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The impact of quota rent and supply elasticity estimates for EU dairy policy evaluation: a comparative analysis

Die Auswirkungen von Annahmen über Quotenrenten und Angebotselastizitäten auf die Bewertung der EU-Milchmarktpolitik: eine vergleichende Analyse

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Abstract

The aim of this paper is to gain better insights in the implications of some of the most important economic assumptions and empirical choices made in partial equilibrium models focusing on dairy. Three partial equilibrium models are considered: the AGricultural Member states MODeling (AGMEMOD) model, the Common Agricultural Policy SIMulation (CAPSIM) model, and the European Dairy Industry Model (EDIM). This paper analyses how quota rent and supply elasticity estimates, as they are used in these models affect milk output and price projections. Sensitivity analysis is also considered in order to take into account uncertainty in quota rent and supply elasticity estimates. Taking into account the considered uncertainty our best estimate is in case of abolishing the quota the EU's aggregate milk production will expand, with the increase being somewhere in the range between 5 and 15%.

Key words

milk quota rent; milk supply elasticity; dairy policy; partial equilibrium models

Zusammenfassung

Das Ziel dieses Beitrags ist es, am Beispiel des Milchmarkts die Auswirkungen wichtiger ökonomischer Annahmen in partiellen Gleichgewichtsmodellen zu untersuchen. Wir beziehen drei Modelle in die Analyse ein: das Agricultural Member states MODeling (AGMEMOD)-Modell, das Common Agricultural Policy SIMulation (CAPSIM)-Modell sowie das European Dairy Industry Model (EDIM). Untersucht wird der Einfluss von Annahmen über die Quotenrenten und die Angebotselastizitäten, wie sie in diesen Modellen zwecks Projektion der Milchmenge und des Milchpreises getroffen werden. Der Unsicherheit bei der Schätzung von Quotenrenten und Angebotselastizität wird durch Sensititätsanalysen Rechnung getragen. Unter Berücksichtigung der bestehenden Unsicherheit lautet die beste Schätzung für den Fall der Abschaffung der Milchquote, dass die Milcherzeugung in der EU in einem Umfang von 5 bis 15 % ausgedehnt werden wird.

Schlüsselwörter

Milchquotenrenten; Angebotselastizität; Milchmarktpolitik; partielle Gleichgewichtsmodelle

* Disclaimer: The views expressed are purely those of the authors and may not in any circumstances regarded as stating an official position of the European Commission.

1. Introduction

Milk quotas were introduced in the European Union (EU) on 1 April 1984.[1] Despite several critiques on the consequences of milk quotas[2], the Council decided under the Luxembourg agreement to extend the milk levy until 31 March 2015. In the so-called Common Agricultural Policy (CAP) 'Health Check' (HC) the European Commission has recently proposed gradual transitional measures to allow a 'soft landing' of the milk sector to quota expiry (COMMISSION OF THE EUROPEAN COMMUNITY, 2008).

When modelling dairy policies, knowledge on the issues mentioned in the following is required. First is the marginal cost of milk production.[3] Low marginal costs (or alternatively high quota rents) signal competitiveness and increase the probability of a positive output response in case of abandoning the milk quota. Second are the milk supply elasticities, which determine the slope of the supply function and therewith the change in output due to a change in the price. Third are the supply shifters which are affecting the position of the supply curve and its movement over time. The final supply response will most likely consist of a combined change along the supply curve and shift of the supply curve. Lastly, the final equilibrium quantity will also be codetermined by the interaction with the demand for dairy products.

The aim of this paper is to gain better insights in the implications for the final results of some important assumptions and empirical estimates used in dairy partial equilibrium (PE) models. Three models that have been used for policy analysis, are considered: the AGricultural MEmber states MODeling (AGMEMOD) model (see for further details CHANTREUIL et al., 2008), the Common Agricultural Policy SIMulation (CAPSIM) model (see for further details WITZKE and TONINI, 2008), and the European Dairy Industry Model (EDIM) (see for further details BOUAMRA-

[1] The objectives of milk quotas were to curb production, limit budget pressure, maintain market price support and ensure revenue stability for dairy farmers. For a historical overview on milk quotas, see BIANCHI (2004).

[2] Notably: protection of inefficient dairy farms, capitalisation of milk quotas into land and support in the farm assets.

[3] Note that when we assume the system to be 'in equilibrium' marginal cost it is likely to coincide with the minimum locus of the average cost curve (no profits).

MECHEMACHE et al., 2008a, b). All three models have recently been used to support the evaluation of the EU's dairy policy in advance of the HC. AGMEMOD and CAPSIM are agricultural multi-product PE models whereas EDIM is a dairy PE model.

The objective of the paper is to analyse to what extent different estimates of milk quota rents and supply elasticities used in dairy models explain differences in policy simulation outcomes between models. For this a stylized equilibrium displacement model (EDM) is developed and utilized. The analysis will in particular focus on the supply side. The comparison of the models' different milk quota rent and supply elasticity estimates will be made with reference to a common baseline and a common policy scenario: the abolishment of the milk quota regime. The empirical variation in estimates over models is used as a basis for sensitivity analyses.

The rest of this paper is organized as follows: section 2 briefly explains quota rents, the main approaches used to obtain estimates of the rental values of milk quota, and introduces the analytical framework used. Section 3 presents and discusses the rental quota values and supply elasticities used in the three models that will be compared. Section 4 shows and interprets the results of the comparative analysis. Finally, section 5 concludes with some concluding remarks.

