Quantitative Analyses on the Effects of the EU Sugar Market Policy

D I S S E R T A T I O N

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List of Abbreviations

ACP	African, Caribbean and Pacific
AGMEMOD	AGricultural MEmber state MODelling
avg	average
CAP	Common Agricultural Policy (of the European Union)
EU	European Union
Eq	Equation
GDP	Gross Domestic Product
IST	Income Stabilisation Tools
LDC	Least Development Countries
MFN	Most-Favored-Nation
MS	Member States (of the European Union)
OLS	Ordinary Least Squares
rse	raw sugar equivalent
SPE	Spatial Price Equilibrium
tel quel	French: ‘as it is’ or ‘unchanged’
TRQ	Tariff-Rate-Quota
VCS MS	Member States of the European Union providing voluntary coupled support
VCS	Voluntary Coupled Support
wse	white sugar equivalent

SUMMARY

The sugar market has long been excluded from the systematic reform process of the EU's Common Agricultural Policy started with the MacSharry reform in 1992. While the markets of most other agricultural products were gradually liberalised by phasing-out direct domestic support measures (administrative prices, production quotas, etc.) and reducing the level of border protection (import tariffs, flexible levies, etc.), the EU's sugar regime remained in place virtually unchanged for about 50 years. In 2006, however, the first major reform of the EU sugar regime was introduced and in 2013 the EU even decided to completely abolish almost all domestic support measures by 2017 (production quotas for sugar and isoglucose, minimum price for sugar beet). But the 2013 CAP reform also established the legal framework for granting voluntary coupled payments for sugar beet which were introduced in 11 of 19 sugar beet producing EU Member States (EU MS).

Against this background the overall aim of the thesis is to examine the effects of changes in the EU sugar regime on the EU sweetener market as well as the global sugar market. Five stand-alone but related articles contributing insights relevant for answering the following research questions which have been poorly addressed in existing literature:

I. What are the consequences of a complete elimination of the EU quota system for sugar and isoglucose at EU MS level?
II. To what extent do coupled subsidies for sugar beet introduced as part of the 2013 CAP reform lead to market distortions among EU MS?
III. How are third countries affected by changes in the EU sugar regime?

All three research questions are quantitatively examined by a model-based ex-ante policy impact assessment building on the spatial price equilibrium model first developed by NOLTE (2008) and the agricultural sector model Agmemod (AGMEMOD CONSORTIUM 2022).

While the first article included in this thesis provides a comprehensive descriptive analysis of the world and EU sugar market, **article (2)** addresses **research question (I)**. The model results show that overall the abolition of the quota system leads to an increase in production in the most competitive EU MS resulting in a decline in the EU market price, a decrease in EU sugar imports and a reduction in production in less competitive EU regions. Based on the model results three groups of EU MS are identified as being most, medium and least competitive in sugar production. The most competitive EU MS are those countries where sugar production is simulated to increase in response to the abolition of the quota system regardless of the assumed world market price environment. This group includes Poland, the United Kingdom, the Netherlands, Belgium, Croatia, Hungary and Lithuania. On the other hand, the model results show a decline in sugar production as a consequence of the quota abolition in Italy, Denmark, Greece and Finland. The key factors determining the competitiveness of EU MS in sugar production are i) production costs comprising beet costs and processing costs corrected for the value of by-products and ii) transportation costs to the major deficit regions inside and outside the EU.

Moreover, the results show that the competitive position of sugar relative to isoglucose improves with increasing world market prices and deteriorates with falling world market prices. This can be explained by the change in raw material costs of sugar and isoglucose production which increase at different rates in response to world market price changes. However, results also show that most isoglucose producing EU MS increase isoglucose production in the post-quota period regardless of the assumed world market price environment. The only exceptions are Italy, Germany and Belgium, where high production costs and/or high transportation costs to the EU deficit regions are likely to lead to a decline in isoglucose production, especially in periods of high world market prices.

