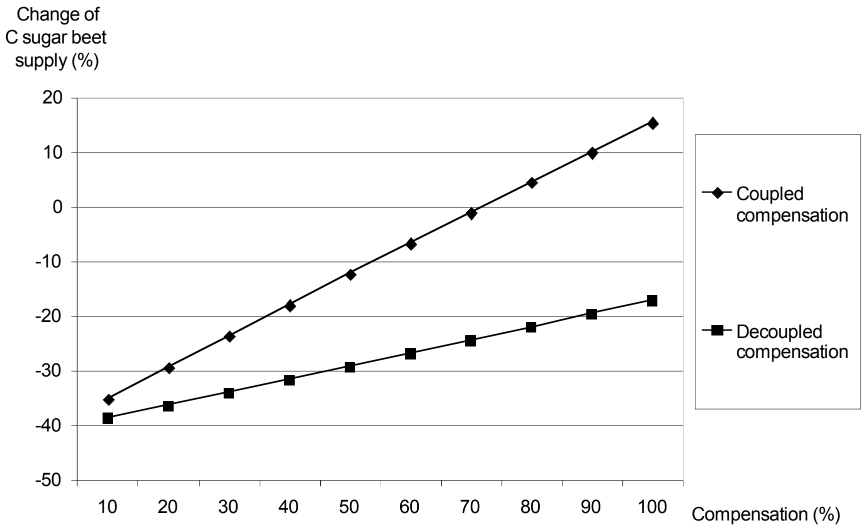

Figure 9. Impact of coupled or decoupled compensation on the C sugar beet supply for a quota reduction of 16% and pooled A and B price reduction of 37%

4. Dairy Quota

Other quota types, such as dairy quota, could also benefit from the quota modelling approach with precautionary supply function. The SEPALE model assumes, currently, that supply of milk does not change due to the high quota rent. Nevertheless, also milk supply depends on some risk behaviour and thus on the quota, quota rent and farm characteristics.

Milk quota are different from sugar quota because there is a high penalty for oversupply. Through undersupply of some dairy farms each year a certain amount of oversupply is free from this penalty, calculated after the end of the milk quota year.

The penalty of oversupply is so high that intentional oversupply beyond the penalty limit can never occur. Intentional supply near the limit of the amount free from penalty depends on speculation whether the national quota are be filled or not.

The precautionary supply approach applied for sugar beet can also simulate this speculative behaviour from dairy farms, through following farm level milk supply profit function:

$$\prod = p\ (x + x_q) - q/2\ (x + x_q)^2 - d\ (x + x_q) - c\ A\ (x + x_q) \qquad (17)$$

subject to:

$$x \leq m \qquad (18)$$
$$x_q = g\ x + s\ \ r \qquad (19)$$

with

p: the price of milk,
x: the deterministic supply of milk without speculative behaviour,
x_q: the supply of milk induced by speculative behaviour,
q: the quadratic cost function parameter,
d: the linear cost function parameter,
c: dual from the global land constraint reflecting changes in land price,
A: inverse of yield,
s: farm dependent precaution coefficient,
g: level of undersupply if the quota rent is zero,
r: rent on milk quota
m: milk quota
$x \geq 0;\ s \geq 0;\ g \leq 0;\ r \geq 0$

The main distinction between the approach applied for sugar beet quota and the approach for milk quota is that x_q is not strictly positive. Some dairy farms have an average undersupply due to risk aversion and stochastic factors. Due to the increased variability, the undersupply also increases with increasing supply. Therefore, the precautionary supply function has two parameters of which g is negative and multiplied by the deterministic supply x. Oversupply is related to the rent of quota and increases with increasing rent. The coefficient s is for that reason positive.

A second distinction between sugar beet and milk is the estimation of the quota rent. Many dairy farms are specialized and therefore a comparison with the second best activity, as has been done for sugar beet, is not possible. An alternative approach could be the use of the information of sold and bought quota.

Conclusions

Adapting a farm level positive programming model for quota implies three challenges: i) estimation of the quota rent, ii) simulating over- or undersupply and iii) quota transfers.

In an application modelling sugar beet, Buysse et al. (2004) use quota rents approximated by the difference between the gross margin of sugar beet and the gross margin of the second best activity. Zero quota rents during simulations initiate quota transfers from sugar beet growers with lower initial quota rents to sugar beet growers with higher quota rents.

To deal with quota oversupply Buysse et al. (2004) employ in a first approach a fixed precaution coefficient. In the conclusion, Buysse et al. (2004) suggest to apply a precautionary C – supply that is a function of quota rent, quota and farm characteristics. Current paper extends the approach of Buysse et al. (2004) by the introduction of the precautionary supply function. Consequently, the applied approach is able to deal with the three main challenges in quota modelling.

Simulation results show that sugar beet supply responds inelastic to pooled A an B sugar beet price reductions, but more elastic than in case of a fixed precaution coefficient such as in Buysse et al. (2004) or Frandsen et al. (2003), which can be explained by the decrease of precautionary C sugar beet supply. Sugar beet supply is more sensitive to quota reductions than to pooled A and B sugar beet price reductions. The decline in sugar beet supply induced by a sugar beet quota reduction is larger with current approach than in Buysse et al. (2004).

Section 4 demonstrates that the approach applied for sugar beet could also be useful for other types of quota, such as dairy quota. Estimation of the quota rent, precautionary parameters and the quota transfer mechanism can be different, but the general structure of the methodology remains very similar.

The main improvement to the proposed approach would be the introduction of more flexibility in both the profit function as in the precautionary supply function. The profit function should allow for input substitution and cross effects between activities other than the competition for limiting inputs. The precautionary supply function is currently the simplest available, but it would be better to extend the function with quadratic terms. Calibration of a more complex and flexible functions requires however additional data or estimations as well.

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