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Liberalising the EU sugar market: what are the effects on third countries?*

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This paper examines the consequences of a liberalisation of the EU sugar policy on Australia and other third countries. Four scenarios are simulated showing the trade and production effects of a gradual phasing-out of EU domestic support measures and EU import tariffs using two partial equilibrium models linked to each other. Compared with previous work, tariff rate quotas are represented in great detail, going beyond the classical single-origin, single-destination approach. Furthermore, supply functions of EU sugar processors are calibrated based on empirical data on production costs to overcome the problem of non-observed production costs due to the existence quota rents. Results suggest that, in particular, sugar production in Balkan countries is adversely affected by a liberalisation of the EU sugar regime. Moreover, the simulation shows that preferential LDC-ACP exporters, among them Fiji and Papua New Guinea, are displaced from the EU market leading to a decline in production. An elimination of EU import tariffs benefits in particular the Ukraine and the world's largest sugar producers, such as Australia, all with currently only limited preferential market access to the EU. During periods of low global sugar prices, these countries even increase sugar production, if the EU sugar market is completely liberalised.

Key words: agmemod, liberalisation, policy impact assessment, SPE model, sugar.

JEL classifications: F17, Q17, Q18

1. Introduction

For decades, the EU sugar market was highly regulated by production quotas, intervention prices, prohibitive import tariffs and exports subsidies. Moreover, the EU sugar regime had long been excluded from the liberalisation process of the EU Common Agriculture Policy (CAP) started with the MacSharry reform in 1992. However, since 2006, the EU sugar market has also been gradually liberalised. While in the 2006 reform EU production quotas were considerably reduced, the EU quota system was completely abolished in 2017. In addition, sugar is no longer excluded from tariff reductions under regional trade agreements that have been concluded between the EU and third countries in recent years.

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While there is extensive literature investigating the consequences of the 2006 EU sugar reform on third countries, focusing particularly on least developing countries (LDCs) as well as African, Caribbean and Pacific (ACP) countries (van Berkum *et al.* 2005; Chaplin and Matthews 2006; Elbehri *et al.* 2008; Matthews 2008; Kopp *et al.* 2016), the trade-distorting effects of the most recent changes in the EU sugar regime have hardly been analysed. Although some quantitative ex-ante policy impact assessments of the 2017 EU sugar reform have been published, these studies focus on the production and price effect within the EU (EC 2011; Smit and Helming 2012; Burrell *et al.* 2014; OECD/FAO 2014). One reason might be that only few models have a sufficiently detailed country coverage also including those smaller countries that are important preferential sugar exporters to the EU, but of minor importance in the overall agricultural trade. Moreover, only few models are able to sufficiently capture the complex global tariff regulation for sugar, where quantities imported at a reduced preferential tariff rate are often limited by tariff rate quotas.

However, third country sugar suppliers may be severely affected by the recent abolition of the EU quota system as well as by a potential further liberalisation of the EU sugar regime. This is mainly for two reasons: first, a gradual phasing-out of all domestic support and border protection measures can be expected to result in a convergence of the EU domestic price and the global sugar price, leading to a decline in the preference margin of countries currently allowed to export to the EU at a reduced or zero-tariff rate. Second, changes in the EU sugar policy are likely to affect the net trade position of the EU, resulting in trade diversions and – depending on the magnitude the effects – a change in the world sugar price.

To our knowledge, so far only the studies of Nolte *et al.* (2012) and Calì *et al.* (2013) have investigated the trade effects of a complete elimination of the EU quota system. Both studies apply a stand-alone version of the spatial price equilibrium (SPE) model for the global sugar market first developed by Nolte (2008). While Nolte *et al.* (2012) present results on the changes in production at the EU Member States (MS) level, as well as the changes in EU imports from different countries of origin, the study by Calì *et al.* (2013) focuses on the changes in sugar production of ACP countries. Overall, both studies show that preferential sugar exporters to the EU are more negatively affected by a liberalisation of the EU sugar regime in a high price market situation (global white sugar prices above 430 US-Dollar per tonne). This is because with high global sugar prices, EU domestic production increases more substantially following the abolition of the quota system, resulting in a stronger decline of EU preferential imports. Thus, the approach of modelling the supply behaviour of EU sugar processors in response to price and policy changes is crucial for any policy impact analysis investigating the effects of changes in the EU sugar regime on third countries. Also, the analysis needs to consider the increasing number of regional trade agreements concluded worldwide in recent years, which are only covered to a limited extent in existing literature. Moreover, in previous works, tariff rate quotas were only defined on a bilateral basis and not between country groups, with the EU being grouped together in one importing region neglecting intra-EU trade.

Against this background, this paper aims to investigate the effects of changes in the EU sugar regime on Australia and other third countries using an extended and updated version of the above-mentioned SPE model linked to the partial equilibrium model Agmemod (AGricultural MEmber state MODeling). Four scenarios are simulated in order to analyse i) the consequences of the recently implemented abolition of the EU quota system, ii) a free trade agreement between the EU and Australia currently being negotiated and iii) the complete liberalisation of the EU sugar market by eliminating the still prohibitive EU most-favoured-nation (MFN) tariffs on sugar. In particular, the effects on EU sugar imports from different countries of origin and the resulting changes in sugar production of Australia and other third countries are presented in detail.

Overall, results show that sugar production of third countries declines as a consequence of progressive liberalisation of the EU sugar market. This decrease in production is mainly the result of the abolition of the EU quota system, while an elimination of EU MFN tariffs can partly, fully or even over-compensate for the negative effect on sugar production.

A free trade agreement with the EU benefits Australia's sugar production most during periods of low global sugar prices when the prohibitive EU MFN tariffs ensure the EU sugar price to range well above the world market price, making the EU a more profitable outlet compared to other export destinations.

The third countries most negatively affected by liberalisation of the EU sugar regime are small preferential sugar exporters that face high trade barriers (tariffs and transportation cost) to other markets and export a significant share of their sugar production to the EU. Basically, those European countries exporting sugar to the EU under the "EU tariff preferences for the Balkan countries" belong to this group, but also other preferential sugar exporters, such as Fiji and Papua New Guinea.

The remainder of the paper is structured as follows: Section 2 provides an overview of the EU sugar market policy and related developments of the EU sugar market. Section 3 describes the two partial equilibrium models applied in the analysis, the method for linking the two models, the key data sources and the simulated scenarios. Section 4 presents the results. The paper concludes with a discussion of the main strengths and limitations of the approach and a summary of the key findings.

2. EU sugar market policy and market development

Compared to other agricultural markets, the sugar market is highly regulated by policy instruments, not only within the EU, but also on a global level (Snape 1963, 1969; Brüntrup 2007; Sandrey and Vink 2007; OECD 2020a).

In the EU, the Common Market Organisation (CMO) for sugar was introduced in 1968 (Reg. No. 1009/67/EWG) and has not been substantially reformed for almost 50 years, despite major policy reforms implemented for other agricultural products since the beginning of the 1990s. At the time, the CMO for sugar was introduced, the key aim was to ensure stable market condition on the EU market (planning security). Further aims were to ensure that domestic sugar production was sufficient to cover domestic demand (self-sufficiency) and to secure and support the income of sugar beet growers. Domestic policy instruments as well as trade-related measures were applied to achieve these goals. Administrative minimum prices and production quotas guaranteed a high price level on the EU domestic market, further stabilised by export subsidies granted for production surpluses and protected against the significantly lower world market price by applying prohibitive EU import tariffs on sugar.