Research question (II) is addressed in **article (4)**. Methodologically, article (4) builds on the approach and market projections described in article (3). The quantitative results of article (4) show that granting coupled subsidies for sugar beet in 11 of 19 sugar beet producing EU MS leads to an overall increase in EU sugar production and a decline in the market price. Sugar production shifts to those mostly rather uncompetitive EU MS where sugar beet growing is subsidised by coupled support. Poland, the third largest sugar producing EU MS, contributes most to the absolute increase in EU sugar production, whereas in relative terms the increase in production is most significant in countries with the highest per hectare payment rates, namely Greece, Italy, Romania and Hungary. However, apart from Poland, most EU MS granting high per hectare payments are small sugar producing countries. Therefore, the overall market-distorting effect of coupled subsidies for sugar beet remains limited. The decline in sugar production in EU MS not benefiting from coupled support does not exceed 0.3 per cent. Moreover, the effects of coupled support for sugar beet on competing crops are minor with relative changes in the area harvested ranging only between +0.3 and -0.1 per cent. These rather limited effects on competing crops can be explained by the fact that in most EU MS sugar beets account for a small share in the total crop area.

Finally, **article (5)** addresses **research question (III)**. The article provides detailed results on the change in EU imports and the corresponding changes in sugar production of third countries resulting from a gradual phasing-out of all EU domestic support and border protection measures. Overall, the results show that the sugar production of third countries declines as a consequence of a progressive full liberalisation of the EU sugar market. This decrease in production is mainly the result of the abolition of the EU quota system which leads to an increase in EU production and a fall in the EU sugar price resulting in an erosion of the preference margin for third countries exporting sugar to the EU at a preferential tariff rate. The third countries found to be most negatively affected from a liberalisation of the EU sugar regime are small preferential sugar exporters that face high trade barriers (tariffs, 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 after a complete liberalisation of the EU sugar market, they receive a significantly lower price on the EU market. In principal, all European countries exporting sugar to the EU under the tariff preferences for the Balkan countries belong to this group, but also other preferential sugar exporters such as Canada, Fiji and Papua New

Guinea. Moreover, the results show that a complete elimination of EU tariffs on sugar can partly, fully or even over-compensate for the negative effect on sugar production of third countries. However, an over-compensation, i.e. increase in sugar production of third countries remains limited to selected countries and to periods of low global sugar prices.

Overall, the results of this thesis contribute to important policy-relevant research questions from which the following key policy recommendations can be drawn:

As the results of article (2) show, the abolition of the quota system may cause some EU MS to completely cease sugar production despite voluntary coupled support introduced in less competitive regions. Rather than trying to maintain sugar production in uncompetitive regions, policy measures should be targeted at supporting the EU sugar sector to faster adapt to the new market environment. This could be achieved by extensive restructuring programmes, as were already part of the 2006 EU sugar reform. By offering financial incentives, less competitive sugar processors could be encouraged to leave the industry accelerating the shift in production from high- to low-cost sugar producing regions. Moreover, supporting regions that cease sugar production with programmes that stimulate investments in innovations and growth of alternative, more competitive sectors would be a better option than granting coupled subsidies.

Moreover, the quantitative modelling results of article (2) and (5) highlight that with increasing market liberalisation, the EU sugar market becomes more dependent on the world market and thus more volatile. Hence, as for any other liberalised (agriculture) market, risk management strategies will become more important for the EU sugar sector. A wide variety of management instruments exist for risk hedging, ranging from purely market-based to fully subsidised instruments. For those risk management instruments that are fully or partly subsidised, the EU Common Agricultural Policy could set the legal framework. However, dealing with risks is inherent in all economic activities and from an economic point of view market interventions can only be justified in case of market failures. Thus, preference should be given to those instruments where the risk is not fully taken over by the government to ensure that risks are still adequately considered in economic decisions.

Besides the consequences of an increasing market liberalisation for the EU sugar sector discussed in article (2) and (4), the result of article (5) highlight that third countries that have traditionally been preferential sugar exporters to the EU are likely to be negatively affected by a liberalisation of the EU sugar regime. For these countries various strategies are applicable in order to support domestic sugar production and mitigate the negative consequences resulting from the liberalisation of the EU sugar regime. 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 programmes 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, 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 programmes could be launched to both create alternative employment opportunities in rural areas and encourage uncompetitive sugar processors to exit the market.