2. The analytical framework

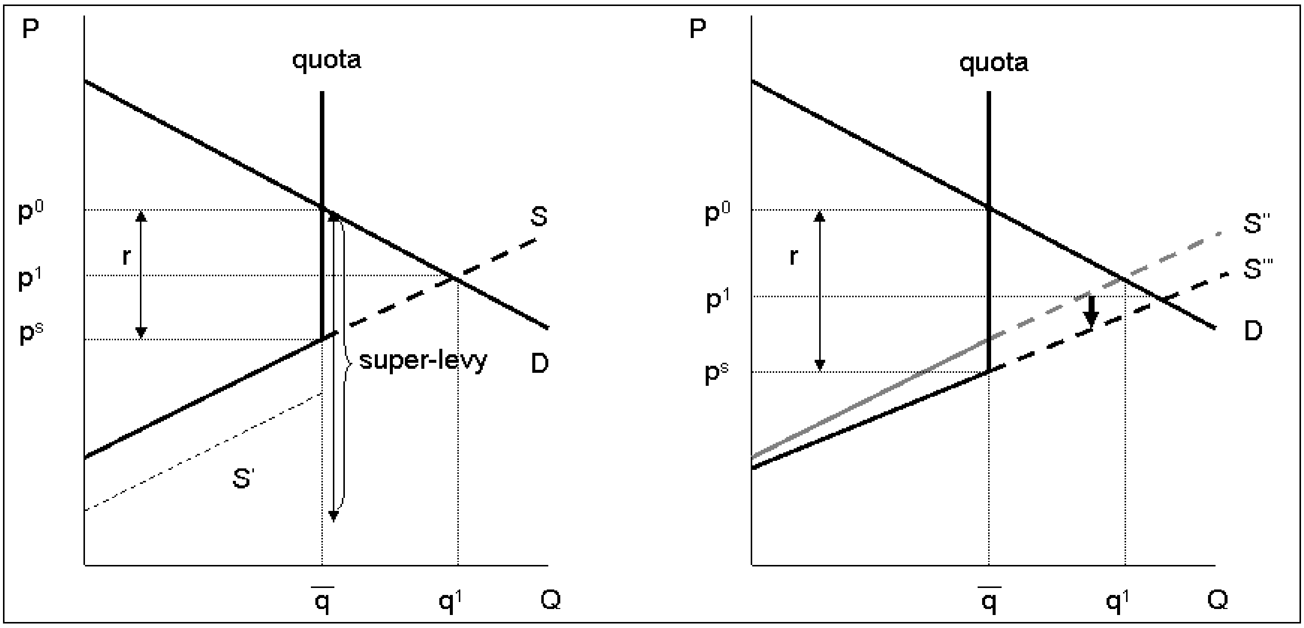
2.1 Milk quota rents

The aggregate quota rent can be defined as the discounted sum of the future stream of annual net benefits to milk producers which comes from maintaining the quota (OECD, 2005). It is, therefore, an income generating asset for the person who holds the quota. The annual quota rent coincides with the lease price a farmer would be willing to pay to hire quota. Quota rent identifies the amount of surplus generated by a restriction on supply, with levels dependent upon the current milk price at farm gate level, marginal costs, and the length of run (short, medium and long). When (binding) quotas are imposed on a market, this creates a difference between the milk market price (p^d) and the minimum price (i.e. marginal cost) necessary to produce an amount of milk equivalent to the binding quota level (p^s). See figure 1 for a graphical presentation. This difference represents the annual rental value of the quota, known as the lease price $r = p^d - p^s$.

When removing the quota constraint a new equilibrium will establish where demand equals supply (see the allocation denoted by p^1, q^1). As figure 1 shows in this case this will lead to an increase in milk production. The main reason is that although the milk market price p^d goes down the shadow value or virtual price for farmers p^s still shows an increase from p^s to p^1 which induces output to increase from $\overline{q}$ to q^1. The milk quota rental value is an important variable in dairy sector models. As can be easily verified from figure 1, the larger the initial quota rental value, the larger the expected milk output expansion in case of abolishment of the quota will be (e.g. difference between $q^1 - \overline{q}$).

Implementation of the milk quota regime into economic models usually proceeds as follows. In order to depict binding quotas, milk supply is usually fixed letting p^s be a free variable. Subsequently the price p^s is simply obtained by subtracting the estimated rental value r of the quota from the (observed) market price p^d. Given that marginal cost p^s is determined, and assuming the slope of the milk supply curve is already obtained by using elasticity information (or earlier econometric work), the intercept of the milk supply is calibrated. Therefore it is indispensable to use reliable information on milk quota rents. Information on

Figure 1. Quota, rental values and supply response



Panel a) Milk quota and dairy market **Panel b) Milk quota and supply inefficiencies**

quota rents can be retrieved following different approaches: the 'micro-econometric approach', the 'quota market approach', and a 'synthetic approach'. Each of the aforementioned approaches has its own characteristics.

The first 'micro-econometric approach' mostly estimates marginal cost functions by relying on market prices from the farm accountancy data network (FADN). Milk quota rent estimates are then derived by subtracting the marginal cost from market milk prices. Some of the most recent studies following this approach can be found in BOUAMRA-MECHEMACHE et al. (2002), INRA-WAGENINGEN CONSORTIUM (2002), COLMAN (2002), MORO et al. (2005), CATHAGNE et al. (2006), WIECK and HECKELEI (2007a, b). This approach needs micro-data and is relatively time-consuming, but explicitly takes into account the behaviour of the dairy farms and their heterogeneity.