However, in 2006 the first major reform of the EU sugar regime was introduced and the CMO for sugar became part of the 'Common Organisation of Agriculture Markets' (Single CMO Regulation, Reg (EG) No. 1234/2007). In addition to internal political pressure due to the fact that up to this point the EU sugar regime was excluded from the substantial reform process introduced for the market organisation of most other agriculture products, the main reason for the fundamental reform of the EU sugar regime was a decision of the World Trade Organisation Dispute Settlement Body. Following a complaint of Brazil, Thailand and Australia (the world's largest sugar exporters) against highly subsidised sugar exports of the EU, the World Trade Organisation (WTO) decided to limit total EU sugar exports to 1.374 million tonnes per year. Thus, the WTO's decision supported the position of Brazil, Thailand and Australia. These countries argued that not only those sugar exports supported directly by export subsidies, but all the sugar produced in the EU – including re-exports of refined sugar – are subject to the maximum limit for subsidised EU sugar exports commitment in the Uruguay Round in 1994. The key reasoning behind this decision was that all sugar exports benefit from high revenues on the domestic market, allowing the EU to export sugar at world market prices below EU production cost (so-called 'cross-subsidising of exports').

In order to comply with its WTO commitments, the EU had to substantially reduce its sugar exports, and thus ultimately its production. Therefore, the core element of the 2006 reform was a reduction of production quotas from 17.5 million to 13.3 million tonnes, organised via a restructuring fund allowing EU sugar processors to return their quota on a voluntary and company-specific basis over a period of four years. Furthermore, the intervention price for white sugar was gradually reduced from 632 Euro per tonne to 404 Euro per tonne (raw sugar: 524 EUR/t to 335 EUR/t) and the minimum beet price from 44 Euro per tonne to 26 Euro per tonne.

Since the 2013 reform of the CAP, the EU sugar regime is part of the Regulation (EU) No. 1308/2013. As part of the 2013 CAP reform, the EU

Commission decided to continue the process started in 2006 of gradually liberalising the EU sugar market by completely abolishing the EU quota system for sugar. Since October 2017, domestic sales of sugar and isoglucose are no longer limited by production quotas. Moreover, the above-mentioned WTO limit on EU sugar exports to third countries was completely eliminated.

The 2013 CAP reform, however, also established the legal framework for granting coupled payments to sugar beet. Eleven, mainly smaller, sugar-producing EU MS have introduced these payments to support their sugar sector in the post-quota period and to compensate sugar beet growers for potential income losses (EC 2021e). Also, the import tariff regime of the EU remained unchanged. This means that the regular MFN tariff rate imposed on EU sugar imports is still prohibitive (419 EUR/t white sugar; 339 EUR/t raw sugar).

However, as Table 1 shows, since 2013, a growing number of countries have been allowed to export sugar to the EU at a reduced or even zero-tariff rate under regional trade agreements. Even though this preferential market access is still limited by tariff rate quotas (TRQs) for most countries, sugar is no longer completely excluded from tariff reductions, as was the case in past decades. Prior to 2013, only LDC and ACP countries, selected major sugar exporters (CXL), including Australia, as well as the Balkan countries were allowed to export to the EU at a reduced tariff rate. Most of these tariff preferences were unilateral, in contrast to the reciprocal regional trade agreements concluded recently, which also provide export opportunities to EU sugar producers.

Table 2 shows the development of the EU sugar market under the above-described policy changes. As a result of the 2006 reform, the EU turned from a net exporter of sugar to a net importer, as the quantity of sugar produced under the quota was no longer sufficient to cover demand. Thus, despite a lower guaranteed price level, the EU remained a secure and profitable outlet for about 3 million tonnes per year for those countries being allowed to export to the EU at a preferential tariff rate. Moreover, other third country sugar producers with no or very limited preferential market access to the EU, such as Australia, are likely to have benefited from the 2006 reform, as these countries faced less competition in the global sugar market due to significantly lower EU sugar exports.

By contrast, the recent abolition of the EU quota system in 2017 has resulted in an increase of EU production, a redirection of sales from EU sugar processors from the world market to the domestic market and a sharp drop in the EU sugar price. Overall, the EU switched from a net import position to a balanced market. Total EU imports decreased by about 30 per cent with imports from Australia, Jamaica, Fiji, Serbia and Guyana declining by more than 50 per cent. Thus, the first years following the abolition of the quota system have already shown that most preferential exporters to EU are likely to be adversely affected by the 2017 reform. Not only are they fully or partly displaced from the EU market by increased EU production, but they

Table 1 Tariff preferences to the EU sugar market for third countries

Country	TRQ 2020/21	Specific tariff	Annual increase of TRQ	Reg (EU) No. / PTA or RTA in force since
	t	EUR/t	t	
LDCs/ACP	–	0	–	2001/ 1975
Balkan	202,210			891/2009
Albania	1000	0	–	891/2009
Bosnia and Herzegovina	13,210	0	–	891/2009
Serbia	181,000	0	–	891/2009
Macedonia	7000	0	–	891/2009
CXL	790,925			891/2009
Australia	9925	98	–	891/2009
Brazil	334,054	98	–	891/2009
Brazil	78,000	11	–	891/2009
Cuba	68,969	98	–	891/2009
India	10,000	0	–	891/2009
Erga omnes	289,977	98	–	891/2009
Columbia	75,020	0	1860	741/2013
Peru	26,620	0	660	405/2013
Central America (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua)	177,000	0	4500	924/2013
Panama	14,520	0	360	923/2013
Ukraine	20,070	0	–	2405/2015
Moldova	37,400	0	–	492/2014
Georgia	–	0	–	RTA, 01-Sep-2014
South Africa	150,000	0	–	2253/2016
Canada	–	262 white sugar 212 raw sugar†	–	RTA, 21-Sep-2017
Ecuador	26,200	0	600	754/2017
Japan	–	0	–	RTA, 01-Feb-2019
Singapore	–	349 white sugar 283 raw sugar‡	–	RTA, 21-Nov-2019
Vietnam	8500§	0	–	1024/2020

†Complete elimination of customs duties within 7 years after entry into force.
‡Complete elimination of customs duties within 5 years after entry into force.
§From 1 January 2021 onwards 20,400 tonnes raw sugar equivalent.
Source: EC (2020b), WTO (2020a), WTO (2020b), EC (2020a).

also achieve lower prices for the quantities still exported to the EU. Furthermore, the change in the net trade position of the EU can be expected to indirectly affect all countries in the global sugar market leading to adjustments in production, consumption and global trade patterns.

3. Modelling the effects of liberalising the EU sugar market

As already explained in the previous sections, the potential effects of liberalising the EU sugar market on Australia and other third countries are

Table 2 EU market balance for sugar from 2003/04 to 2019/20 (October to September)

EU-28	Avg. 2003/04 to 2005/06	Avg. 2014/15 to 2016/17	Avg. 2017/18 to 2019/20
Production (mill t wse)	19.7	17.1	18.8
Under-quota (mill t wse)	17.7	13.5	-
Outside-quota (mill t wse)	2.0	3.6	18.8
Consumption (mill t wse)	18.2	19.1	18.5
Food	16.5	16.9	16.9
Industrial	0.6	0.8	0.8
Bioethanol	1.0	1.4	0.8
Imports (mill t wse)	2.7	3.0	2.1
Countries of origin (1000 t wse)			
Brazil	777	371	313
Mauritius	488	375	217
Fiji	167	166	63
Guyana	159	129	56
Serbia	156	166	63
Eswatini	129	209	191
Jamaica	121	33	8
Cuba	100	322	173
Australia	1	3	0
Other	637	1201	1000
Exports (mill t wse)	5.3	1.4	2.2
Countries of destinations (1000 t wse)			
Syria	588	34	87
Israel	545	250	395
Algeria	357	112	17
U Arab Emirate	348	26	29
Switzerland	283	85	65
Indonesia	206	0	0
Sri Lanka	180	24	61
Norway	150	118	115
Other	2644	782	1467
Change in stocks (mill t wse)	−1.0	−0.5	+0.2
EU market price (EUR/t)	675	450	365
EU reference price EUR/t)	632	404	404
World market price (EUR/t)	264	391	329

2003/04 refers to the sugar marketing year, that is October 2003 to September 2004. wse: white sugar equivalent. EU totals may not add up due to rounding. mill t: million tonnes
Source: EC (2021d), EC (2020), Eurostat (2021), EC (2021a), USDA (2021), IMF (2021), OECD (2020b).

highly complex. The analysis of these effects therefore requires a modelling approach that reflects both the supply behaviour of EU sugar processors as well as the global bilateral trade relations and related trade policies as accurately as possible. Therefore, the effects of liberalising the EU sugar market are examined by applying two partial equilibrium models linked to each other. The first model is the partial equilibrium model Agmemod (Chantreuil *et al.* 2012; Agmemod Consortium 2022), which is linked to the spatial price equilibrium (SPE) model of the global sugar market first developed by Nolte (2008). The following section gives further details on the exact model versions applied in the analysis and the method used to link the two models.