Overall, the research conducted in this thesis focuses on the effects of policy changes on sugar production and the resulting changes in trade patterns. In recent years, however, policy measures aimed at reducing per capita consumption of sugar have been widely discussed in the public and among policymakers due to health concerns associated with high levels of sugar intake. These policy measures, such as sugar taxes, are currently not reflected in the two partial equilibrium models applied in this thesis. Moreover, in light of global efforts to increase sustainability, policy measures aimed at supporting growth of the bioeconomy sector may be introduced in the coming years resulting in growing demand of sugar for non-food purposes. Future research should therefore focus on a more sophisticated representation of the demand side in economic models. This would allow to quantify the expected long-term effects of policy measures targeting shifts in sugar demand.

ZUSAMMENFASSUNG

Der Zuckermarkt war lange Zeit von dem systematischen Reformprozess der Gemeinsamen Agrarpolitik (GAP) der Europäischen Union (EU) ausgeschlossen, der mit der MacSharry Reform im Jahr 1992 eingeleitet wurde. Während die Märkte für die meisten anderen landwirtschaftlichen Erzeugnisse durch Abschaffung der direkten internen Stützungsmaßnahmen (administrative Preise, Produktionsquoten usw.) und Verringerung des Außenschutzes (Einfuhrzölle, variable Abschöpfungen usw.) mehr und mehr liberalisiert wurden, blieb die EU-Zuckermarktordnung rund 50 Jahre in nahezu unveränderter Form bestehen. Erst im Jahr 2006 wurde die erste grundlegende Reform der EU-Zuckermarktordnung eingeführt und im Rahmen der im Jahr 2013 beschlossenen GAP Reform hat die EU sogar die Abschaffung nahezu aller internen Stützungsmaßnahmen (Produktionsquoten für Zucker und Isoglukose, Mindestpreis für Zuckerrüben) ab dem Jahr 2017 beschlossen. Gleichzeitig wurden mit der Reform jedoch auch die rechtlichen Rahmenbedingungen für die Gewährung von gekoppelten Direktzahlungen für Zuckerrüben geschaffen, die seither in 11 von 19 Zuckerrüben produzierenden EU-Mitgliedstaaten (EU-MS) gezahlt werden.

Ziel der vorliegenden Dissertation ist es, die Auswirkungen von Änderungen der EU-Zuckermarktpolitik auf den heimischen und globalen Zuckermarkt zu analysieren. Dazu umfasst die Arbeit fünf eigenständige Artikel, die thematisch und methodisch in einem engen Bezug zueinanderstehen. In ihrer Gesamtheit tragen die unterschiedlichen Artikel zur Beantwortung der folgenden Forschungsfragen bei, die in der vorhandenen Literatur bisher nur unzureichend adressiert worden sind:

I. Welche Auswirkungen hat die vollständige Abschaffung des EU-Quotensystems für Zucker und Isoglukose in den EU-Mitgliedstaaten?
II. Inwieweit führen die mit der GAP Reform 2013 eingeführten gekoppelten Direktzahlungen für Zuckerrüben zu Marktverzerrungen zwischen den EU-Mitgliedstaaten?
III. Welche Folgen haben Änderungen der EU-Zuckermarktordnung für Drittstaaten?

Alle drei Forschungsfragen werden im Rahmen einer modellbasierten ex-ante Politikfolgenabschätzung quantitativ untersucht. Dabei bauen die Analysen auf dem räumlichen Preisgleichgewichtsmodell, das in seiner ersten Fassung von Nolte (2008) entwickelt wurde, und dem Agrarsektormodell Agmemod auf (AGMEMOD Consortium, 2022).

Während **Artikel (I)** der Dissertation eine umfassende deskriptive Analyse des Welt- und EU-Zuckermarktes enthält, befasst sich **Artikel (2)** mit der **Forschungsfrage (I)**. Grundsätzlich führt die Aufhebung des EU-Quotensystems zu einem Anstieg der Erzeugung in wettbewerbsfähigen EU-Mitgliedstaaten und bewirkt damit einen Rückgang des EU-Marktpreises, eine Verringerung der EU-Zuckerimporte sowie eine Reduzierung der Erzeugung in weniger wettbewerbsfähigen Regionen. Auf Basis der Ergebnisse werden in der Analyse drei Gruppen von EU-Mitgliedstaaten mit hoher, mittlerer und geringer Wettbewerbsfähigkeit der Zuckererzeugung identifiziert. Die erste Gruppe umfasst diejenigen EU-Mitgliedstaaten, in denen die Zuckererzeugung den Modellergebnissen zufolge nach