The second 'quota market approach' can be followed in case quotas are freely tradable and well-functioning quota buying or lease markets are established. From this market then a milk quota price in terms of rent or lease prices can be extracted. In this case, marginal costs are estimated by the difference of milk price minus the rental/lease price. Quota market approaches require information on buying/selling or lease prices. If only buying/selling prices have to be used (which present an estimate of the net present value of the market access right associated with the quota) a number of assumptions (choice of discount rate and time horizon) are necessary to derive an estimate of the annual quota rental value. If lease prices are available, one should for example be careful with time: just before the expiration of the quota year they may be subject to incidental shocks or circumstances and not provide a realistic picture of the structural position of the sector. In addition the expectations of farmers play a role (among others with respect to the survival of the quota system). Finally, also the taxation regime imposed on farmers is likely to affect the farmers' willingness to pay for quota and might complicate the comparability over member states due to regime differences.

The third 'synthetic approach', consists of guesstimating the potentially occurring quota rental values at Member State (MS) level. Synthetic approaches heavily rely on expert judgements and lack direct empirical estimation but synthesises quota rental values based on various sources of information such as previous studies and recent market developments. This makes this approach sensitive to 'ad-hocery' and easily introduces some degree of arbitrariness. The approach might have, as an advantage over the two other approaches, that it is better capable of taking recent market developments and institutional changes into account (see also GRINSTED and NIELSEN (2004) for a further discussion of options for estimating milk quota rents).

Several important caveats have to be considered when introducing quota rent estimates in PE models. First, it will be often the case that the time period used to obtain the estimates does not directly match with the base year used for calibration of the supply model. Given the time lags with which data become available, in particular the 'micro-econometric approach' is likely to not be able to reflect the most recent market developments. So the obtained estimates, before being used into models need to be updated with respect to the appropriate time period. Second, one should check whether the specifications of the model used for projections and the micro-model used for estimation of the milk quota rental values match with respect to the time horizon used (length of run, similarity in selection of the sets of variable and quasi-fixed factors). Finally, in particular for the micro econometric approach, but to a lesser also for the other approaches, there is an issue of aggregation. Estimates obtained at farm level have often to be transformed in aggregate or sector estimates loosing information on farm heterogeneity. Without going into all technical details, this discussion makes clear that the estimation and use of the rental values of milk quota (and/or the marginal costs of milk production) is not trivial and always subject to a degree of uncertainty. In section 4 a sensitivity analysis is carried out in order to partially depict this uncertainty.

As regards their implementation, milk production quotas are imposed through the payment of a fine (the so-called super-levy) for each unit of milk a farmer produces in excess of his quota (COUNCIL REGULATION, 2003). If this rule is applied at farm level, it means that the producer gets the market price in the limit of his quota and for the excess production he will receive the market price minus the fine (see figure 1, panel a). Usually the fine is so large that the net return for a kilogram of surplus milk will by no means cover costs.[4] However, as can be recalled from figure 1 (left panel), if the farmer had a quota rent r larger than the super-levy it would be rational to produce in excess of his quota. If he overproduces, then the total quantity is such that the marginal cost of production (evaluated at this level of production) is equal to the market price minus the fine. In order to well-understand why systematic excess production (see figure 2) is observed in some EU countries it is important to also exactly know how this system is applied. The same holds for underproduction.[5] For example it must be known whether producers really pay the fine or only a part because this will determine at farm level the incentive to produce over the quota or not.

Another aspect of the way quotas are implemented is the current quota redistribution mechanism which is applied and which varies over member states. The effects of quota and its tradability on asset value has been analysed in BURRELL (1989), DAWSON (1991), BOOTS (1999) and COLMAN (2000), among others. Limits on quota trade (e.g. the use of the quota instrument by policy makers in such a way to artificially keep dairy production in non-competitive regions or member states) are likely to introduce inefficiencies in milk supply. As a consequence, when removing milk quota an efficiency gain effect might show up, implying a downward shift of the milk supply curve (see figure 1, right panel).

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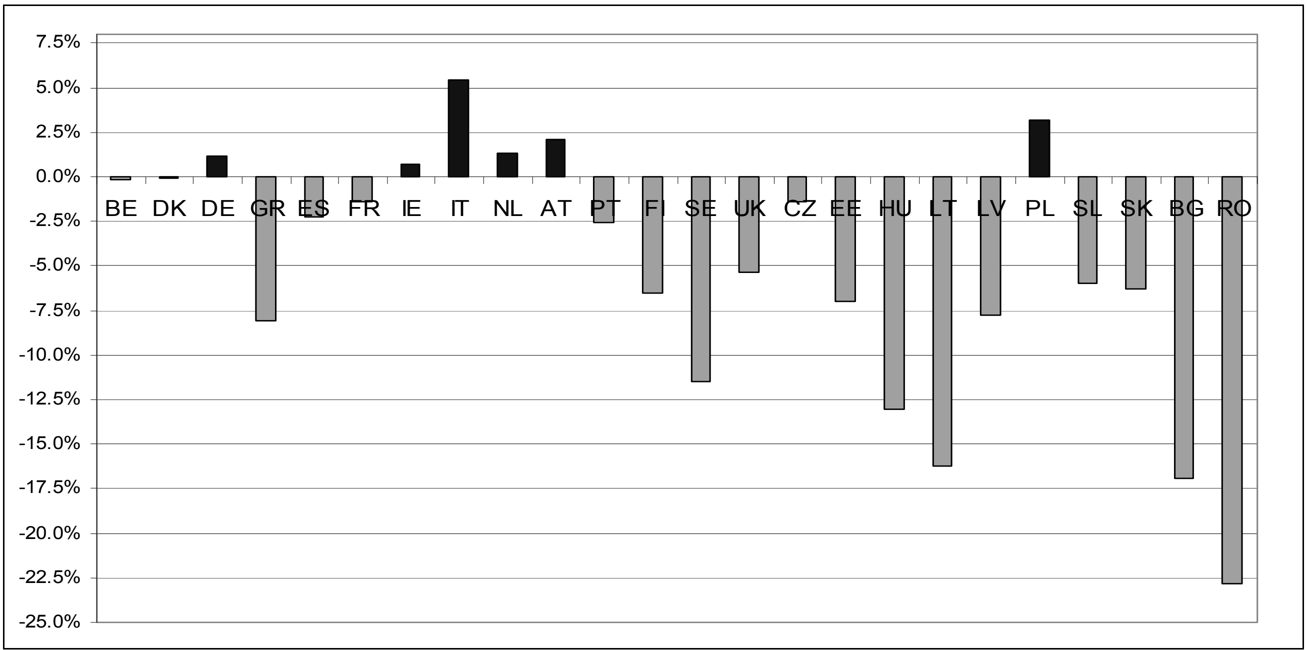
4 The superlevy for 2008 is expected to be 27.83 €/100 kg which corresponds to the fourth and final reduction from the initial 35.63 €/100 kg that applied before the 2003 Fischler reform (EUROPEAN COMMISSION, 2008).

5 According to figure 2, 18 out of 24 EU member states not completely fill their quota. See RÉQUILLART et al. (2008: 27-32) for a more elaborate discussion and an argument why a country which under-produces can still have a binding milk quota (regional constraints-effect). So there is not necessarily a one to one link between the actual observed fulfilment of the quota as displayed in figure 2 and the quota rent estimate used in the models (e.g. table 1).

Figure 2. Milk quotas total percentage overrun on total production (2007/08)



Source: EUROPEAN COMMISSION (2008)

2.2 The analytical equilibrium displacement model

To evaluate the impact of different estimates of quota rents and supply elasticities as they are used in the AGMEMOD, CAPSIM and EDIM models, a simple EDM is developed. EDMs are frequently used tools in agricultural policy analysis (e.g. SUMNER and WOHLGENANT, 1985; GARDNER, 1987; SUMNER, 2005). Since the main emphasis is on the supply side, the supply side is disaggregated at member state level, whereas demand is aggregated at EU level. Aggregate demand for milk is defined as

(1) $D = D(p^d, z^d)$,

where p^d represents the demand price (equals the market price) of milk and z^d a variable reflecting the impact of non-own price variables (such as income, preference shifter, etc.). Aggregate supply S consists of the MS (MS = *i*) supplies S_i as given by

(2) $S = \sum_{i=1}^{I} S_i = \sum_{i=1}^{I} S_i(p_i^s, z_i^s)$,

with p_i^s representing the MS milk supply prices, defined as the minimum price the dairy farmers need to produce an amount of milk equivalent to its binding quota. In case in a MS the milk quotas are not binding the supply price will equal the demand price. Similar as with demand, z_i^s denotes a supply shift variable, representing all non-own price factors (such as input prices, technological change, genetic progress in milk yields, etc.).

Equilibrium at the market, with binding milk quotas, occurs at situation where $p^d = p^s + r$ (see figure 1). Taking into account that there are several MSs, the equilibrium price conditions can be stated as:

(3) $p^d = p_i^s(1 + r_i), \quad i = 1,...,I$,

where r_i representing the MS specific quota rent expressed in terms of an ad valorem tariff equivalent. Finally, an equilibrium condition holds where

(4) $D = S$.

To investigate the impacts on the dairy sector from changes in sector, market and policy conditions, the total differential of each equation is taken and expressed in the form of relative changes ($dX / X = EX$) and elasticities based on the EDM framework. The set of demand, supply, price and equilibrium conditions can be restated as follows:

(5) $ED = \eta_p^d Ep^d + \eta_z^d Ez^d$,

(6) $ES = \sum_{i=1}^{I} \left(\eta_p^{s,i} Ep_i^s + \eta_z^{s,i} Ez_i^s \right)$,

(7) $Ep^d = Ep_i^s + \frac{r_i}{1 + r_i} Er_i \quad i = 1,...,\mathrm{I}$,

(8) $ED = ES$,

The model is solved then for the market price of milk (demand price) and the aggregate supply of milk. Substituting (5) and (6) in (8) yields

(9) $\eta_p^d Ep^d + \eta_z^d Ez^d = \sum_{i=1}^{I} \left(\eta_p^{s,i} Ep_i^s + \eta_z^{s,i} Ez_i^s \right)$.

Subsequently (7) can be used to rewrite (9) in terms of the market price of milk p^d as

(10) $\eta_p^d Ep^d + \eta_z^d Ez^d = \sum_{i=1}^{I} \eta_p^{s,i} \left[Ep^d - \frac{r_i}{1 + r_i} Er_i \right] + \sum_{i=1}^{I} \eta_z^{s,i} Ez_i^s$,

that can be solved for p^d as

$$(11)\quad Ep^d = \frac{\left[\sum_{i=1}^{I}\eta_z^{s,i}Ez_i^s - \eta_z^d Ez^d - \sum_{i=1}^{I}\eta_p^{s,i}\frac{r_i}{1+r_i}Er_i\right]}{\left(\eta_p^d - \sum_i^I \eta_p^{s,i}\right)}.$$

Assuming no changes in z_i^s and z^d equation (11) can be further simplified to

$$(12)\quad Ep^d = \frac{-\sum_{i=1}^{I}\eta_p^{s,i}\frac{r_i}{1+r_i}Er_i}{\left(\eta_p^d - \sum_i^I \eta_p^{s,i}\right)}$$

Note that the change in the EU market price of milk is a function of the MS specific quota rents and own price milk supply elasticities. As regards the supply side, note that in case of quota expiry the magnitude of the farm milk price decrease depends on the one hand on the magnitude of the quota rent and on the other hand on the slope of the supply curve (related to the price elasticity of supply). As equation (11) makes clear, exogenous shifters or other non-own price factors also play a role and their changes will affect the final equilibrium. Removing the milk quota in this framework comes down to decreasing the quota rents by 100% for all MSs in equation (12).

Given the solved change in the market price (12) and market equilibrium, the corresponding change in the EU's milk production can be obtained by substituting (12) (or 11 in case z-variables are non-zero) into (5) as

$$(13)\quad ES = ED = \frac{-\eta_p^d\sum_{i=1}^{I}\eta_p^{s,i}\frac{r_i}{1+r_i}Er_i}{\left(\eta_p^d - \sum_i^I \eta_p^{s,i}\right)}$$

where the change in the total milk supply is a function of the same variables as provided in the market price equation (12). With respect to the demand side, its slope (related to the price elasticity of demand) is also an additional important factor explaining the new equilibrium. Summarizing, the increase in production due to abolition of the quota is larger i) the higher the quota rent, ii) the more elastic the supply curve, and iii) the more elastic the demand curve.

Exploiting equations (5) to (8) and for convenience sake doing as if there is only one supplying country, allows to write the change in the quota rent as a function of changes in the demand price of raw milk and changes in exogenous shifter variables, as

$$(14)\quad Er = \frac{1+r}{r\eta_p^s}\left[(\eta_p^s - \eta_p^d)Ep^d + (\eta_z^s Ez^s - \eta_z^d Ez^d)\right]$$

So the quota rental value is a time dependent factor subject to dynamic changes in for example milk yields, exogenous demand shifts, etc.

3. Quota rents and supply elasticity estimates

This section continues with an overview on the milk quota rents used by AGMEMOD, CAPSIM, and EDIM. Also the quota rents used by the Global Trade Analysis Project (GTAP) are considered as additional reference. In addition the milk supply elasticities are also presented.

AGMEMOD (see for further details CHANTREUIL et al., 2008) calculates EU-15 MS milk quota rents as a difference from the actual fat content producer (raw) milk price from NewCronos (Eurostat) and the marginal milk production costs as estimated in RÉQUILLART et al. (2008). For the EU-12 milk quota rents are approximated by taking 10% of the quota lease price (as described by RÉQUILLART et al., 2008) and dividing it by the producer milk price. From the quota rents and milk prices in 2000, milk production costs are retrieved and projected into the future in order to give an annual milk cost index. The production cost index is determined by changes in feed costs and the other input costs.

CAPSIM (see for further details WITZKE and TONINI, 2008) uses as a default assumption the quota rent used by RÉQUILLART et al. (2008), calculated from milk prices and econometrically estimated marginal costs for the starting point of the recent simulation (i.e. 2008). This was done in order to reflect the current situation while removing short-run impacts such as the quota over-run for a given year. The simulated quota rent for 2008 used in EDIM are thus a more suitable starting point for a comparative static model like CAPSIM than, for example, the historical marginal costs and quota rents in 2005.

EDIM (see for further details BOUAMRA-MECHEMACHE et al., 2008a, b) uses the set of long run quota rents estimated by MORO et al. (2005). These estimates are for the EU-15 and based on a detailed micro-analysis using FADN data, consistently applying the same methodology to each EU MS. The estimated rents are updated for the relevant base year and some corrections were applied for countries where clear evidence was available about the quota's no longer being binding (for the UK and Sweden the quota rent for that reason was adjusted to zero).

From table 1 it appears that the weighted average of milk quota rents used by AGMEMOD, CAPSIM and GTAP are very similar whereas EDIM is using, on average, larger estimates. Table 1 also shows the by country average values over the three models and the associated coefficient of variation (CV). The calculated average CV over all member states (including only countries with non-zero mean) is 0.88, indicating a significant dispersion.

Since for the first eleven countries (Belgium-Finland) the average CV is 0.46, it is in particular 'disagreement' between the modellers whether countries have either zero (notably the CAPSIM and EDIM estimates for UK and Sweden) or non-zero (see AGMEMOD estimates for UK, Sweden and new member states Czech, Hungary, Poland and Latvia) quota rents that contribute to increasing the dispersion in the estimates.

In the GTAP computable general equilibrium model, instead of using only one set of estimated quota rents, LIPS and RIEDER (2005) prefer to rely on several sources. In so doing, they obtain estimates for the ratio between milk

Table 1. Milk quota rental values used in several equilibrium models (% milk prices)

Countries	AGMEMOD (1)	CAPSIM (2)	EDIM (3)	GTAP (4)	Average (1+2+3)	Coefficient of variation (1+2+3)
BE	34.3	30.3	46.7	20.0	37.1	0.23
DK	8.8	15.1	31.5	26.0	18.5	0.63
DE	20.2	10.3	45.4	20.0	25.3	0.71
GR	12.7	9.1	34.3	0.0	18.7	0.73
ES	29.5	42.1	40.9	24.0	37.5	0.19
FR	15.1	19.4	36.4	22.0	23.6	0.48
IE	35.0	27.6	36.0	31.0	32.9	0.14
IT	9.7	27.9	33.3	23.0	23.6	0.52
NL	36.0	48.2	43.6	23.0	42.6	0.14
AT	33.4	30.6	37.1	17.0	33.7	0.10
PT	8.6	14.1	19.9	0.0	14.2	0.40
FI	4.0	6.9	40.7	15.0	17.2	1.19
SE	15.0	0.0	0.0	10.0	5.0	1.73
UK	15.8	0.0	0.0	27.0	5.3	1.73
CZ	3.0	0.0	0.0		1.0	1.73
EE	0.0	0.0	0.0		0.0	
HU	3.0	0.0	0.0		1.0	1.73
LT	0.0	0.0	0.0		0.0	
LV	8.9	0.0	0.0		3.0	1.73
PL	8.0	0.0	0.0		2.7	1.73
SL	0.0	0.0	0.0		0.0	
SK	0.0	0.0	0.0		0.0	
BG	0.0	0.0	0.0		0.0	
RO	0.0	0.0	0.0		0.0	
EU15		20.1	21.0	22.0		
EU25		16.3				
EU27		15.1				0.32
EU27 weighted	17.66	16.61	28.73	18.73	21.0	6.7

Note: quota rents equal to zero indicate that milk quotas are not considered to be binding. The average and standard deviation is country specific and taken across the three models: AGMEMOD, CAPSIM and EDIM.

Source: extracted from BOUAMRA-MECHEMEACHE et al. (2008a, b); CHANTREUIL et al. (2008) and WITZKE and TONINI (2008)

market price and milk shadow prices for Austria and Germany from national experts. They then rely on KLEINHANSS et al. (2001), who provide an aggregate EU raw milk quota rent of 7.9 billion Euros in order to get an aggregate residual quota rent for all EU-15, with the exception of Austria, Germany, Greece, and Portugal.[6] The authors then use information on raw milk prices and quota quantities at MS level in order to disaggregate the residual quota rent for each EU MS. They also do this relying on quota rent estimates from the INRA-WAGENINGEN CONSORTIUM (2002). For consistency, the obtained quota rents are downsized in order to meet the constraint of the guesstimated residual quota rent.

A common element across the different studies is that none of them fully relies on a single approach. Micro-econometric estimates are usually taken as an initial source which is then confronted with expert information in order to reflect recent market developments.

As regards the supply elasticities, all studies use aggregate supply functions at MS level. AGMEMOD and EDIM use empirical supply elasticity estimates, whereas CAPSIM bases itself on other studies. Table 2 presents an overview of the supply elasticities used by the three models. EDIM has a dynamic supply side structure, with the supply elasticity being different for different lengths of run and non constant over time. The estimates used here are their short-run values (see BOUAMRA-MECHEMACHE et al., 2008a). As is shown in table 2 all models have inelastic supply responses, which roughly range from 0.30 to 0.65. Also the average values and standard deviations are shown by country. The average CV is close to 0.45, which signals a considerable dispersion of the elasticity estimates. Note, however, that the average CV of the elasticities is about half of that of the quota rental values, indicating that the modellers 'disagree' more about the latter than about the milk own-price elasticities.

4. An in-depth comparative analysis

In this section the impact of different quota rents and supply elasticities on the milk supply and price projections is assessed using the EDM-framework as described in section 2. As a common base year, year 2007 is selected for both milk quantity and milk prices in order to have a similar reference yardstick for comparison.[7] With respect to the

[6] The last two countries listed have no quota rents since their quotas are not binding for the base year. Therefore, they are exempt from any quota rent calculations.

[7] Results are always compared to (the common) base year even though results for the abolition of the quota refer to a period 7 years ahead (2014). Although an unchanged quota scenario

Table 2. Dairy supply elasticities used in considered dairy models

Countries	AGMEMOD (1)	CAPSIM (2)	EDIM (3)	Average (1+2+3)	Coefficient of variation (1+2+3)
BE	0.760	0.352	0.280	0.464	0.56
DK	0.550	0.308	0.420	0.426	0.28
DE	0.630	0.218	0.373	0.407	0.51
GR	0.570	0.284	0.313	0.389	0.40
ES	0.710	0.329	0.284	0.441	0.53
FR	0.590	0.288	0.341	0.406	0.40
IE	0.770	0.349	0.402	0.507	0.45
IT	0.830	0.294	0.337	0.487	0.61
NL	0.780	0.272	0.442	0.498	0.52
AT	0.750	0.229	0.292	0.424	0.67
PT	0.550	0.310	0.421	0.427	0.28
FI	0.520	0.331	0.428	0.426	0.22
SE	0.590	0.238	0.459	0.429	0.41
UK	0.600	0.278	0.387	0.422	0.39
CZ	0.160	0.253	0.561	0.325	0.65
EE	0.500	0.347	0.576	0.474	0.25
HU	0.560	0.235	0.664	0.486	0.46
LT	0.500	0.277	0.576	0.451	0.34
LV	0.540	0.234	0.576	0.450	0.42
PL	0.540	0.235	0.650	0.475	0.45
SL	0.500	0.307	0.576	0.461	0.30
SK	0.500	0.150	0.576	0.409	0.56
BG	0.500	0.264	0.170	0.311	0.55
RO	0.500	0.295	0.159	0.318	0.54
EU27 weighted	0.634	0.271	0.398	0.434	0.42

Source: extracted from BOUAMRA-MECHEMEACHE et al. (2008a, b); CHANTREUIL et al. (2008) and WITZKE and TONINI (2008). Averages and standard deviations are country specific and based on an across model comparison.

demand for raw milk in the EU a demand elasticity of -0.4 and a demand shift of 1% per annum (estimates based on SOREGAROLI et al., 2005) are specified. With respect to the country specific milk supplies the elasticity estimates are those from table 2, while for each country a generic autonomous supply shifter of 0.5% per annum is used (capturing the net impact of non-milk price factors).[8] It is assumed that the considered milk reform takes place over a period of 7 years. Note that the results from this analysis include the interaction of the supply (of all member states) with the calibrated aggregate EU demand curve for raw milk implying endogenous quantities and milk prices.

Table 3 compares the impact of the (weighted average) quota rents and supply elasticities assumed in the three PE models considered using the EDM framework. As can be seen the (weighted average) milk supply elasticity is lowest for CAPSIM, highest for AGMEMOD, with EDIM taking an intermediate position. As regards the marginal costs CAPSIM and AGMEMOD are quite similar, with EDIM's estimate being about 15% lower. Equivalently, the (weighted average) quota rent estimate for EDIM (29% of the milk price) is significantly higher than that used in CAPSIM (17%) and AGMEMOD (18%). Column 3 presents the change in the virtual or shadow price for farmers (i.e. the change in p^s). In principle, multiplying the price change (column 3) with the milk price elasticity (column 1) should give the projected milk supply increase (column 4). It is not exactly the case here, due to the weighting procedure used. The very similar and relatively low quota rental value estimates used in CAPSIM and AGMEMOD play an important role in explaining the limited supply increase obtained from the EDM framework. It is the difference in milk supply elasticities which explains the difference in outcomes between CAPSIM and AGMEMOD.

As table 3 further shows a relatively low marginal cost (e.g. EDIM), and/or a relatively elastic supply response (e.g. AGMEMOD) generate, ceteris paribus, a relatively larger supply increase for quota expiry. Note that in case of CAPSIM, with a relatively low quota rent and relatively inelastic supply response, the induced price decline is much less. This causes the projected supply increase to be about 7%. The projected output increases, using the EDIM and AGMEMOD estimates, are rather similar, although they strongly differ with respect to their supply elasticity estimates. Note that the interaction with demand renders the model outcomes to converge with respect to the projected milk supply increase, whereas model outcomes diverge with respect to the projected milk price declines. Moreover, it downplays the impact of differences in supply elasticities on the final output volume. With an inelastic demand for raw milk, the possibilities to expand production are limited: the price will quickly decline and curb the expansion of output.

could have been calculated for 2014 then results should have been compared to model-specific baselines. Given the interest in focusing on differences over models comparison to a base year which all three models share in common is preferred.

8 This is a rough estimate based on an analysis of the empirical specifications of the supply functions in the models.

Table 3. The impact of different quota rent and supply elasticity estimates (2014)

Estimates used by	Milk price elasticity (1)	Marginal cost (€/kg) (2)	Shadow price change (%) (3)	Projected supply increase (%) (4)	Projected price decline (%) (5)
AGMEMOD	0.63	0.241	12.4	10.1	-7.8
			(7.2)	(4.8)	
CAPSIM	0.27	0.243	20.4	7.2	-0.6
			(7.5)	(2.8)	
EDIM	0.40	0.205	27.3	11.5	-11.2
			(12.0)	(4.6)	
	Sensitivity analysis for milk quota rents and milk supply elasticities				
	High quota rents				
AGMEMOD	0.63	0.210	17.3	13.5	-16.3
CAPSIM	0.27	0.212	29.5	9.7	-6.9
EDIM	0.40	0.174	32.2	15.7	-21.9
	Low quota rents				
AGMEMOD	0.63	0.264	9.0	7.8	-2.0
CAPSIM	0.27	0.259	16.8	5.8	3.0
EDIM	0.40	0.232	21.7	8.7	-4.1
	High supply elasticities				
AGMEMOD	0.84	0.241	9.8	11.0	-9.9
CAPSIM	0.47	0.243	13.7	9.4	-6.1
EDIM	0.60	0.205	19.6	13.6	-16.6
	Low supply elasticities				
AGMEMOD	0.43	0.241	16.5	8.8	-4.5
CAPSIM	0.09	0.243	32.2	3.3	9.2
EDIM	0.20	0.205	41.6	7.5	-1.3

Note: in parentheses price and quantity changes are reported for EU-27 as from the original results of these models evaluated in 2020 under a quota abolition scenario with milk quotas expanded by 2% each year 2009/10 to 2013/14 for AGMEMOD and EDIM whereas for CAPSIM it corresponds to quota expiry. Results are for EU-27 for AGMEMOD and CAPSIM whereas for EDIM they are for EU25 (see for further details BOUAMRA-MECHEMEACHE et al. (2008a, b), CHANTREUIL et al. (2008), and WITZKE and TONINI (2008)).

Source: own calculations

Table 3 also presents sensitivity analysis for milk quota rents and milk supply elasticities. High and low values for both quota rents and supply elasticities were defined. In case of high quota rents each model's country specific quota rent estimates are increased by the estimated empirical standard deviation (see table 1 for details). For the low quota rents a similar procedure was followed, but now the standard deviation was subtracted for the country specific values. Similarly high and low values for the elasticities were calculated. In order to avoid negative and non-plausible rent and supply elasticities where required a 'correction' was made to this procedure.[9]

As table 3 shows in case of high quota rents (decline of marginal costs by 13.5%) the expansion of production increases. The average increase in the EU's projected output (as compared to the standard projections presented in the upper part of table 3) over all three models is 35% higher than in the standard case, with only marginal differences between models. In absolute terms, using the estimates from EDIM yields a supply increase projection of about 16% as compared to the baseline (2007 production). Note that with the AGMEMOD and EDIM estimates, the projected milk price declines are about 100% larger than in the standard case. For the estimates from CAPSIM the difference even comes close to a factor 10. In case of low quota rents the average increase in marginal costs is about 10% (with CAPSIM's estimates generating an increase of 6.6% and with EDIM's estimates the increase being 13.2%). The associated declines in the projected output increases (due to the increased marginal cost) corresponding with the estimates from AGMEMOD, CAPSIM and EDIM are respectively -22.8, -19.4 and -24.3%. Note that in case of the CAPSIM estimates now even a small price increase is projected.[10] The changes in the projected price declines are in general much larger than those with respect to milk output.

The lower part of table 3 focuses on the sensitivity with respect to different own-price elasticities for raw milk. In case of high price elasticities (about 50% higher than in the yardstick but still inelastic on the EU weighted average) the average projected supply increase is about 20% higher than in the standard case. Note that this is less than in the high quota rent case where a 35% higher output increase was found. The projected price changes are relatively close to the price changes projected for the standard case except for the case with the CAPSIM estimates. In case of low price elasticities (on average about half of the yardstick; AGMEMOD -32%, CAPSIM -67%, EDIM -50%), the average projected supply increase is about 34% lower than in the standard case. Note that for all cases considered it holds

9 For countries where there is significance evidence that quota are binding a lower limit was fixed at 25% of the average country specific rent. For the milk supply elasticities an absolute lower bound was fixed at 0.05 to at least preserve some responsiveness of raw milk supply to prices.

10 This is caused by the combination of low price elasticities, high marginal costs and the exogenous shift variables, which create a net impact of the demand growing faster than supply. Since the impact of the shift variables is not the main focus of this paper, it is particular the differences between models rather than the absolute values which are important here.

Table 4. The importance of individual MSs in explaining the EU's milk supply

Estimates used by	MSs with expanding production and a share in the EU's output expansion greater or equal to 15%	MSs with expanding production and a share in the EU's output expansion between 0% and 15%	MSs with declining production
AGMEMOD	DE, **NL**	**BL**, **DK**, **GR**, **ES**, FR, **IE**, **IT**, **AT**, **PT**, SE, UK	FI, **CZ**, EE, HU, LT, LV, **PL**, SL, SK, BG, RO
CAPSIM	**NL**	**BL**, **DK**, DE, **GR**, **ES**, FR, **IE**, **IT**, **AT**, **PT**, FI	SE, UK, **CZ**, **PL,** EE, HU, LT, LV, SL, SK, BG, RO
EDIM	DE, FR, **NL**	**BL**, **DK**, **GR**, **ES**, **IE**, **IT**, **AT**, **PT**, FI	SE, UK, **CZ**, EE, HU, LT, LV, **PL**, SL, SK, BG, RO

Note: in bold font are countries which are in the same expansion category across the three EDM simulations.

Source: own table

that the (absolute) projected output changes using the estimates of AGMEMOD and EDIM move in line with each other, whereas those used by CAPSIM provides the most conservative supply increase projections.

So far the focus has been on the impacts at EU level, although in the calculations heterogeneity between EU member states was taken into account. Table 4 provides some further insights with respect to the role of different MSs in the three EDM simulations in the standard case. It appears that they partly differ in the importance they attribute to individual MSs. All three converge on the importance of the Netherlands, which on average explains 20% of the EU's aggregate supply response. In case the EDIM and AGMEMOD estimates are used, Germany is identified as an important contributor (average share in EU's total milk expansion is 21%), whereas with CAPSIM's estimates Germany ranks as a MS with a moderate expansion share. As regards the MSs with a declining milk production, the predicted increase of milk output by the UK and Sweden in case the AGMEMOD estimates are used could be traced back to their positive quota rent estimates for these member states.

5. Conclusion

The main aim of this paper is to provide a model comparison of three key dairy PE models that were used for analysing the EU's planned dairy policy reform (future quota abolition). The main focus was on the supply side and more precisely on the impacts of differences in the rental values of milk quota (or the linked marginal costs of dairy production) and the responsiveness of milk supply with respect to milk price. Simple graphical and algebraic (EDM) expositions were made to set the yardstick for comparison and hypothesise the expected impacts of quota rents and elasticities on projected milk output and milk price changes. Based on a comparison of the coefficients of variation (CV) associated with the empirical estimates of the quota rent and elasticity values used in the models, it appears that the uncertainty or 'disagreement' of the modellers with respect to the quota rent estimates is much larger than with respect to the supply elasticities. In particular different estimates with respect to having binding or non-binding quota for Sweden and the UK, as well as for some new member states (notably Poland and Hungary) contributed to the relative large uncertainty observed for quota rents. If these latter issues would be excluded the CVs for quota rents and elasticities would be of a similar order of magnitude.

The EDIM model took a relatively intermediate position with respect to the supply elasticity. However, it used, relative to AGMEMOD and CAPSIM, high quota rental value estimates (low marginal costs). In CAPSIM supply is relatively least responsive to the milk price, whereas its weighted average quota rent estimate is quite similar to that of AGMEMOD.

The differences over the models in quota rental value and supply elasticity estimates were used to calculate country specific means and standard deviations, which were subsequently used for a sensitivity analysis. From this it was found that high quota rental values and high supply elasticity values led to a relative increase of the projected EU milk output expansion of about 35% and 20% on average, respectively. As such the empirical evidence showed that output predictions made in this study were more sensitive with respect to quota rent uncertainty than supply elasticity uncertainty. However, in case of the low quota rents and low price elasticities results are more diverse and it can no longer be stated that one kind of uncertainty is dominating the other one. In all cases it was found that the uncertainty in quota rents or supply elasticities is likely to affect the projected price changes (decline) much more than the projected output changes. Taking into account the here considered uncertainties and differences in key parameter estimates in the models our best estimate is that the EU's aggregate milk production will expand when abolishing the quota, with the increase being somewhere in the range between 5 and 15% (see also table 3).

All the results are ceteris paribus and being subject to the same autonomous demand and supply shift effects, which in reality might be dependent on exact model specification and therefore differ over models. Moreover it is assumed that the linearization of the EDM framework provides a sufficient approximation of the real underlying models. Potential efficiency effects resulting from inefficiencies due to the way the quota are currently implemented or supply response effects due to capacity slacks or 'non-economic' behaviour (i.e. the sector temporarily behaving off its supply curve) were out of the scope of the analysis and also ignored in the original dairy policy analyses done with the considered models.

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