3.1 Method

3.1.1 The Agmemod model

Agmemod is a recursive-dynamic partial equilibrium model for the agricultural sector of the EU. While the model covers the agriculture sector (32 crop and 21 livestock products, primary as well as processed) of all 28 EU MS, most other countries are grouped to one 'Rest of the World' aggregate. For each sector and country, the model endogenously determines market prices and market balances on a yearly basis. However, trade flows between countries are not represented in the model. In recent years, the primary application of Agmemod has been the generation of medium-term projections at the EU MS level for key agriculture markets including sugar and isoglucose (EC 2017, 2018, 2019). For that purpose, the representation of the sugar market in the model was completely revised. In this revision, the main focus was put on the supply side. The supply function of sugar takes the following form[1]:

Supply function:

$$S_{su} = \text{Min}\left\{ (bsc_{st} * loc_{st} - UOD_{st}) * XTR_{su}, \right.$$

$$\left. \text{Max}\left\{ 0, \alpha_{su} * \left(\frac{PS_{su} + BPV_{su} - CPO_{su}}{gdpd} \right)^{\epsilon_{su}} - UOD_{st} * XTR_{su} \right\} \right\} \quad (1)$$

As Equation 1 shows, sugar processors react to the processing margin, that is the producer price (PS) of sugar (su) less processing cost (CPO) plus the by-product values (BPV) for beet pulp and molasses. The parameter ε determines how sensitively sugar processors react to changes in the processing margin. All values are expressed in real value terms; that is, nominal values are divided by the GDP deflator (gdpd). Furthermore, sugar production is limited to the available beet slicing capacity not used for the processing of sugar beet (st) into ethanol. This capacity is calculated in the first part of the equation by multiplying the daily beet slicing capacity (bsc) by the length of the sugar processing campaign (loc) corrected for the quantity of sugar beet processed into ethanol (UOD) multiplied by the sugar extraction rate (XTR) converting beet quantity into sugar quantity. Finally, the sugar supply function is shifted by the quantity of sugar beet – expressed in white sugar equivalent – required for ethanol production. The intercept parameter α is calibrated to production costs (beet costs plus processing costs) endogenously determined during the model run to overcome the problem of non-observed production costs, that is the fact that, with binding production quotas in place, observed market prices do not reflect marginal costs of production (see

[1] Endogenous variables are written in capital letters, exogenous variables in lower case letters.

Jensen and Pohl Nielsen 2004; Jongeneel and Tonini 2009 for details). Due to space constraints, the approach for deriving production costs is not described in detail here. However, following the approach of LMC (2013) the basic idea is to calculate beet costs from the gross margin of the most competitive alternative crop to sugar beet and to add net-processing costs of sugar (CPO – BPV).

3.1.2 The SPE model

The applied SPE model is an updated and extended version of the model first developed by Nolte (2008). It covers the sugar sector of 113 countries and 6 country aggregates. In addition, the isoglucose sector of EU MS is also represented. The major strength of the SPE approach is that it allows for a detailed representation of bilateral trade policies, including tariff rate quotas that are modelled explicitly rather than being captured by ad valorem tariff equivalents. The following block of equations describes the unlinked version of the SPE model:

Supply function of sugar:

$$S\_su_j = \text{Max}\left\{0, \alpha_j * \left(PS\_su_j + p\_subs\_su_j\right)^{\epsilon\_s\_su_j} - \gamma_j\right\} \quad \perp S_{suj} \geq 0 \tag{2}$$

Supply function of isoglucose:

$$S\_iso_j = \text{Max}\left\{0, \alpha_j * \left(PS\_iso_j + p\_subs\_iso_j\right)^{\epsilon\_s\_iso_j}\right\} \quad \perp S\_iso_j \geq 0 \tag{3}$$

Demand function for sweetener:

$$D\_sweet_i = \alpha_i * \left(PD\_sweet_i - c\_subs_i\right)^{\epsilon\_d\_sweet_i} \quad \perp D\_sweet_i \geq 0 \tag{4}$$

Ending stocks of sugar:

$$EST\_su_i = \alpha_i * PD\_sweet_i^{\epsilon\_est_i} \quad \perp EST\_su_i \geq 0 \tag{5}$$

Market clearing:

$$S\_su_j \geq \sum_{sch,\, i} X\_su_{sch,i,j} \quad \perp PS\_su_j \geq 0 \tag{6}$$

$$S\_iso_j \geq \sum_{sch,\, i} X\_iso_{sch,i,j} \quad \perp PS\_iso_j \geq 0 \tag{7}$$

$$D\_sweet_i + EST\_su_i - ost\_su_i \leq \sum_{sch,\, i} X\_su_{sch,j,i} + \sum_{sch,\, i} X\_iso_{sch,j,i} \perp PD\_sweet_i \geq 0 \tag{8}$$

Trade from country-of-origin j to country of destination i (spatial arbitrage condition):

$$\begin{aligned}&\big(PS\_su_j + PSH\_capa_j + PSH_{sch,j,i} + exw\_fas_j + loading_j\\&+freight_{j,i} + tc_{ch,j,i})*(1 + tar\_av_{sch,j,i}) + tar\_sp_{sch,j,i}\\&+PSH\_MD_{sch,j} + PSH\_MO_{sch,i} + PSH\_MOMD_{sch}\\&+unloading_i + inld.trans_i \geq PD\_wse_i \quad \perp X\_su_{schj,i} \geq 0\end{aligned} \tag{9}$$

$$\begin{aligned}&\big(PS\_iso_j + PSH\_capa\_iso_j + landtrans\_iso_{j,i} + tc\_iso_{sch,j,i}\big)\\&*\big(1 + tar\_av\_iso_{sch,j,i}\big) + tar\_sp\_iso_{sch,j,i} + PSH\_MD\_iso_{sch,j}\\&+PSH\_MO\_iso_{sch,i} \geq PD\_wse_i \quad \perp X\_iso_{schj,i} \geq 0\end{aligned} \tag{10}$$

Processing capacities:

$$S\_su_j \leq capa_{suj} \quad \perp PSH\_capa_j \geq 0 \tag{11}$$

$$S\_iso_j \leq capa\_iso_j \quad \perp PSH\_capa\_iso_j \geq 0 \tag{12}$$

Tariff rate quotas:

$$X\_su_{sch,j,i} \leq trq_{sch,j,i} \quad \perp PSH_{sch,j,i} \geq 0 \tag{13}$$

$$\sum_i X\_su_{sch,j,i} \leq md\_trq_{sch,j} \quad \perp PSH\_MD_{sch,j} \geq 0 \tag{14}$$

$$\sum_j X\_su_{sch,j,i} \leq mo\_trq_{sch,i} \quad \perp PSH\_MO_{sch,i} \geq 0 \tag{15}$$

$$\sum_{j,i} X\_su_{sch,j,i} \leq momd\_trq_{sch} \quad \perp PSH\_MOMD_{sch} \geq 0 \tag{16}$$

$$\sum_i X\_iso_{sch,j,i} \leq md\_trq\_iso_{sch,j} \quad \perp PSH\_MD\_iso_{sch,j} \geq 0 \tag{17}$$

$$\sum_j X\_iso_{sch,j,i} \leq mo\_trq\_iso_{sch,i} \quad \perp PSH\_MO\_iso_{sch,i} \geq 0 \tag{18}$$

where,

j, exporting country; *p_subs*, producer subsidy; *i*, importing country; capa, processing capacity; *sch*, trade regime (scheme); *c_subs*, consumer subsidy; *su*, sugar; *tar_av*, ad valorem tariff; *iso*, isoglucose; *tar_sp*, specific tariff; *sweet*, sweetener (su&iso); *trq*, tariff rate quota; *S*, supply; *md*, multi-destination; *D*, demand; *mo*, multi-origin; *EST*, ending stocks; *momd*, multi-origin-multi-destination; *ost*, opening stocks; *exw_fas*, freight cost from plant to port; *X*, traded quantity; *loading*, loading cost; *PS*, producer price; freight, ocean freight; *PD*, consumer price; *tc*, transaction cost; *PSH*, quota/capacity rent; *unloading*, unloading costs; α, intercept; inld._trans, freight cost from port to market; γ, additive intercept; *landtrans*, cost for trading over land; ε, elasticity/exponent

A key extension compared to the last published version of the model (Calì *et al*. 2013) is a more detailed representation of tariff rate quotas that goes beyond the classical single-origin, single-destination approach. In addition to the classical country-by-country tariff rate quotas (Eqn 13), Equations 14 to 16 also allow to limit exports of a single country to a group of countries (multi-destination TRQs, Eqn 14), exports of a group of countries to a single country (multi-origin TRQs, Eqn 15) and the trade volume between two country groups (multi-origins–multi-destination TRQs. Eqn 16) (Nolte *et al*., unpublished report). This extension can be considered an important methodological improvement, especially with regard to the representation of the EU tariff regime. This is because given the breakdown of EU demand to the individual MS level, tariff rate quotas of the EU can no longer be modelled as single-origin, single-destination TRQs. Instead, multi-destination as well as multi-origin–multi-destination TRQs are applied in order to ensure that cumulative exports of a single country (e.g. Australia) or a group of countries (e.g. Central American countries) to all EU MS do not exceed a quantitative limit. Furthermore, also EU production quotas are technically modelled as multi-destination TRQs to allow for over-quota production. That means cumulative sales of an individual EU MS to all other EU MS, including domestic sales, are restricted to the level of the production quota, while production quantities exceeding the quota level can be exported to third countries within the quantitative WTO export restriction. Besides a more sophisticated representation of tariff rate quotas, the model was extended to EU isoglucose sector. Moreover, EU demand and ending stocks were broken down to the individual EU MS level. Thus, the extended model version covers complete market balances including changes in stocks for all EU MS. Unlike previous model versions, the approach therefore also allows intra-EU trade to be simulated.

3.1.3 Model linkage

The two models are linked by applying similar supply functions for all EU MS in both models. More specifically, in the SPE model Equation 2 is replaced by the following equation:

Supply function of sugar:

$$S\_su_j = \max\left\{0, \alpha_j * \left(PS\_su_j - npc\_su_j\right)^{\epsilon\_s\_su_j} - \gamma_j\right\} \quad \perp S\_su_j \geq 0 \qquad (19)$$

where the parameter npc_su represents net-processing costs including all producer subsidies. Similar to the supply function of Agmemod (Eqn 1), the additive intercept parameter γ is used to model ethanol demand for sugar beet; that is, γ equals the quantity of sugar beet required for ethanol expressed in white sugar equivalent ($UOD_{st} * XTR_{su}$ *in* Eqn 1). The intercept parameter α is calibrated to producer prices derived during the calibration run, where the model is solved with fixed supply, demand and stock quantity and one representative price fixed to the world market price level. During this calibration run, an additional constraint ensures in the linked version of the SPE model that for all EU MS the producer's price (PS) equals the level of production costs derived in Agmemod:

Constraint for EU producer prices:

$$PS\_su_j \geq ps\_eu_j \quad \perp PSH\_PS\_su_j \gtreqless 0 \tag{20}$$

Trade:

$$\begin{aligned}\big(&PS\_su_j + PSH\_PS\_su_j + PSH\_capa_j + PSH_{sch,j,i} + exw\_fas_j \\ &+loading_j + freight_{j,i} + tc_{sch,j,i}\big)*\big(1 + tar\_av_{sch,j,i}\big) + tar\_sp_{sch,j,i} \\ &+PSH\_MD_{sch,j} + PSH\_MO_{sch,j} + PSH\_MOMD_{sch} \\ &+unloading_i + inld.\_trans_i \geq PD\_wse_i \perp X\_su_{ch,j,i} \geq 0\end{aligned} \tag{21}$$

Finally, in the simulation run of the SPE model, the dual variable *PSH_PS_su* is fixed to the values derived from the calibration run, as otherwise the simulation run would not exactly replicate the data set entering the calibration run.

In the simulation of policy shocks, an iterative method is applied where one model is solved based on the results of the other model. After the initial model run of the SPE model, which is going to be the final result of the stand-alone model version, supply balances of sugar and isoglucose are transferred to Agmemod and fixed during the subsequent model run. As supply quantities deviate from the previous model run, they trigger changes in land allocation and thus price changes of competing crops leading to a change in beet costs, raw material costs of isoglucose production as well as the value of by-products. The resulting changes in production cost are transferred back to the SPE model, and the model is then solved based on the re-calibrated supply functions (first iteration run). This process is repeated until both models converge.

3.1.4 Data and calibration

Both modelling approaches described in the previous section require a comprehensive database. Market balances for sugar are obtained from F.O.Licht (2019) and USDA (2014) supplemented by national statistics (SI-STAT 2018; Agreste 2019) and FAOSTAT (2018). Market balances for isoglucose are compiled based on production figures published by the EU sugar market observatory and trade data extracted from Eurostat (2021). Data on production costs for sugar and isoglucose are based on LMC (2013). Maximum processing capacities were derived from CEFS (2017) and have been corrected for factory closures in Romania, France, Germany and Poland (F.O.Licht 2019a, 2019b, 2019c). Elasticities are obtained from various sources and range between 0.04 to 0.83 for supply; 0.01 to 0.16 for demand, and 0.01 to 0.2 for stock demand. Intra-EU transportation costs for major routes were provided by the Nordzucker company. For routes not covered in the provided dataset, transportation costs were estimated by OLS regression based on the distance between countries (CEPII 2015). As in previous versions of the SPE model, transaction costs are assumed to equal 10 euro per tonne for quantities imported under TRQs. In addition, a reduction in transaction costs is assumed for well-established routes.[2] Finally, information on recently agreed trade agreements and the respective level of specific and ad valorem tariff rates, and the level of TRQs (if any) were extracted from ITC (2020) and EC (2021c). Over the projection period, the level of TRQs was for most countries set equal to the last reported year. However, for preferential EU tariff rates, a tariff reduction and/or increase in TRQs according to Table 1 are assumed. Finally, for countries allowed to trade only under one scheme, that is countries for which tariff preferences are not explicitly modelled, the applied tariff is set to the weighted ad valorem tariff equivalent of the CN Code 1701 extracted from World Bank (2020).

In order to obtain projection results until 2030, Agmemod is solved based on the macro-economic and policy assumptions as well as world market price development of the EU agricultural outlook (EC 2019). In the calibration run of the SPE model, EU MS are calibrated to Agmemod projections, while non-EU MS are calibrated to the EU agricultural outlook (Salputra 2019). For countries neither covered in Agmemod nor in the EU agricultural outlook, annual growth rates are applied calculated from F.O. Licht (2019). Countries not available in the F.O. Licht statistics are calibrated to supply balances derived by scaling supply, demand and stock quantities to the projection of the EU agricultural outlook for the respective continent.[3]

[2] The reduction in transaction cost was calculated based on a country's share of exports to a specific destination in production; that is, each percentage was valued at a discount of 0.614 EUR/t assuming the same absolute value (but opposite sign) for the change in transaction cost as estimated by Nolte *et al.* (2012). As transaction costs enter the model as exogenous parameter, the reduction in transaction costs assumed over the projection period is set to the average level over the period from 2012 to 2018. The share of exports to a specific destination in production was calculated based on trade flows extracted from CEPII (2020).

[3] Please note that the supply of Africa has been reduced by 18% compared to the EU agricultural outlook projection as a supply increase from 11.4 mill t to 18.6 mill t between avg. 2016–18 and 2030 (+62%) was considered as too optimistic. Even after this correction, the supply increase in Africa is still 33%.

Finally, market clearing at the global level is ensured by scaling the demand of the 'Rest-of-Aggregates' of each continent.[4]

3.2 Scenarios

Overall, four scenarios are simulated to examine the effects of a gradual elimination of EU domestic support and border protection measures on Australia and other third countries. Agmemod is solved for the period 2004 to 2030, while the SPE model runs from 2013 to 2030. The following sections briefly describe the key assumptions of each scenario.

3.2.1 Quota scenario

The quota scenario is used as the reference scenario for the analysis; that is, all effects of the investigated liberalisation steps are quantified relative to the quota scenario. In the quota scenario, the policy framework of the CAP financial period 2007 to 2013 is maintained, meaning that the EU quota system and the WTO export limit remain in place until 2030. Voluntary coupled support payments for sugar beet are ignored, since these payments were only introduced as part of the 2013 CAP reform in order to support the sugar sector in less competitive EU MS in the aftermath of the abolition of the EU quota system. Moreover, all recently concluded regional trade agreements are assumed to remain in place, as these agreements are not part of the EU sugar regime.

3.2.2 Quota abolition scenario

The quota abolition scenario (hereafter 'no quota') assumes a continuation of the 2014 to 2020 CAP policy framework and is based on the assumptions of the EU agricultural outlook (EC 2019). Regarding sugar, this means that the EU quota system is abolished in 2017, while voluntary coupled support payments for sugar beet are introduced in 2015 and remain in place until 2030.

3.2.3 EU–Australia free trade agreement

The EU–Australia free trade agreement scenario (hereafter 'FTA-EU-AUS') is based on the same assumptions as the no quota scenario. In addition, the scenario assumes that the EU and Australia conclude a free trade agreement. A trade agreement between the two countries has been under negotiation since 2018, but no proposals on the exact tariff reduction for sugar have so far been published (EC 2021b). Thus, the scenario assumes duty-free and quota-free trades between both partners. The results of the scenario should therefore be interpreted as the maximum effect of a possible free trade agreement between the EU and Australia.

[4] A precondition for the calibration run of the SPE model is that world supply plus global opening stocks are equal to the sum of world demand plus global ending stocks.

3.2.4 EU full liberalisation

In the EU full liberalisation scenario (hereafter 'EU MFN_zero'), all MFN import tariffs of the EU are set to zero from 2021 onwards. This implies that third countries lose their tariff preferences to the EU market. Furthermore, in addition to the EU production quotas all remaining domestic support instruments for the EU sugar sector are removed, in particular all voluntary coupled payments for sugar beet. Thus, EU MS previously supported by coupled payments are likely to become less competitive.

4. Results

This section presents the results of the scenarios described above. First, the effects of linking the models are presented; that is, the resulting change in sugar production in response to a change in production costs caused by price adjustments of competing crops to sugar beet. Second, this section describes the change in EU sugar imports from different countries of origin and resulting changes in sugar production of Australia and other third countries relative to the quota scenario.

4.1 Iteration effects of model linkage

Figure 1 shows, as an example, the change in production costs and the resulting change in sugar for major sugar-producing EU MS calculated as the difference between the result of the initial stand-alone model run and the result after the first iteration. As the figure reveals, despite a major initial policy shock in the scenario EU MFN_zero, the resulting changes in production cost and sugar production are only minor, hardly exceeding 0.01 per cent in most EU MS. This is also confirmed by the results of the other two policy scenarios and does not change even when compared for different years (not shown here due to space constraints). In all scenarios, both models converged already after the second iteration; that is, the results of the second iteration run no longer deviated from the previous model run.

4.2 EU imports

Table 3 presents the effects of simulated scenarios on the EU sugar balance and EU imports by country of origin. Imports from individual countries are shown for those countries belonging to the top 20 countries of origins for EU sugar imports in one of the simulated scenarios. In addition to the base period (avg. 2016–14) and target year 2030, the table also shows results for the average of the period 2024–26, as in particular the tariff reduction scenarios show quite a dynamic development over the simulation period.

Overall, the simulation results presented in Table 3 clearly show that the abolition of the EU quota system and the resulting increase in EU sugar production lead to a substantial decline in total EU imports. If the EU sugar

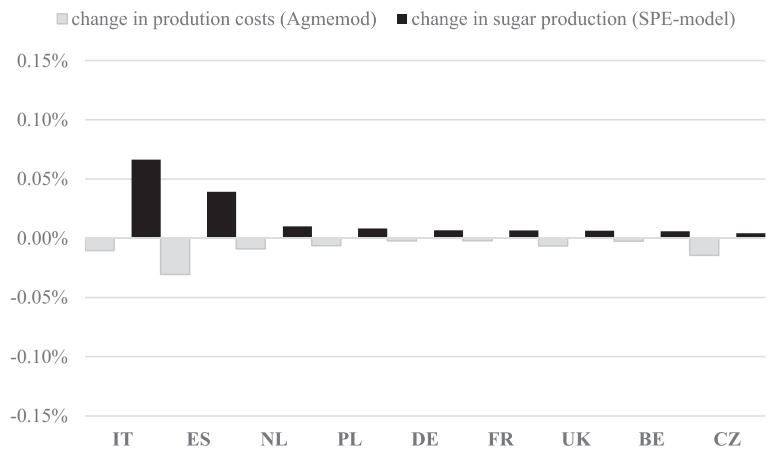

Figure 1 Change in production costs of sugar and sugar production for selected EU MS after 1. iteration in per cent (scenario 'EU MFN_zero', 2030/31). Source: own simulation.

market is further liberalised by allowing Australia to export to the EU at a zero-tariff rate, EU imports recover during periods of low global sugar prices – as in the period from 2024 to 2026 – but do not return to the level simulated for the quota scenario. Given a complete elimination of EU MFN tariffs, however, EU imports increase significantly, even exceeding the level of the quota scenario during periods of low global sugar prices.

Focusing on the different countries of origin for EU sugar imports, results clearly reveal that LDC-ACP exporters are the first group of preferential exporters to be displaced from the EU market, if the EU sugar market is progressively liberalised. Under the quota scenario, results suggest that LDC-ACP countries lose market shares compared to the base period mainly due to increasing imports under regional trade agreements concluded in recent years (see Table 1). These tariff preferences are used in particular by Central American countries and EU neighbouring countries as well as South Africa and Canada. Moreover, a decline in EU sugar consumption combined with a reduction in ending stocks result in lower EU import needs compared to the base period. In the no quota scenario, most LDC-ACP countries are completely forced out of the EU market by increasing EU sugar production. By 2030, among the group of LDC-ACP countries, only Fiji keeps delivering sugar to the EU, while imports from other LDC-ACP exporters drop down to zero. This can be explained by the fact that compared to other LDC-ACP exporters Fiji faces higher trade barriers for exports to other alternative outlets. On one hand, Fiji is located in a sugar surplus region and has to compete with Australia and Thailand in the Oceania regions for exports to neighbouring countries. On the other hand, most other LDC-ACP exporters, in particular African countries, can easily redirect sugar exports to other preferential trading partners as they are located in a sugar deficit region and belong to other preferential trading areas, such as the Southern African

Table 3 Model results for the EU sugar balance and EU imports by country of origins (1000 t)

	Avg. 2014–2016[†]	Avg. 2024/25 to 2026/27				2030/31			
	Base period	Quota	No quota	FTA EU-AUS	EU MFN zero	Quota	No quota	FTA EU-AUS	EU MFN zero
EU price (EUR/t)	658	607	468	454	399	610	424	427	405
WMP (EUR/t)	377	372	365	367	377	403	399	399	403
EU Production[‡]	15,931	14,621	17,139	16,539	14,937	15,278	17,637	17,510	16,936
EU Consumption[‡]	17,222	16,907	17,093	17,161	17,640	16,618	16,915	16,871	17,190
EU Exports	1172	655	988	1249	1294	1228	1348	1270	1414
EU Imports	3027	2924	905	1806	3908	2461	616	630	1600
EU Stock change	562	−17	−37	−65	−89	−106	−10	−1	−68
LDC-ACP	1717	1218	112	106	-	720	98	108	-
Zimbabwe	390	-	-	-	-	-	-	-	-
Mauritius	206	-	-	-	-	-	-	-	-
Eswatini	200	54	-	-	-	-	-	-	-
Guyana	158	52	0	-	-	36	-	-	-
Sudan	126	-	-	-	-	-	-	-	-
Mozambique	113	324	-	-	-	289	-	-	-
Senegal	85	185	-	-	-	75	-	-	-
Jamaica	68	-	-	-	-	-	-	-	-
Congo, D. R.	65	46	-	-	-	-	-	-	-
Côte d'Ivoire	62	226	-	-	-	-	-	-	-
Fiji	51	122	111	106	-	124	98	108	-
Belize	50	64	-	-	-	70	-	-	-
Dominican Rep.	41	-	-	-	-	-	-	-	-
Mali	31	56	-	-	-	-	-	-	-
Papua New Guinea	10	5	1	-	-	-	-	-	-
Other	61	4	-	-	-	126	-	-	-
CXL	808	835	108	1229	3011	835	54	54	287
Brazil	729	754	108	54	3011	754	54	54	287
Cuba	63	6	-	-	-	63	-	-	-
Australia	9	9	-	1175	-	9	-	-	-

Table 3 (*Continued*)

	Avg. 2014–2016[†]	Avg. 2024/25 to 2026/27				2030/31			
	Base period	Quota	No quota	FTA EU-AUS	EU MFN zero	Quota	No quota	FTA EU-AUS	EU MFN zero
India	6	9	-	-	-	9	-	-	-
Balkan	162	209	203	183	1	207	188	188	287
Serbia	153	181	181	169	-	181	181	180	281
Macedonia	4	10	9	8	1	9	7	7	6
Bosnia and Herzegovina	4	13	13	6	-	13	-	-	-
Albania	1	4	-	-	-	4	-	-	-
Other RTA	340	662	482	287	897	699	276	280	1027
Costa Rica	93	141	117	115	-	136	135	135	-
Colombia	62	80	74	1	-	89	5	9	-
Honduras	55	42	71	72	-	23	44	45	-
South Africa	50	150	-	-	-	150	-	-	-
Moldova	26	37	37	37	10	37	37	37	62
Peru	22	28	28	28	-	32	-	-	-
Ukraine	13	20	20	20	886	20	20	20	964
Panama	12	15	15	13	-	17	5	5	-
Guatemala	7	-	-	-	-	-	-	-	-
Nicaragua	-	5	-	-	-	49	29	29	-
Canada	-	113	99			112	-		
Ecuador	-	30	20	-	-	33	-	-	-

[†]Average of the sugar marketing years (Oct.-Sep.) 2014/15 to 2016/17.
[‡]Excluding bioethanol.
Source: own simulation.

Customs Union (including Botswana, Eswatini, Lesotho, Namibia and South Africa) or the Southern African Development Community (including Mauritius, Mozambique, Tanzania, Zambia and Zimbabwe).

Exports of CXL countries including the world's largest sugar exporters Brazil and Australia remain stable in the quota scenario compared to the base period. Thus, results suggest that these countries are able to compete with exports entering the EU under recently concluded regional trade agreements. The abolition of the EU quota system and resulting increase in EU sugar production, however, leads to a substantial decline in EU imports from CXL countries with imports from Australia, Cuba and India dropping down to zero. Under a free trade agreement between the EU and Australia, EU preferential imports from Australia substantially increase, but only during periods of low global sugar prices when prohibitive EU MFN tariffs allow the EU sugar price to range well above the world market price making the EU a more profitable outlet compared to other traditional export destinations of Australia. However, if EU MFN tariffs are eliminated, Australia and most other third preferential exporters are squeezed out of the EU market by higher imports from Brazil and certain EU neighbouring countries, in particular Ukraine and Serbia.

Non-European countries with preferential market access to the EU under regional trade agreements, namely Central American countries, Columbia, South Africa, Panama, Ecuador and Canada, gain market shares in the quota scenario compared to the base period. Thus, assuming no change in the EU sugar regime, results suggest that these countries are likely to benefit from increasing preferential market access to the EU. However, with the abolition of the EU quota system, only Central American countries and Colombia keep exporting to the EU, as long as EU MFN tariffs remain in place. If the EU tariff regime is completely liberalised, EU imports from these countries drop down to zero.

In contrast to EU imports from most other preferential exporters, EU imports from the Balkan countries, in particular Serbia and Macedonia, as well as EU neighbouring countries (Ukraine, Moldova) remain rather stable or even increase under the simulated policy shocks. Hence, these countries are either more competitive than other preferential exporters or they face higher trade barriers (tariffs and transportation costs) to other markets.

4.3 Changes in production

Table 4 presents the change in sugar production relative to the quota scenario. Results are presented for those individual countries mostly affected in relative terms, either directly or indirectly. In addition, the table shows the aggregated results per continent as well as the change in production for the top three sugar producers within each region.

Focusing on the changes in sugar production by continent, all simulated policy shocks lead to an increase in EU production when compared to the quota scenario, while sugar production on other continents declines resulting in a net increase at the global level. Overall, the largest decline in sugar production outside the EU is simulated for the quota scenario, while sugar production decreases less or even increases in the two tariff reduction scenarios. This implies that a liberalisation of the EU domestic sugar market, that is the abolition of the EU quota system, negatively affects sugar production in most third countries, while a liberalisation of the EU tariff regime benefits most third country suppliers and may partly, fully or even over-compensate for the negative effect resulting from the abolition of the EU quota system. At the continent level, by 2030 the strongest decline in sugar production is simulated for non-EU-Europe, followed by Africa, Oceania, America and Asia.

However, the effects at the individual country level are diverse. As far as the abolition of the EU quota system is concerned, the third countries being affected most negatively are small preferential sugar exporters that face high trade barriers to other markets and export a significant share of their sugar production to the EU in the quota scenario. Even if these countries are able to maintain exports in the no quota scenario, they receive a significantly lower sugar price on the EU market. Basically, all Balkan countries belong to this group, in particular Macedonia and Albania, but also other preferential sugar exporters, such as Canada and Fiji. Besides preferential sugar exporters, also other third countries are adversely affected from the abolition of the EU quota system due to trade diversions. The sugar production of Russia, for example, declines substantially due to increasing competition in the Asian region mainly as a result from Brazil redirecting its sugar exports from the EU market to Asian countries.

A free trade agreement between the EU and Australia can over-compensate negative effects on Australia's sugar production resulting from the abolition of the EU quota system. However, this effect remains limited to periods of low global sugar prices, when prohibitive EU MFN tariffs ensure the EU sugar price to range well above the world market price making the EU a more profitable outlet compared to other destinations. While benefiting Australia's sugar production, a free trade agreement between the EU and Australia also causes sugar production of other preferential sugar exporters to decline further, as they are squeezed out of the EU market by increasing EU imports from Australia. In particular, simulations results show a further decrease in sugar production of Canada, Macedonia, Columbia, Fiji and Papua New Guinea ranging between 4.6 and 1.7 per cent in the period 2024–26 relative to the no quota scenario.

Not only for Australia, but also for other third countries, a complete elimination of EU MFN tariffs may over-compensate the decline in production resulting from the abolition of the quota system. However, this effect remains limited to the period 2024–26 when low global sugar prices result in a significant increase in EU sugar imports from Brazil at the expense of domestic sugar production. During these periods, especially the world's

Table 4 Model results for the change in sugar production relative to the quota scenario

	Avg. 2014–2016†	Avg. 2024/25 to 2026/27				2030/31			
	base period	Quota	No quota	FTA EU-AUS	EU MFN zero	Quota	No quota	FTA EU-AUS	EU MFN zero
	1000 t	1000 t	%	%	%	1000 t	%	%	%
EU-28	15,931	14,621	17.2	13.1	2.2	15,278	15.4	14.6	10.9
Non-EU Europe	8172	10,443	−2.1	−1.9	−1.1	11,197	−4.8	−4.4	−4.8
Russia	5241	6520	−2.8	−2.7	−3.2	7115	−6.6	−6.2	−6.7
Ukraine	1779	2334	−1.5	−1.2	5.3	2612	−0.8	−0.8	−0.1
Serbia	478	359	−3.4	−3.3	−3.8	338	−4.2	−3.7	−7.8
Bosnia & Herzegovina	93	223	−3.1	−3.0	−8.0	176	−4.2	−3.8	−6.3
Moldova	40	87	−1.5	−1.5	−1.7	76	−3.8	−3.5	−0.9
Macedonia	4	10	−13.3	−16.9	−23.1	9	−17.8	−17.7	−21.0
Albania	2	4	−7.3	−7.1	−10.8	4	−5.9	−5.6	−7.5
Other	534	906	2.2	2.6	0.0	868	−2.2	−0.4	−1.6
Africa	9968	13,847	−1.7	−1.5	−1.3	15,504	−1.8	−1.5	−1.5
Egypt	2313	3712	−1.6	−1.6	−1.9	4615	−4.0	−3.8	−4.1
South Africa	1488	2754	−2.1	−2.0	−1.9	3169	−0.5	−0.4	−0.1
Eswatini	612	803	−2.1	−1.9	−1.8	869	−0.4	−0.4	−0.1
Morocco	543	693	−2.4	−0.3	−0.3	806	−5.2	−2.3	−2.5
Ethiopia	317	461	−3.0	−2.8	−2.2	522	−1.9	−1.9	−1.6
Mozambique	308	436	−2.9	−2.8	−2.2	457	−2.2	−2.2	−1.9
Malawi	238	225	−0.5	−0.4	0.2	210	−0.5	−0.3	−1.4
Senegal	130	185	−3.5	−3.4	−2.6	193	−0.6	−0.6	−0.3
Guinea	35	50	−3.3	−3.1	−2.4	52	−0.5	−0.4	−0.2
Other	3985	4529	−1.0	−0.9	−0.5	4610	−0.1	−0.1	0.2
America	62,481	63,031	−1.3	−1.1	0.6	66,109	−0.8	−0.8	−0.3
Brazil	36,201	35,284	−1.6	−1.3	0.9	36,950	−0.9	−0.9	−0.1
United States	7303	7668	−1.3	−1.0	0.7	7659	−1.1	−1.0	−1.1
Mexico	5782	6271	−0.7	0.0	0.4	6759	−0.4	−0.4	0.0
Colombia	2169	1967	−0.4	−3.1	−3.1	2079	−0.8	−0.7	−1.1

Table 4 (*Continued*)

	Avg. 2014–2016†	Avg. 2024/25 to 2026/27				2030/31			
	base period	Quota	No quota	FTA EU-AUS	EU MFN zero	Quota	No quota	FTA EU-AUS	EU MFN zero
	1000 t	1000 t	%	%	%	1000 t	%	%	%
Guyana	178	81	−5.2	−5.1	−4.5	65	−2.4	−2.4	−2.7
Panama	156	154	−0.6	−0.5	−3.1	152	−2.2	−2.1	−3.1
Canada	90	113	−13.0	−16.9	−15.6	112	−12.2	−12.2	−11.7
Belize	81	96	−5.5	−5.3	−4.7	100	−2.5	−2.5	−2.8
Barbados	9	7	−0.5	−0.3	0.2	5	1.5	1.5	1.2
Other	10,512	11,389	−0.7	−0.5	0.3	12,227	−0.4	−0.4	−0.2
Asia	61,262	80,294	−0.8	−0.4	0.2	89,271	−0.4	−0.4	−0.1
India	24,479	31,497	−0.7	0.0	0.4	36,443	−0.4	−0.3	0.0
Thailand	9888	14,245	−0.6	−0.5	0.3	15,562	−0.3	−0.3	0.0
China	9661	12,735	−0.6	−0.4	0.3	13,546	−0.3	−0.3	0.0
Philippines	2276	2428	−3.7	−3.5	−2.8	2487	−1.4	−1.4	−1.1
Japan	719	813	−4.9	−4.6	−3.7	815	−3.1	−3.1	−2.6
Nepal	208	305	−2.8	−2.6	−2.1	359	−1.8	−1.8	−1.5
Other	14,031	18,271	−0.6	−0.4	0.3	20,059	−0.4	−0.4	−0.1
Oceania	4671	4698	−1.4	−0.1	0.2	4647	−0.9	−0.9	−0.4
Australia	4458	4491	−1.2	0.3	0.7	4442	−0.6	−0.6	−0.1
Fiji	171	162	−6.3	−9.0	−10.6	164	−9.0	−8.8	−8.8
Papua New Guinea	41	44	−6.5	−8.1	−8.1	42	−0.3	−0.3	0.0
World	162,486	186,934	0.3	0.3	0.3	202,007	0.3	0.3	0.3

†Average of the sugar marketing year (October to September) 2014/15 to 2016/17. Results are sorted by production level in base period in descending order for each continent.
Source: own simulation.

largest sugar-producing countries including Australia, can increase production compared to the quota scenario. As far as non-EU European countries are concerned, a complete elimination of EU MFN tariffs may overcompensate the decline in production resulting from the abolition of the quota system only in the Ukraine. Moreover, also Moldova is likely to benefit from lower trade barriers to the EU in the long-run, although sugar production does not fully recover.

Despite most countries benefitting from a complete elimination of EU MFN tariffs, there are also countries where sugar production is simulated to decline further as a consequence of a complete liberalisation of the EU sugar policy. In particular, preferential exporters that are squeezed out of the EU market belong to this group, such as the Balkan countries and certain South and Central American countries (Colombia, Panama). Sugar production of Fiji declines in the period 2024–26, but recovers by the end of the projection period. Thus, results suggest that Fiji's sugar production is not necessarily significantly affected by a completed elimination of EU MFN tariffs, even if EU imports from Fiji fall to zero. This is mainly due to potential trade diversion in the Oceania region, as even marginal changes in the trade flows of Brazil and other large sugar exporters can create (or erode) export opportunities for Fiji to neighbouring countries, such as New Zealand.

Apart from preferential exporters to the EU, also some other sugar exporting countries, such as Egypt and Russia, are negatively affected by an elimination of EU MFN tariffs due to trade diversions. While Egypt faces higher competition in the Asian region from European sugar exporters, among them highly competitive EU MS, such as the Netherlands and Poland, Russia's sugar productions decline mainly due to increasing imports from Serbia.

5. Conclusion

This paper examines the consequences of a liberalisation of the EU sugar policy on Australia and other third country sugar suppliers. For that purpose, four scenarios are simulated that show the effects of i) the recently implemented abolition of the EU quota system, ii) a free trade agreement between the EU and Australia that has been under negotiation since 2018 and iii) a further potential liberalisation of the EU sugar market by eliminating the still prohibitive EU MFN tariffs on sugar. All scenarios were simulated using the partial equilibrium model Agmemod and the SPE model first developed by Nolte (2008). To take advantage of both modelling approaches, the two models were linked to each other.

The strength of Agmemod is in determining sugar supply of EU MS based on empirical data on production costs taking into account the position of sugar beet in the crop rotation. Hence, the approach overcomes the problem of non-observed production costs, that is the fact that with binding production quotas in place, observed market prices do not represent marginal costs of production and cannot be used to properly calibrate the supply functions of partial equilibrium models as long as the size of the quota rent is unknown.

Moreover, a key strength of Agmemod is that the model outcome is regularly validated by market experts from different EU MS, and aligned with the projections published by the EU Commission (Salputra *et al*. 2017; EC 2019; Salamon *et al*. 2019). This validation process is particularly important with respect to the EU sugar market. This is because as a consequence of the abolition of the quota system the EU sugar market is currently undergoing a fundamental restructuring process that depends heavily on strategic decisions of sugar companies with respect to factory closures or investments in new capacities.

The key strength of the SPE model is the detailed representation of global bilateral trade flows and trade policies with TRQs modelled explicitly rather than being captured by ad valorem tariff equivalents. Compared to previously published model versions, the representation of TRQs has been further improved going beyond the classical single-origin, single-destination approach. Furthermore, EU import demand was broken down to the individual MS level allowing intra-EU trade to be captured.

Moreover, a crucial advantage of the SPE approach over other modelling approaches is that trade flows between trading partners can emerge in response to the implemented policy shock, even though the trade volume is zero in the base period. Given prohibitive EU MFN tariff rates on sugar leading to zero initial trade flows in the base period for all countries not benefiting from preferential market access to the EU, this characteristic of the SPE approach is particularly important. By contrast, other commonly applied modelling approaches, such as the Armington approach (Armington 1969), which is used in virtually all general equilibrium models, simulate changes in trade flows relative to the base year. This means that with the Armington approach, small import flows always stay small and zero import flows always stay zero (Calì *et al*. 2013).

Despite the strength of both models, some remaining limitations need to be mentioned:

First, both models are partial equilibrium models and do therefore not endogenously account for strategic decisions. These can only be captured by adjusting the model parameters according to exogenous information such as expert knowledge. As already mentioned above, this limitation is particularly relevant with respect to the EU sugar market, since strategic decisions on factory closures or investments in new capacities might change the level of EU sugar production, resulting in a higher or lower EU import demand.

Second, a limitation of the SPE approach is that the model does not replicate an observed trade matrix. This means the simulated bilateral trade flows might considerably deviate from the trade flows observed in a given year. Also, the SPE model does not cover the refining sector, as all sugar is modelled in white sugar equivalent. This might lead to an underestimation of

EU imports, since raw sugar cannot be imported and re-exported as refined sugar. Finally, as all prices are modelled in Euro, the SPE model does not account for fluctuations in exchange rates.

Third, the analysis does not take into consideration the withdrawal of the United Kingdom (UK) from the EU (the so-called 'Brexit'). This is because at the time of writing this paper, negotiations on the terms of the Brexit had not yet been concluded. The UK, however, has one of the biggest sugar refining sectors in the EU and ranks among the largest EU sugar deficit regions. Thus, the country has in the past been an important export destination for both preferential third country sugar exporters as well as sugar exporting EU MS. Brexit-related changes in the trade regime between the UK and the EU as well as the UK and other third countries could therefore significantly affect the results.

After the completion of Brexit, however, import tariffs on sugar have not changed significantly. EU MS and LDC and ACP countries are still allowed to export quota-free and duty-free to the UK. Moreover, the UK has already concluded bilateral free trade agreements with several other preferential trading partners of the EU, among them Canada and the Ukraine (EC 2021c; GDS 2021). Finally, there is currently a duty-free import quota of 260 thousand tonnes of raw sugar in place open for every third country (EC 2021c). Until 2030, this import quota is likely to be replaced by a tariff rate quota for Australia, as the UK and Australia signed a free trade agreement on 17 December 2021. The agreement is the first post-Brexit trade agreement negotiated by the UK from scratch, rather than adopting the terms of trade enjoyed by the UK as an EU MS. According to the final agreement, the tariffs on sugar will be eliminated over a period of eight years with a duty-free quota of 80,000 tonnes on entry into force, rising in equal instalments to 220,000 at Year 8 (DFAT 2021). However, given the overall only minor changes in the UK's tariff regime for sugar, taking Brexit into account would most likely not significantly affect the results. Moreover, considering Brexit in the analysis can be expected to affect all scenarios in a similar way, resulting in only marginal effects on the differences between scenarios. This is also confirmed by other studies, such as the EU impact assessment on the trade effects of a free trade agreement between the EU and Australia. Assuming no change in the UK's trade policy, the study found hardly any difference in the trade effects for the EU-27 and EU-28 (EU-27 + UK) (BKP Economic Advisor 2020).

Despite remaining limitations, the linked model approach has proven to be particularly suitable for analysing the effect of a change in the EU sugar policy on third countries. The Agmemod model contributes by i) providing validated projection results at EU MS level, ii) determining sugar supply of EU MS based on empirical data on production cost and iii) capturing competitive relations between sugar beet and other crop sectors. The SPE model, on the other hand, contributes because of its i) detailed global country coverage and ii) comprehensive representation of bilateral trade relations and trade policies including multilateral tariff rate quotas.

Results of the model iteration runs show that, despite major initial shocks introduced in the simulated policy scenarios, the resulting changes in production cost and sugar supply are only minor and hardly exceed 0.01 per cent in most EU MS. This can mainly be explained by the rather small share of sugar beet in the total crop area in most countries, ranging on average between 0.4 and 4.7 per cent in the period 2014–16 (exceptions: NL: 16.3%, BE: 10.6%). Hence, even large relative changes in the sugar beet area harvested result only in minor changes in the total area allocation, with small corresponding price changes. However, despite the rather small effects in the model iteration runs, a key benefit of the linked model approach compared to the stand-alone version of the SPE model is that it allows the effects of market shocks indirectly affecting the global sugar market, such as changes in world market prices of competing crops to sugar beet, to be quantitatively assessed. These price changes directly affect beet costs and thus the competitive position of the EU in the global sugar market, leading to changes in the net trade position of the EU and trade diversions worldwide.

Overall, results show that sugar production of third countries declines as a consequence of progressive liberalisation of the EU sugar market. This decrease in production is mainly the result of the abolition of the EU quota system, while an elimination of EU MFN tariffs can partly, fully or even over-compensate for the negative effect on sugar production. However, an over-compensation, that is increase in sugar production, remains limited to periods of low global sugar prices when EU imports from Brazil increase significantly at the expense of EU sugar production. Similarly, a free trade agreement with the EU benefits Australia's sugar production most during periods of low global sugar prices when the prohibitive EU MFN tariffs ensure the EU sugar price to range well above the world market price, making the EU a more profitable outlet compared to other export destinations.

The third countries most negatively affected by liberalisation of the EU sugar regime are small preferential sugar exporters that face high trade barrier (tariffs and transportation cost) to other markets and export a significant share of their sugar production to the EU. Even if these countries are able to maintain or even increase exports to the EU, they receive a significantly lower sugar price on the EU market. Basically, all European countries exporting sugar to the EU under the EU tariff preferences for the Balkan countries belong to this group, but also other preferential sugar exporters, in particular Canada, Fiji and Papua New Guinea.

In order to mitigate the negative consequences of a liberalisation of the EU sugar market for those countries, various strategies are applicable. First, the governments of these countries could aim to negotiate new trade agreements in order to increase export opportunities to other profitable outlets. Second, investment programs could be launched in order to increase competitiveness of the domestic sugar industry and create alternative outlets in the non-food sector (e.g. ethanol and bioplastics). Third, countries adversely affected by preference erosion could shift their production and export strategy towards fast-growing profitable niche markets, such as organic sugar. Finally, restructuring programs could be launched to both create alternative employment opportunities in rural areas and encourage uncompetitive sugar processors to exit the market.

With regard to future research, the approach presented in this paper could be particularly improved by calibrating the SPE model to an observed trade matrix. As already shown by Nolte *et al.* (2012), this can be done by attaching non-linear cost terms to each trade flow. However, this approach has not yet been implemented in the applied version of the SPE model. Furthermore, a differentiation between raw and refined sugar, that is an extension of the SPE model to the refining sector, would allow for an even more sophisticated representation of trade policies in the SPE model and thus further improve the depiction of bilateral trade flows.

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Data availability statement

The data that support the findings of this study cannot be shared with any third party due to confidentiality agreements between the author's institution and LMC International Ltd. as well as IHS Markit Ltd. Data are available on request from the author with the permission of LMC International Ltd. and IHS Markit Ltd.

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