Aufhebung der Produktionsquoten langfristig steigen wird. Zu dieser Gruppe gehören insbesondere Polen, das Vereinigte Königreich, die Niederlande, Belgien, Kroatien, Ungarn und Litauen. Andererseits zeigen die Modellergebnisse, dass die Zuckererzeugung vor allem in Italien, Dänemark, Griechenland und Finnland infolge der Quotenabschaffung deutlich sinken könnte. Schlüsselfaktoren für die Wettbewerbsfähigkeit der Zuckererzeugung in den EU-Mitgliedstaaten sind dabei i) die Höhe der Produktionskosten, die sich aus den Rübenkosten zuzüglich Verarbeitungskosten abzüglich Nebenprodukterlösen ergeben sowie ii) die Höhe der Transportkosten zu den Defizitregionen innerhalb und außerhalb der EU. Darüber hinaus zeigen die Ergebnisse, dass sich die Wettbewerbsposition der Zuckererzeugung gegenüber der Isoglukoseerzeugung mit steigenden Weltmarktpreisen verbessert und mit sinkenden Weltmarktpreisen verschlechtert, was vor allem auf unterschiedlich stark steigende Rohstoffkosten zurückzuführen ist. Grundsätzlich steigern jedoch die meisten EU-Mitgliedstaaten, die bereits unter dem EU-Quotensystem Isoglukose produziert haben, ihre Isoglukoseerzeugung nach Aufhebung der Produktionsquoten. Lediglich in Italien, Deutschland und Belgien könnte die Isoglukoseerzeugung aufgrund hoher Produktionskosten und/oder hoher Transportkosten zu den EU Defizitregionen langfristig sinken, insbesondere in Phasen hoher Weltmarktpreise.

Die **Forschungsfrage (II)** wird in **Artikel (4)** behandelt. Inhaltlich und methodisch baut der Artikel (4) auf dem Modellansatz auf, der zur Erstellung der in Artikel (3) beschriebenen Marktprojektionen entwickelt wurde. Die in Artikel (4) dargestellten quantitativen Ergebnisse zeigen, dass die Gewährung von gekoppelten Direktzahlungen für Zuckerrüben in 11 von 19 Zuckerrüben erzeugenden EU-Mitgliedstaaten insgesamt zu einem Anstieg der EU-Zuckererzeugung und einem Rückgang des EU-Zuckerpreises führt. Die Zuckerproduktion verlagert sich in diejenigen zumeist wenig wettbewerbsfähigen EU-Mitgliedstaaten, in denen der Zuckerrübenanbau durch gekoppelte Direktzahlungen subventioniert wird. Dabei trägt Polen als drittgrößter Zuckererzeuger der EU am stärksten zum absoluten Anstieg der EU-Zuckererzeugung bei, während der relative Anstieg der Erzeugung in Ländern mit den hohen gekoppelten Hektarprämien am stärksten ist, d. h. in Griechenland, Italien, Rumänien und Ungarn. Abgesehen von Polen handelt es sich bei den EU-Mitgliedstaaten, die hohe Hektarprämien gewähren, jedoch um kleine Zucker erzeugende Länder. Die marktverzerrende Wirkung der gekoppelten Beihilfen für Zuckerrüben bleibt daher insgesamt gering. So beträgt der Rückgang der Zuckererzeugung in EU-Ländern, in denen der Rübenanbau nicht durch gekoppelte Direktzahlungen unterstützt wird, nicht mehr als 0,3 Prozent. Auch die Auswirkungen der gekoppelten Zahlungen für Zuckerrüben auf Konkurrenzkulten zur Zuckerrübe bleiben begrenzt, d. h. die Änderungen der Anbaufläche von Konkurrenzkulten liegt lediglich zwischen +0,3 und -0,1 Prozent. Hauptursache hierfür ist, dass Zuckerrüben nur einen geringen Anteil an der gesamten Ackerfläche haben.

Abschließend behandelt **Artikel (5)** die **Forschungsfrage (III)**. Der Beitrag untersucht die Effekte einer schrittweisen vollständigen Aufhebung aller EU-internen Stützungsmaßnahmen sowie Reduzierung des EU-Außenschutzes auf die Veränderung der EU-Einfuhren und die sich daraus ergebenden Veränderung der Zuckererzeugung in Drittstaaten. Insgesamt zeigen die Ergebnisse, dass die Zuckerproduktion in Drittländern durch eine schrittweise vollständige Liberalisierung des EU-Zuckermarktes zurückgeht. Dieser Produktionsrückgang in Drittstaaten ist in erster Linie eine Folge des EU-Quotenausstiegs, der zu einer Steigerung der EU-Erzeugung sowie zu einem Rückgang des EU-Marktpreises und damit der Präferenzmarge für Einfuhren aus denjenigen Drittstaaten führt, die zu einem präferenziellen Zollsatz Zucker in die EU exportieren können. Dabei sind diejenigen präferenziellen Zuckerexporteure am stärksten negativ von einer schrittweisen Aufhebung der EU-internen Stützung- und Außenschutzmaßnahmen betroffen, die aufgrund hoher Handelsbarrieren (Zölle, Transportkosten) kaum Zugang zu alternativen Absatzmärkten haben und daher einen erheblichen Teil ihrer Zuckerproduktion in die EU exportieren. Selbst wenn es diesen Ländern gelingt nach einer vollständigen Liberalisierung des EU-Zuckermarktes ihre Zuckerexporte in die EU aufrechtzuerhalten oder sogar zu steigern, erzielen sie auf dem EU-Markt einen deutlich geringeren Preis. Grundsätzlich gehören alle europäischen Länder, die im Rahmen der EU-Zollpräferenzen für die Balkanländer Zucker in die EU exportieren, zu dieser Gruppe, aber auch andere präferenzielle Zuckerexporteure, wie Kanada, Fidschi und Papua-Neuguinea. Darüber hinaus zeigen die Ergebnisse, dass eine vollständige Abschaffung der EU-Importzölle die negativen Auswirkungen des EU-Quotenausstiegs auf die Zuckerproduktion in Drittstaaten teilweise, vollständig oder sogar überkompensieren kann. Eine Überkompensation, d.h. ein Anstieg der Zuckerproduktion in Drittstaaten, beschränkt sich jedoch auf wenige Länder und Phasen mit niedrigen globalen Zuckerpreisen.

Insgesamt leisten die Ergebnisse der Dissertation einen Beitrag zu wichtigen politikrelevanten Forschungsfragen, aus denen sich die folgenden zentralen politischen Empfehlungen ableiten lassen:

Wie die Ergebnisse von Artikel (2) zeigen, könnte die Abschaffung des Quotensystems dazu führen, dass einige EU-Mitgliedstaaten die Zuckerproduktion vollständig einstellen, trotz der Einführung von gekoppelten Direktzahlungen in weniger wettbewerbsfähigen Regionen. Anstatt zu versuchen, die Zuckererzeugung in nicht wettbewerbsfähigen Regionen aufrecht zu erhalten, sollten politische Maßnahmen jedoch darauf abzielen, den EU-Zuckersektor dabei zu unterstützen, sich schneller an die neuen Rahmenbedingungen nach dem Ende der Quote anzupassen. Wie bereits im Rahmen der EU-Zuckerreform 2006 könnte dies durch umfassende Umstrukturierungsprogramme erreicht werden, die für weniger wettbewerbsfähige Zuckerverarbeiter finanzielle Anreize zum Ausstieg aus der Erzeugung schaffen, was die Verlagerung der Produktion von Regionen mit hohen Kosten auf Regionen mit niedrigeren Kosten beschleunigen würde. Darüber hinaus wäre es ökonomisch sinnvoller, finanzielle Mittel, die derzeit in die Finanzierung gekoppelten Direktzahlungen für Zuckerrüben fließen, zur Finanzierung von Innovations- und Investitionsprogrammen einzusetzen, die das Wachstum alternativer, wettbewerbsfähiger Sektoren beschleunigen könnten.

Darüber hinaus zeigen die quantitativen Modellergebnisse der Artikel (2) und (5), dass der EU-Zuckermarkt mit zunehmender Marktliberalisierung stärker vom Weltmarkt abhängt und somit volatiler wird. Wie für jeden anderen liberalisierten (Agrar-)Markt gewinnen daher auch für den EU-Zuckersektor Risikomanagementinstrumente an Bedeutung. Zur Absicherung von Risiken existieren unterschiedlichste Instrumente, die von rein marktorientierten Instrumenten bis hin zu vollständig subventionierten Instrumenten reichen. Die Gemeinsame Agrarpolitik der EU kann für Risikomanagementinstrumente, die ganz oder teilweise subventioniert werden, den rechtlichen Rahmen bilden. Zu bedenken ist hierbei jedoch, dass der Umgang mit Risiken Teil jeder wirtschaftlichen Aktivität ist und Markteingriffe daher nur bei Marktversagen gerechtfertigt sind. Um sicher zu stellen, dass Risiken von den wirtschaftlichen Entscheidungsträgern weiterhin angemessen berücksichtig werden, sind daher grundsätzlich Instrumente zu bevorzugen, bei denen das Risiko nicht vollständig auf den Staat übertragen wird.

Neben den in Artikel (2) und (4) dargestellten Folgen einer zunehmenden Marktliberalisierung für den EU-Zuckersektor zeigen die Ergebnisse von Artikel (5), dass Drittländer, die in der Vergangenheit Zucker im Rahmen von Präferenzregelungen in die EU exportiert haben, von einer Liberalisierung des EU-Zuckermarktes voraussichtlich negativ betroffen sein werden. Für diese Länder sind unterschiedliche Strategien denkbar, um die heimische Zuckererzeugung zu unterstützen und die negativen Folgen einer Liberalisierung des EU-Zuckermarktes abzufedern. Hierzu zählen beispielsweise i) der Abschluss neuer Handelsabkommen, um die Exportmöglichkeiten zu anderen profitablen Absatzmärkte zu erhöhen, ii) die Einführung von Investitionsprogrammen zur Erhöhung der Wettbewerbsfähigkeit der heimischen Zuckerindustrie und/oder zur Schaffung von alternativen Absatzmöglichkeiten im Non-Food-Bereich (z. B. Ethanol, Bioplastik), iii) eine Neuausrichtung der Produktions- und Exportstrategie auf schnell wachsende, rentable Nischenmärkte, wie z. B. Biozucker und iv) die Auflegung vom Restrukturierungsprogrammen, die einerseits Anreize zur Aufgabe der Erzeugung an nicht wettbewerbsfähigen Standorten setzen und andererseits alternative Beschäftigungsmöglichkeiten im ländlichen Raum schaffen.

Insgesamt konzentrieren sich die im Rahmen dieser Arbeit durchgeführten Analysen auf die Auswirkungen von Politikänderungen auf die Erzeugung und den Handel mit Zucker. Vor dem Hintergrund wachsender gesundheitlicher Bedenken im Zusammenhang mit einem hohen Pro-Kopf-Verbrauch von Zucker haben in der öffentlichen und politischen Debatte in den letzten Jahren jedoch politische Maßnahmen an Bedeutung gewonnen, die auf eine Reduzierung des Zuckerverbrauchs abzielen. Diese politischen Maßnahmen, wie z. B. Zuckersteuern, sind derzeit in den partiellen Gleichgewichtsmodellen, die für diese Arbeit weiterentwickelt wurden, nicht abgebildet. Angesichts der weltweiten Bemühungen um mehr Nachhaltigkeit könnten in den kommenden Jahren außerdem Maßnahmen zur Förderung des Bioökonomiesektors eingeführt werden und die Zuckernachfrage im Non-Food-Bereich erhöhen. Zukünftige Forschungsarbeiten sollten daher einen Schwerpunkt auf eine detaillierte Abbildung der Nachfrageseite in ökonomischen Modellen legen. Dies würde es ermöglichen, die zu erwartenden langfristigen Auswirkungen von Politikmaßnamen zu quantifizieren, die auf Verschiebungen in der Zuckernachfrage abzielen.

1 General introduction

This section outlines the background of the thesis and identifies the overarching research questions addressed by the individual articles of this cumulative dissertation. Moreover, the section provides an overview of the structure and conceptual coherence of the contributed articles.

1.1 Background and research objectives

The sugar market has long been excluded from the systematic reform process of the EU's Common Agricultural Policy (CAP) started with the MacSharry reform in 1992. While the markets of most other agricultural products were gradually liberalised by phasing-out direct domestic support measures (administrative prices, production quotas, etc.) and reducing the level of border protection (import tariffs, flexible levies, etc.), the EU's sugar regime remained in place virtually unchanged for about 50 years. In 2006, however, the first major reform of the EU sugar regime was introduced and in 2013 the EU even decided to completely abolish almost all domestic support measures by 2017 (production quotas for sugar and isoglucose, minimum price for sugar beet). But the 2013 CAP reform also established the legal framework for granting voluntary coupled payments for sugar beet. These payments are currently granted in 11 of 19 sugar beet producing EU Member States (EU MS). While there is extensive literature investigating the consequences of the 2006 EU sugar reform (Elbehri et al. 2008; Neumair 2008; Thomsen 2006; Chaplin et al. 2006; van Berkum et al. 2005), only few studies have looked at the effects resulting from the most recent reform of the EU sugar regime (EC 2011; Smit et al. 2012; Burrell et al. 2014; OECD/FAO 2014). In particular, studies examining the effects on individual EU member states, taking the competition between sugar and isoglucose[1] into account, are lacking. Moreover, only few studies have assessed the trade-distorting impact of the EU sugar regime (Kopp et al. 2016; Calì et al. 2013; Nolte et al. 2012; Elbehri et al. 2008; Chaplin et al. 2006; van Berkum et al. 2005). This thesis aims to fill this gap. Specifically, in addressing the following three research questions:

I. What are the consequences of a complete elimination of the EU quota system for sugar and isoglucose at EU MS level?
II. To what extent do coupled subsidies for sugar beet introduced under the 2013 CAP reform lead to market distortions among EU MS?
III. How are third countries affected by changes in the EU sugar regime?

All three research questions are quantitatively examined by a model-based ex-ante policy impact assessment building on the spatial price equilibrium model (hereafter, SPE model) first developed by Nolte (2008) and the agricultural sector model Agmemod (AGMEMOD Consortium 2022). In order to be able to address the research questions raised above, both models have been revised in terms

[1] Isoglucose (which is also widely referred to as high fructose corn syrup, HFCS) is a liquid sweetener produced from corn or wheat starch and can be considered as the main caloric-sweetener used to substitute beet or cane sugar. Thus, in order to protect the sugar sector from competition, until 2017 also sales of isoglucose on the EU internal market were limited by production quotas.

of model structure and parametrisation. Particularly noteworthy is the extension of both models to the EU isoglucose sector and the calibration of the supply function of EU MS to empirical data on production costs. Moreover, the models' databases were updated to the most recent market developments and policies. Finally, the two models were linked to take advantage of both modelling approaches. The model improvements were gradually implemented within the framework of different research projects. The research conducted in the course of the projects provided the basis for the individual articles included in this cumulative thesis. The next section gives further details on these articles, explains how they fit into the overall structure of the thesis and contribute to address the overreaching research questions.

1.2 Structure and conceptual coherence of the contributed articles

The thesis comprises a compilation of five stand-alone but related articles (see Table 1) published in international peer-reviewed journals, scientific conference proceedings or high impact policy reports. While paper (2), (4) and (5) address the main research questions of this thesis (see previous section), article (1) and (3) provide background information and thus lay the basis for the subsequent analyses. The following paragraphs describe in more detail the contribution of the individual articles and how they build on each other.

Table 1: Articles included in the thesis

Article	Author(s)	Title	Published in:
(1)	Haß, M.	Der Markt für Zucker	*German Journal of Agricultural Economics*, 66 (2017), Supplement: pp. 20-43.
(2)*	Haß, M.	Der Zuckermarkt im Wandel: Was passiert nach dem EU-Quotenende?	*Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues* e.V., 2017, Bd. 52, S. 73-84.
(3)	Banse, M. Haß, M. Salamon, P. Zirngibl, M.-E. