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Modelling the effects of an abolition of the EU sugar quota on internal prices, production and imports

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Abstract

We apply a spatial price equilibrium model of the world sugar market to simulate an abolition of the European Union (EU) quota system in 2015/16. To overcome the normative nature of the approach, we calibrate the model by attaching a non-linear cost term to each trade flow. This is in some regards similar to positive mathematical programming. We suggest an economic interpretation and an econometric specification of the cost term. EU sugar production is simulated to increase from 13.3 to 15.5 million tons in case of quota abolition by 2019/20. Ten member states increase production, nine reduce it. Preferential imports are significantly reduced. Simulated effects are found to be more pronounced the higher the world market price.

Keywords: CAP, structural change, sugar, TRQ, spatial modelling, trade preferences, PMP

JEL classification: F11, F17, Q17, Q18

1. Introduction

The reform of the European Union's (EU) common market organisation (CMO) for sugar entering into force in 2006¹ was assessed as a success by the European Commission (*Agra-Europe Weekly*, 2009). The majority of EU beet sugar production is now concentrated in the member states (MS) with the most efficient industries. The price for food manufacturers and consumers of sugar was decreased. Processors and beet growers were compensated for their loss of quota and the latter even for a part of the reduction of the statutory price for sugar beet within the quota. The restructuring scheme² was successful in reducing the overall sugar quota

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1 Council Regulation (EC) 2006/318.

2 Council Regulation (EC) 2006/320.

of the EU by almost 6 million tons, including renouncements of inulin-syrup and isoglucose, equivalent to one-third of the pre-reform level of A- and B-quotas. This reduction in quantity was regarded necessary in order to keep the common market in balance, once imports from least developed countries (LDC) under the 'Everything but arms' initiative (EBA) and ACP (African, Caribbean and Pacific countries) under the Economic Partnership Agreements (EPA), the successors of the Lomé and Cotonou treaties, became fully duty and quota free as of 2009 and 2015, respectively. As a consequence, the European Commission decided not to enact a further mandatory quota cut in February 2010, as it would have been entitled to should the restructuring process not have led to a sufficient reduction in quantity (Agra-Europe Weekly, 2010).

Agricultural economists, however, while acknowledging the success of the reform with respect to the specified objectives, were disappointed by some specific aspects which led to a needless loss of efficiency. In particular, they criticised that free movement of quotas especially between MS is still not possible and that the incentives set by the restructuring scheme led to the persistence of sugar sectors in MS that are not competitive. A proper implementation of one or both of these measures could have facilitated a structural adaption of the EU sugar industry embodying a full concentration of production in regions with a comparative advantage for beet production and of processing enterprises being able to optimally exploit economies of scale (Nolte and Grethe, 2010).

The current CMO is expiring after the sugar marketing year (MY) 2014/15. No concrete proposal for a successor has yet been tabled, but a communication document by the European Commission (2010) mentions a non-disruptive end of sugar and isoglucose quotas as an option to be examined. That makes an abolition of the quota a rather likely possibility. In that case, producers in the EU would still be protected by comparatively high most favoured nation (MFN) tariffs. However, increased competition within the EU alone can be expected to lead to a substantial structural reallocation of sugar production to more competitive regions. It will lead to discouragement of a part of the preferential imports from ACP, LDC and others and thus to an increased market share of domestic producers. In case of world market prices (WMP) as high as they have been in the MYs 2009/10 and 2010/11, it seems even possible that the EU might re-emerge as an exporter of sugar on the world market—without export refunds, although it is highly questionable whether this high level of WMP is sustainable.

The objective of this paper is to model the abolition of EU sugar quotas after 2014/15 in order to analyse its impact on production, prices and imports of the EU. For that purpose, an ESTJ³ spatial price equilibrium

3 Enke (1951), Samuelson (1952), Takayama and Jugde (1964).

(SPE) model is applied. The preferential imports of the EU, which are next to quota bound production and relatively stable consumption the only variable element in the current market balance, are of crucial importance for the effectiveness of the EU sugar policy. They are also of interest of their own, though, since for the countries of origin, they are a major source of export earnings and agricultural gross domestic product. Therefore, the SPE model, which is particularly suited to simulate bilateral policy changes for homogeneous products, is an adequate choice as a tool for this analysis. The approach is known, though, to perform poorly in reproducing observed trade matrices. To overcome this problem, we calibrate the model by attaching a non-linear cost term to each trade flow. This approach is similar to positive mathematical programming (PMP), a method developed in the 1990s to solve the problem of normative farm or sector supply models being unable to reproduce an observed set of decision variables.

The abolition of quotas in the EU can be viewed as a structural break in the sugar policy with the potential to induce a considerable reallocation of production between MS. As a consequence, isoelastic supply functions, whose parameters are estimated over a rather limited range of observed price variations, will have difficulties in properly depicting the supply response to this structural break, most notably the possible liquidation of sugar industries in some MS. Thus, we decided to employ a different functional form, which is described in more detail below.

In the next section, we give a short overview of the modelling approach. In Section 3, we describe the scenarios we simulate with respect to the development of the WMP, which will be a crucial determinant of the imports of various preferential trading partners, of possible exports of EU producers, of the price level on the community market and thus of the level of production and the structural consolidation of the EU sugar industry. In Section 4, we present and discuss the results and in the final section, we draw conclusions with respect to both the stated research objective and the adequacy and potential of the applied model.

2. The modelling approach

2.1. The original SPE model

The model we use for the simulation of the scenarios formulated in Section 3 is an ESTJ model of the world sugar market with all sugar modelled in white sugar equivalents (WSE). It has first been developed and described by [Nolte \(2008a\)](#) and since been applied for the simulation of various scenarios of EU and world sugar policies ([Nolte, 2008b](#); [Nolte et al., 2010b, 2011](#)). For reasons of transparency and flexibility, it is formulated as a mixed complementarity problem (MCP) rather than an optimisation problem ([Nolte et al., 2010b](#)). In its basic, uncalibrated version, the equations of the model are as

follows⁴:

$$D_i = \alpha_i * (PD_i - c_subs_i)^{\beta_i} \quad (1)$$

$$S_j = \text{MAX}\{0, \gamma_j + \delta_j * (PS_j + p_subs_j)^{\varepsilon_j}\} \quad (2)$$

$$\text{EST}_i = \zeta_i * \text{stock_shr}_i * D_i * PD_i^{\eta_i} \quad (3)$$

$$D_i + \text{EST}_i \leq \sum_{\text{sch}} \sum_j X_{\text{sch},j,i} \quad \perp PD_i \geq 0 \quad (4)$$

$$S_j + \text{ost}_j \geq \sum_{\text{sch}} \sum_i X_{\text{sch},i,j} \quad \perp PS \geq 0 \quad (5)$$

$$S_j \leq \text{quota}_j \quad \perp PPQ_j \geq 0 \quad (6)$$

$$X_{\text{sch},j,i} \leq \text{trq}_{\text{sch},j,i} \quad \perp PQ_{\text{sch},j,i} \geq 0 \quad (7)$$

$$\begin{aligned} & (PS_j + \text{PSH}_j + PQ_{\text{sch},j,i} + \text{exw_fas}_j + \text{loading}_j + \text{freight}_{j,i} + \text{tc}_{\text{sch}} - \text{ex_sub}_{j,i}) \\ & * (1 + \text{tar_av}_{\text{sch},j,i}) + \text{tar_sp}_{\text{sch},j,i} + \text{unloading}_i + \text{inld_transport}_i \geq PD_i \quad \perp X_{\text{sch},j,i} \geq 0 \end{aligned} \quad (8)$$

where i denotes consuming regions; j , producing regions; sch , scheme (MFN, EBA, etc.); D_i , demand; PD_i , consumer price; c_subs_i , consumer subsidy; β_i , demand elasticity; α_i , multiplicative intercept; S_j , supply; PS_j , producer price; p_subs_j , producer subsidy; γ_j , additive intercept (zero for isoelastic functions); δ_j , multiplicative intercept (calibrated for isoelastic functions); ε_j , exponent (supply elasticity for isoelastic functions); EST_i , ending stocks; stock_shr_i , observed stocks/consumption ratio; ζ_i , multiplicative intercept of the stock holding equation; η_i , elasticity of stockholding; $X_{\text{sch},j,i}$, trade from region j to region i under scheme sch ; ost_j , opening stocks (ending stocks of previous period); quota_j , production quota; PPQ_j , quota rent (production quota); $\text{trq}_{\text{sch},j,i}$, tariff rate quota; $PQ_{\text{sch},j,i}$, quota rent (TRQ); exw_fas_j , freight costs from plant to port (ex works—free alongside ship); loading_j , loading costs for ocean vessels; $\text{freight}_{j,i}$, ocean freight rates; tc_{sch} , transaction costs; $\text{ex_sub}_{\text{sch},j,i}$, export refunds; $\text{tar_av}_{\text{sch},j,i}$, *ad valorem* tariffs; $\text{tar_sp}_{\text{sch},j,i}$, specific tariffs; unloading_i , unloading costs for ocean vessels; inld_transport_i , inland transport (plant/port to wholesale market).

Complementary slackness provides quota rents to fall to zero if tariff rate quotas (TRQ) or production quotas are not filled and imports to be zero if the duty paid price for imported sugar from the exporting regions is higher

4 Endogenous variables are written in capital letters while exogenous parameters are written in lower case letters.

than the domestic wholesale price in the importing region. The scheme dimension of trade flows greatly facilitates the simulation of discriminatory or preferential trade policies in the model. In particular, it enables the model to simulate more than one preferential scheme between two countries, as it is the case with the EU trade preferences for sugar. The EU currently imports sugar under four preferential schemes. These are first the CXL⁵ quotas, in total some 600,000 tons, open to countries which supplied certain MS prior to their accession. These suppliers negotiated TRQ upon accession in order not to be worse off in terms of market access. The second scheme of preferential imports is granted to a number of Western Balkans countries and quota limited as well. In total these quotas amount to some 360,000 tons. The third scheme is the EBA initiative granting preferential access to LDC. In the implementation phase from 2001 until 2009, these imports were quota limited. The quotas were abolished, however, as of October 2009 and imports since can flow freely. Finally, ACP countries are granted preferential access to the EU sugar market. Traditionally the members of this group were the largest exporters of sugar to the EU possessing an aggregate TRQ of 1.3 million tons. Since October 2009, these quotas are replaced by gradually increasing regional thresholds which will only be binding if overall imports to the EU threaten to cause an oversupply of the community market. As of 2015, this restriction will fall as well.

Since the version of the model published in Nolte *et al.* (2010b) some changes in the structure of the normative model have been introduced. In particular, we modelled stock holding as described in equation (3).

For some countries, notably all EU MS, the supply functions (2) are not isoelastic, but contain an additional, additive intercept γ_j . This allows for production to cease at a positive price in the respective region, which can be expected as a possible and likely result of major structural breaks such as those modelled in this study. The MAX function ensures supply cannot assume negative values.

The model includes 106 producing and 90 consuming regions. It offers a comprehensive coverage of trade policies, in particular of regional (RTA) and preferential trade arrangements.

2.2. Critique of the SPE model and response

The SPE model in its original form essentially behaves like a normative, i.e. optimisation model notwithstanding it usually being used as a tool of positive economic analysis. The linear programming (LP) formulation of the transport module is technically restricted to a non-degenerate solution of a maximum of $2n-1$ trade flows, n being the number of exporting and importing regions. The model suffers thus from two sources of misspecification which usually prohibit it from reproducing an observed matrix of trade flows, even if all real world constraints were captured adequately,

5 Number of the WTO goods schedule of the EU (140 in roman numerals).

which is almost impossible for a sufficiently large and complex model. Besides the solution of the normative transport model representing an optimal situation subject to the subset of real-world constraints known to the modeller, however well the (linear) model is specified, the restriction to a maximum number of trade flows does not allow replication of observed trade patterns of products that show trade flows that exceed the number of constraints. In particular, it does not allow for cross-hauling. As a consequence, the model performs poorly in reproducing observed matrices of trade flows as is noticed by many authors (Bröcker, 1988; Harker, 1988; Batten and Westin, 1989; Roy, 1990; Ostrovsky, 2005; Nolte, 2008b, to name but a few), some of which also tried to offer alternative approaches for the modelling of spatial trade in homogeneous commodities. None of these, however, proved successful in replacing the SPE model.

As a consequence of the mentioned points of critique and various observed trends in international agri-food trade, notably the growing importance of intra-industry trade, consumer concerns about food safety and the emergence of biotechnology in agriculture, Sarker and Surry (2006) argue that trade models resting on the assumption of homogeneous products will in future be 'less and less suited to study trade in agri-food products'. Most agricultural economists, including the authors of this article, will agree that the arguments put forward by Sarker and Surry (2006) correctly describe the trends of global agricultural trade in the first 10 years after the Uruguay Round. Some recent developments on global agricultural markets, however, seem to point in another direction. In mid-2007, for instance, the sugar refining industry in the Persian Gulf, which had by then been supplied entirely by raw sugar from Brazil, switched completely to raw sugar of Indian origin for a period of more than a year. Indian sugar had become competitive, because the country had a large exportable surplus in that year and ocean freight rates surged at the same time, affecting freight costs from distant Brazil relatively stronger. Moreover, the Indian government granted a transport subsidy for sugar exports (ISO, various issues). This example clearly rebuts the assumption of product heterogeneity for the case of raw sugar. In fact, no existing spatial modelling framework allowing for cross hauling would have been able to reproduce this complete switch of origins as a result of changing c.i.f. prices of raw sugar from different origins. A further example illustrates that a complete shift cannot only occur between origins, but even between different crop species: In the first half of the grain MY 2008/09, South Korea is reported to have replaced imports of maize from the USA completely by imports of feed wheat from Ukraine (AgriMarket, 2009).

As a consequence, while the hypothesis of Sarker and Surry appears to be valid for processed agri-food products, it must be rejected for agri-bulk commodities, especially those not intended for final human consumption, as is the case with the two examples discussed above. As an economic explanation of the observed dispersion of trade flows in these products, we adopt the hypothesis of non-constant and non-uniform transaction costs which is put

forward in *Nolte et al. (2010a)*.⁶ From a modeller's point of view, this hypothesis allows modification of the SPE framework by attaching a non-linear cost term to each trade flow, a procedure which is referred to as calibration in mathematical programming literature. The model resulting from this calibration is able to cope with the described problems as an alternative to the original SPE while it avoids resting on the assumption of heterogeneity with regard to origin, the so-called *Armington (1969)* assumption.

2.3. The calibrated SPE model⁷

Nolte (2008b) suggests overcoming the problem of non-reproducibility of observed trade matrices by attaching additional cost terms to each trade flow, an approach that was originally developed by agricultural supply modellers (*Howitt, 1995*) to overcome a similar problem as the one we deal with in trade modelling: The solution of an LP farm or higher aggregate supply model did not reflect the observed production programme of the farm. The reasons are similar to those we mentioned already: The neoclassical assumptions are not fulfilled in reality and the number of activities is bound by the number of binding, linearly independent constraints, besides the fact that all models suffer, of course, from the fact that real world constraints cannot be captured fully in the model.

In the case of SPE as well as supply models, it is necessary that the additional cost terms be at least partly non-linear in order to overcome the limitation in the number of trade flows and activities. The absolute value of the additional cost terms as well as their first-order derivative will have a large influence on the simulation behaviour of the model. It is therefore essential that both be empirically well-founded. The absolute size of the cost term is determined endogenously by the calibration procedure, but only for trade flows and activities that are observed in the base equilibrium. The first-order derivative of the cost term needs to be positive in order to avoid non-convexities of the model which would lead to multiple local rather than one global optimum of the model. In reality, this would mean, that the costs of trade between two regions are increasing with the amount of trade of the product in question. However, an increase in freight costs cannot be observed, and there are good arguments to even assume the contrary, decreasing freight costs due to economies of scale. Furthermore, discussions with traders led to the conclusion that an SPE model parameterised with empirically well-founded freight costs proves to be an excellent instrument for predicting local prices. From the previously said, it must be concluded that the non-linear part of the calibration term does not reflect freight cost, but rather other

6 The latter has been put forward already by *Ostrovsky (2005)*. It might be useful at this stage to remind the reader that this theory does not reject product heterogeneity among functional commodities in general, for instance where high and low protein wheat are concerned. It merely rejects product heterogeneity with regard to origin.

7 Further details on the procedures applied here and additional discussion of some theoretical and technical aspects of the calibration can be found in *Nolte et al. (2010a)*.

components of total trade costs, which can be summarised under transaction costs.

A large first-order derivative of the calibration term would lead to a strong increase in total trade costs with total volume of trade on the route. This, however, conflicts with observations that at least for the major importing and exporting regions of agri-bulk commodities, the relation of c.i.f. and f.o.b. prices is rather close to the sum of freight costs, tariffs and other policy costs as well as administrative costs—irrespective of the volume of trade. In other words, the theory of SPE is confirmed by such observations. With a relatively large influence of the non-linear component of trade costs, significant spatial price disequilibria would be given rise to, which cannot be observed in reality. It must thus be concluded that this non-linear component, i.e. the first-order derivative of the calibration term cannot be all too large.

An attempt to calibrate SPE models which is similar to ours has recently been made by Paris, Drogué and Anania (2009) and an application of the procedure in an SPE model of EU trade preferences for bananas has been published by Anania (2010). In their approach, they tackle the net trade position of a country by attaching linear cost terms to trade flows. As a result, the model is not only able to reproduce an observed net-trade position of a country, but also to reproduce observed local prices and to eliminate inconsistencies in observed trade costs. Due to their calibration term being linear, however, the model is still limited to $2n - 1$ trade flows, and thus not able to reproduce observed trade matrices, or more precisely, only as one solution out of an infinite number of possible solutions due to their model not being strictly convex, at least in the base period. As Anania and McCalla (1991) have shown, the SPE approach can lead to trade matrices with more than $2n - 1$ trade flows, however only if quantitative restrictions to certain bilateral trade flows such as TRQ or trade embargos are present. This is, of course, also true for the calibrated SPE of Paris, Drogué and Anania (2009).

As a possible explanation of how transaction costs are influenced positively by the volume of trade between two regions, we use the hypothesis that exporters in one country pursue a risk minimising strategy by diversifying their export destinations. Heckeley (2002) illustrated that the presence of risk can provide a justification for a non-linear objective function in the case of calibrated constrained supply models. The same argument is applicable to trade models where traders have to manage risk. In particular, they might want to insure themselves against price crashes in specific markets and thus be willing to export to markets where lower than optimal f.o.b. prices for their products can be fetched. They also might be willing to sell for a lower than optimal f.o.b. price in order to be present in certain markets which could potentially become optimal f.o.b. price destinations.

To test the hypothesis of increasing transaction costs as a function of the quantity traded between two regions, the model is solved with all quantities, prices and rents fixed exogenously and trade costs variable. This step, which in some aspects is analogue to the first step of classical PMP, is performed for six

consecutive years, for which data on production, consumption and stock changes (F.O. Licht, 2009) as well as bilateral trade data (ITC, 2007; Eurostat, 2009; USDA, 2009) are available (1999/2000–2004/05).⁸ One fundamental difference between our approach and the analogue first step of original PMP is, however, that we use *a priori* information on the shadow prices of constraints. Constraints in the trade module of our model are production and consumption quantities as well as TRQ (equations (4), (5) and (7)). The corresponding shadow prices are local prices, some of which are observed and some of which are derived from the WMP, as well as TRQ rents, which are derived from the difference between f.o.b. WMP and preferential export prices. In doing so, we avoid the inconsistency of the first step of PMP as described by Heckeles and Wolff (2003). In the next step, we compare the trade costs from the first step to observed freight rates and calculate the difference. On routes where trade is both observed and simulated by the normative, uncalibrated version of the SPE, this difference is zero. In case trade is observed, but not simulated by the model, the difference is negative. In cases where trade is not observed, but simulated, which happened very rarely, the difference is positive. In the next step, an ordinary least square regression of the relationship between the trade cost difference and the share of the trade on one route in the total production of the exporting country is performed.

Many trade flows that occur, though, are not determined by economic reasoning of the involved agents, but rather politically induced. That is, of course, the case for trade that occurs under TRQs, but unfortunately also in less obvious situations, such as for instance the former C-sugar (now out-of-quota sugar) exports of the EU which are not directly subsidised, but are also not flowing freely, since the set of destinations is determined by the licensing policy of the EU. Another case are the exports of Cuba to China and Russia. To avoid a bias in the estimation results from politically induced trade flows, we include only those observations where we can be relatively sure they follow economic rather than political rationales, i.e. those by established exporters of sugar at world market conditions.⁹

The regression confirms the hypothesis that per unit trade costs increase with the share of domestic production that is shipped to one destination, with a coefficient of EUR 0.614 per per cent of domestic production.¹⁰ It also confirms the expectation that this increase is not very large. Although the regression and the coefficient are highly significant, the r^2 of the model is very low, indicating, that although there is certainly a positive correlation

8 Unfortunately, the quality of the bilateral trade data is rather poor (Nolte, 2008a) and the data need to be processed to match the balances of supply, demand and stock changes. This affects the reliability of the estimations.

9 Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Colombia, Brazil, Argentina, South Africa, Thailand and Australia.

10 The regression equation is: Cost difference/ton j , $i = \beta_0 + \beta_1 * \text{production share } i + \varepsilon_j$, i , R^2 : 0.024, F -test: 0.000, where indices i and j denote the country of origin and destination, respectively.

between the two variables, there are other determinants which have a much stronger influence on transaction costs and/or measurement errors of freight costs might have occurred. The estimated coefficient of EUR 0.614 effectively means that if one country exports its entire production to one other country, costs would increase by EUR 61.40 per ton. This seems rather high if compared with ocean freight rates in the range of EUR 20–40 per ton on the most frequented routes. On the other hand it does not seem very high if compared with import tariffs and tariff equivalents of other policy measures which easily exceed several hundred EUR per ton in a large number of countries. In any case, the case of one country exporting its entire production to one destination virtually never occurs.

In the next step, analogue to the second step of classical PMP, we replace the price transmission equation (8) of the normative SPE by equation (9), containing an additional, calibrated cost term for every possible trade flow.

$$\begin{aligned}
 & (PS_j + PPQ_j + PQ_{sch,j,i} + exw_fas_j + loading_j + freight_{j,i} + tc_{sch} - ex_sub_{j,i}) \\
 & * (1 + tar_av_{sch,j,i}) + tar_sp_{sch,j,i} + unloading_i + inld_transport_i \\
 & + \theta_{sch,j,i} + \iota * \frac{\sum X_{sch,j,i}}{S_j} \geq PD_i \quad \perp X_{sch,j,i} \geq 0
 \end{aligned} \tag{9}$$

In equation (9), i is the estimated coefficient of transaction costs as a function of the production share which is traded on one route. θ is a linear parameter,¹¹ which is calibrated such that when added to i multiplied by the production share, the result is identical to the calculated difference between observed freight cost and endogenously determined trade costs in the first step of our calibration procedure. The resulting model perfectly reproduces the observed matrix of trade flows, analogue to the third step of PMP.

3. Scenarios

After the expiry of the current CMO as of MY 2015/16, we use as a reference scenario for our analysis the continuation of current policies, specifically, current levels of quotas and tariffs. Our main counterfactual scenario embodies an abolition of the quota regulation, of the production charge of EUR 12 per ton and of any price policy instruments in the current CMO such as private storage aid in case of an undercut reference price or additional import quotas in case of a price surge. Trade policies such as tariffs and TRQ remain unchanged. Since the European Commission communication explicitly states a non-disruptive end of quotas as an option, we simulate three annual steps of a 10 per cent increase of quotas before finally

11 Complying with the hypothesis that exporters are willing to pay a premium to be present in a market, this parameter is negative in most cases. In general, the larger the exports to that market, i.e. the more important this market is for the exporter, the higher this premium.

abolishing them completely in the fourth year. Our projection horizon is the MY 2019/20.

A second dimension of scenarios is derived from different expectations with respect to the development of the WMP, which will especially have an influence on the amount of preferential imports. As a reference, we take projections from [OECD and FAO \(2010\)](#) and convert the London f.o.b. price for white sugar in USD, in a Middle East c.i.f. price for white sugar in EUR. We chose the Middle East as a reference location, since it is extremely unlikely that that region might change its net trade position.¹² As scenarios for a lower and higher than expected WMP, we deduct or, respectively, add one standard deviation calculated from a 10 years time series of WMP observations. These prices amount to USD 342 and 536 per ton of white sugar, respectively, instead of USD 439, London f.o.b. The resulting Middle East c.i.f. landed prices for white sugar in EUR are EUR 362 for the reference situation, EUR 292 for a low and EUR 431 for a high WMP.¹³

Additionally, it would also have been interesting to model the effects of an agreement of the Doha Round of WTO negotiations and its interplay with the effects of the quota abolition. This extra dimension of scenarios would, however, have increased the total number of scenarios to 12 rather than 6 as it is now. In case of a variation of the applied modalities, which also would have been interesting, the number of scenarios would even increase further. Furthermore, even if a WTO agreement were to be concluded within short time, the implementation phase would not be completed by the end of our projection horizon. We, therefore, settled with the two dimensions of WMP development and EU quota policy in order to keep the analysis focused.

4. Results

The results of the simulation runs are presented in Tables 1 and 2 below. Table 1 shows the results for the EU and its MS. In the reference scenario with a perpetuation of the quota system and standard assumptions about the WMP development (the column is shown in bold letters), total production is 13.3 million tons and the production quota is filled by each MS. The internal price is at EUR 544 per ton, and thus comfortably above the reference price of EUR 404.40. Total imports under preferential schemes amount to 3 million tons.

Under standard assumptions regarding the WMP, an abolition of the quota after 2014/15 leads to an increase of EU production to 15.5 million tons. The internal price falls to EUR 400, slightly less than the reference price under the

12 Freight differentials for the Euronext white sugar contract in different ports are also determined by using the Middle East as a reference location ([Euronext, 2005](#)).

13 The model is driven by real (2004/05) rather than nominal prices. The results are reconverted into nominal EUR for the convenience of the reader. The projected cumulated inflation between 2004/05 and 2019/20 is 28.4 per cent. EUR 1 in nominal terms is thus equivalent to EUR 0.779 in real terms.

Table 1. Model results for the EU (2019/20)

	Quota			Abolition of quota			
	Low WMP	Standard	High WMP	Low WMP	Standard	High WMP	
1. P_{WM} (€/t)	292	362	431	290	356	416	
2. P_{EU} (€/t)	446	544	630	393	400	408	
3. Demand _{EU} (mill. t WSE)	16.3	16.3	16.3	16.3	16.3	16.3	
4. Imports _{EU} (mill. t WSE)	3.0	3.0	3.0	1.9	0.9	0.0	
5. Production _{EU} (mill. t WSE)	13.3	13.3	13.3	14.5	15.5	17.6	
	Quota	Production (1,000 tons WSE)		Production (1,000 tons WSE)			
6. Austria	351	351	351	351	347	370	399
7. Belgium/ Luxemburg	676	676	676	676	643	702	777
8. Czech Republic	372	372	372	372	379	397	419
9. Denmark	372	372	372	372	363	390	425
10. Spain	498	498	498	498	402	444	497
11. Finland	81	81	81	81	73	78	84
12. France	3,437	3,437	3,437	3,437	4,376	4,632	5,779
13. Germany	2,898	2,898	2,898	2,898	3,347	3,595	3,908
14. Greece	159	159	159	159	116	127	141
15. Hungary	105	105	105	105	62	78	98
16. Italy	508	508	508	508	378	425	484
17. Lithuania	90	90	90	90	73	78	84
18. Netherlands	805	805	805	805	749	806	878
19. Poland	1,406	1,406	1,406	1,406	1,504	1,612	1,749
20. Portugal	10	10	10	10	4	6	9
21. Romania	105	104	105	105	91	93	102
22. Slovakia	112	112	112	112	100	107	116
23. Sweden	293	293	293	293	299	313	330
24. UK	1,056	1,056	1,056	1,056	1,171	1,228	1,299

Source: Simulations. The figures for production and consumption do not include isoglucose and out-of-quota sugar.

current CMO. This discourages a substantial share of preferential imports, which fall to 0.9 million tons. The WMP is only slightly affected by the abolition of EU production quotas, falling by EUR 6 or about 2 per cent. Out of 19 MS which continued to produce sugar after the restructuring period from 2006 to 2009, 10 are simulated to increase their production beyond their quotas after abolition. Nine are simulated to decrease production. These are, as widely expected, MS located at the southern and northern peripheries of the EU. Out of those MS which expand their production, France, Germany and Poland see the largest increase, in absolute as well as in relative terms.

Table 2. Model results for EU Imports, 1,000 tons WSE (2019/20)

	Quota			Abolition of quota		
	Low WMP	Standard	High WMP	Low WMP	Standard	High WMP
1. Total	3,024	3,022	3,021	1,947	932	—
2. CXL	604	604	604	604	595	—
3. Cuba	54	54	54	54	54	—
4. Brazil	537	537	537	537	537	—
5. Australia	9	9	9	9	—	—
6. Other countries	4	4	4	4	4	—
7. BALKAN	181	181	181	103	—	—
8. Croatia	180	180	180	103	—	—
9. Albania	1	1	1	1	—	—
10. LDC	385	542	665	—	—	—
11. Benin	2	3	3	—	—	—
12. Congo, D.R.	4	11	14	—	—	—
13. Ethiopia	86	174	230	—	—	—
14. Guinea	1	3	4	—	—	—
15. Madagascar	9	13	15	—	—	—
16. Malawi	49	69	85	—	—	—
17. Mozambique	173	157	126	—	—	—
18. Senegal	3	12	15	—	—	—
19. Sierra Leone	0	1	1	—	—	—
20. Zambia	59	98	172	—	—	—
21. ACP	1,854	1,695	1,571	1,240	337	—
22. Congo, Rep.	4	8	8	—	—	—
23. Côte d'Ivoire	33	44	44	—	—	—
24. Mauritius	474	442	415	361	106	—
25. Swaziland	611	389	362	539	193	—
26. Zimbabwe	—	36	28	—	—	—
27. Barbados	32	30	25	19	—	—
28. Belize	117	109	88	42	—	—
29. Dominican Republic	111	153	157	—	—	—
30. Guyana	304	285	246	154	—	—
31. Papua New Guinea	43	34	22	25	—	—
32. Fiji	125	116	107	100	39	—
33. Other countries	—	51	68	—	—	—

Source: Simulations.

In case of a lower WMP of EUR 292, the EU price strongly decreases in the non-abolition scenario to EUR 446. Production in the EU is slightly affected negatively, with one MS, Romania, not filling its quota anymore. An abolition of the quota leads to an increase of EU production to 14.5 million tons. As can be expected, this is less than under the standard WMP development. The decrease of preferential imports is also less pronounced.

Under assumptions of a high WMP of EUR 431, the community price increases to EUR 630. An abolition of EU quotas under this setting is simulated to trigger a strong production increase to 17.6 million tons, which even exceeds the pre-2006 level of quotas as well as internal demand. As a consequence of the latter, the EU turns to be an exporter of more than 1 million tons again. Preferential imports, on the other hand, are entirely displaced from the EU market. The price on the EU market falls to EUR 408. This makes it the only scenario in which after abolition of quotas the internal price in MY 2019/20 is above the current reference price. The effect on the WMP which falls by EUR 15 or 3.5 per cent is considerably stronger than under the standard and low WMP scenarios.

Table 2 presents the results for preferential imports of the EU under the various policy and WMP scenarios simulated in this paper. The EU currently imports sugar under four different schemes. The first of these is CXL. The scheme is strictly quota limited and all countries holding quotas, being competitive exporters at WMP, fill these quotas as long as the price premium on the EU market can gap the in-quota tariff of EUR 98 per ton (raw sugar) plus bilateral freight costs. This is the case in all scenarios that maintain the EU production quota. Without quota, the TRQ are only filled in case of a low WMP. Under an increasing WMP, first, Australia then the other countries cease to export to the EU.

The second scheme of quotas covered in the table is granted to a number of western Balkans countries and quota limited as well. While Croatia and Albania fill their TRQ under the three non-abolition scenarios, they reduce or terminate these exports under the abolition scenarios depending on the level of the WMP. Serbia and Macedonia do not export to the EU under any of the scenarios.

The next group of countries in the table are the LDC. Imports under the non-abolition scenario and standard WMP development are about 542,000 tons. In case of a low WMP, exports of LDC to the EU fall to 385,000 tons. In case of a high WMP, they increase to 665,000 tons. If the EU quota system is abolished, imports from LDC do not occur anymore irrespective of the WMP.

The last group presented in Table 2 are ACP countries,¹⁴ which under the EPA will enjoy quota and duty-free market access as of MY 2015/16 as well. Under the non-abolition scenario and standard WMP development, these imports are simulated to be 1.7 million tons at the end of the projection horizon. The abolition of the EU production quota and the resulting price decrease lead to a reduction of these exports by 80 per cent to 337,000 tons. Under low WMP, imports are simulated to be 1.9 million tons. In case of production quota abolition in the EU, imports fall by one-third to 1.2 million tons. Under a high WMP, imports from ACP are 1.6 million tons in the non-abolition scenario. The abolition of the quota leads to a complete stop of imports from ACP.

14 Countries belonging to both groups, LDC and ACP, are listed under LDC.

While the group of LDC responds to a WMP increase by an increase of exports to the EU, the behaviour of the group of non-LDC ACP countries is the opposite (under the non-abolition scenarios). This pattern is not mirrored by all countries in the respective groups, though. Generally, a WMP increase triggers an increase of the domestic price in ACP and LDC, which are usually shielded by *ad valorem* tariffs. Since this increases the propensity for the countries to sell domestically or to neighbours within a RTA, the reduced supply on the EU market leads to an increasing price level there, too. As a consequence, countries whose domestic prices increase stronger than the EU price tend to reduce exports to the EU. Those whose domestic prices increase less than the EU price have an incentive to increase their shipments to the EU.

5. Conclusions

The paper applies an ESTJ SPE model with calibrated non-linear cost terms attached to each trade flow in order to simulate the effect of an abolition of the EU production quota system for sugar after the expiry of the current CMO as of MY 2015/16. The variables in the focus of the analysis are production quantities, domestic and WMP, and preferential imports of the EU under various schemes. The strong increase of WMP since mid-2009 shows that preferential imports of the EU can be inhibited by a high WMP since exporting countries may find it more profitable to export to regional markets or to substitute imports on their domestic markets. Therefore, two sub-scenarios taking into account a lower than expected and a higher than expected WMP are simulated.

Under all WMP scenarios, the abolition of the quota leads to an increase in production in the EU and correspondingly to a decrease in preferential imports. The higher the WMP, the more pronounced is this tendency. If the WMP is sufficiently high, preferential imports are entirely displaced and the EU turns to exporting to the world market again.

If the WMP develops as projected by OECD and FAO (2010), production in the EU will increase by 2.2 to 15.5 million tons in case of quota abolition. MS in the geographical centre of the EU, which are known to be more competitive producers of sugar beet, increase their level of production beyond the former quota, whereas countries at the southern and northern limits of the community decrease their production. No country ceases to produce sugar under any of the simulated scenarios, although the functional form of the supply curves explicitly allows this to happen. It must, however, be noted that it is questionable whether sectors which are simulated to shrink very strongly are still viable at that level of production.

The simulation revealed that the WMP for sugar by virtue of the abolition of quota limitation of LDC and ACP imports, as well as reduction of the internal price by the 2006 CMO reform has gained a strong influence on the internal price level of the EU. Table 1 shows that under the non-abolition scenario, a WMP variation triggers a movement of the community price in the same direction which in our cases is even more pronounced in absolute terms

than the WMP shift itself. This is due to preferential trading partners' alternative markets usually being shielded by *ad valorem* tariffs such that prices on these markets, which they compare with the EU price in order to decide where to ship their exports, also vary stronger than the WMP. Since the quota-bound production in the EU is not price responsive, these price variations cannot be dampened by reactions of EU producers. This changes if the production quota in the EU is abolished. The world market triggered variations of the community price then are merely 10–15 per cent of the WMP variations themselves. Price variability is thus significantly reduced. The sub-scenarios for different WMP developments must, however, not be confused with temporary price spikes, to which producers, unlike in our model, cannot react. The effects of such price spikes on preferential imports can be expected to be more pronounced than what is shown in our results. While the EU price turns out to be influenced by the world market, the quota policy of the EU does not have the potential to prompt a significant effect on the WMP.

To close the discussion about the results, it should be mentioned that as in any simulation study they are subject to some degree of uncertainty. Sources of uncertainty can arise from aspects covered by the model such as the supply behaviour of preferential importers to the EU, where detailed and reliable information is hard to come by. Previous simulation exercises with the model have shown that the level of supply elasticities has the potential to greatly influence the overall results. With respect to the supply response of LDC, recent studies by Nolte *et al.* (2010b, 2011) found that increased production in individual LDC will *ceteris paribus* lead to increased imports from the LDC in question. However, this increase comes to a large degree at the expense of the market shares of other preferential importers and only slightly increases total preferential imports of the EU.

In recent years, the link between the sugar market and the crude oil market has intensified due to production of ethanol from sugar cane and beet. On a global level, this will affect the sugar market by diverting sugar crops from sugar production to ethanol production and hence shift the sugar supply curve of countries with an ethanol production programme to the left. We would thus argue the global effect is sufficiently captured by simulating our scenarios over a large range of WMP. It is more complex to investigate single country effects of ethanol production based on sugar cane or beet, particularly in EU MS, though.

Sugar is different from other crops in that it is not a primary, but a processed product. Since transport and storage of sugar beet and cane are rather costly and virtually impossible over long distances or periods, the primary production and the first stage of processing are closely linked, both spatially and temporally. Reallocations in sugar production have thus wider repercussions than what can be simulated in an agricultural sub-sector model. The 2006 reform of the CMO has shown that policy makers take this into account by compensating producers for scaling down production and by linking restructuring aid to social criteria. In this sense, the reader should keep in mind that the results we simulate in this article are only one aspect

of the socio-economic effects of an abolition of sugar production quotas in the EU.

As a final caveat on the discussion of the results, we would like to point to the uncertainty stemming from the substitutability of sugar and isoglucose. Both products are caloric sweeteners and have been covered by the same CMO before the merger into the CMO for all agricultural products managed by the EU's common agricultural policy into one document. It can therefore hardly be imagined that quotas for sugar production will be abolished and those for isoglucose will be maintained. The current market share of isoglucose in EU consumption of caloric sweeteners is only about 4 per cent, but this has certainly the potential to increase. In the USA for instance, the market share of starch based sweeteners is about 40 per cent (Bichara Rocha, 2010). The situation in the EU is different from that in the USA since the ratio of sugar and cereal prices—the former being the most important substitute in consumption, the latter being the key inputs and thus determinants of production costs—is much less favourable to isoglucose producers in the EU than it is in the USA. An abolition of sugar quotas will furthermore widen this gap. Consequently, a market share of 40 per cent is extremely unlikely to be attained. However, anything from a substantial increase to a complete displacement of isoglucose from the EU market for caloric sweeteners seems possible and will have an effect on sugar production by decreasing or increasing its market share.

In our analysis, we apply functional forms for the supply of the EU (and some other beet producing countries) which are different from isoelastic functions and allow production to cease at a positive price. This leads to functions which are very price responsive if compared to standard elasticities from literature. Implicitly, our supply functions have elasticities usually larger than 2, in some cases even more.¹⁵ However, it is commonly acknowledged, that current marginal costs of sugar production in the EU move somewhere between EUR 300 and 450 per ton and that EU production is not competitive at prices below EUR 200–250 per ton. The only way, though, to simulate this with a continuous function is to choose one with a rather high price elasticity, which furthermore increases, the closer it moves to zero.

The paper introduced a new method of modelling international trade by calibrating an ESTJ SPE model with quadratic cost terms. This approach goes beyond the work of Paris, Drogué and Anania (2009), who engaged in calibrating an SPE with linear cost terms, in several regards. With the cost terms being non-linear, we are able to build a strictly convex model which perfectly calibrates to any observed base situation. We, furthermore, offer an economic explanation for the cost functions we introduce and engage in an econometric specification of these. A first practical consequence can be seen in Table 1. The internal price for white sugar in the EU under the non-abolition, standard WMP scenario is simulated to be EUR 544 per ton in 2019/20. Nolte *et al.* (2011) using

15 This is also a result of the supply functions being combined beet supply and processing functions. The latter is assumed to be perfectly elastic in the long run.

a normative version of the model and using the same WMP projections by OECD and FAO (2010) simulated the internal price to be only EUR 491. With production quotas in place, the price on the EU market is equivalent to the opportunity costs of the marginal ACP or LDC supplier including bilateral transaction costs. Recall that in our model the latter are a function of the share of domestic production being shipped to a particular destination. For many ACP and LDC this share and hence the transaction costs increased after 2009, contributing to a higher EU price in our model.

Several questions with respect to the implications and the further potential of this approach are still open and being addressed in a technical paper (Nolte et al., 2010a). These are, among others, possible solutions for the immense data requirement for a geographically sufficiently disaggregated model to perform meaningful trade policy analysis and an enhanced empirical base for the estimation of the cost functions.

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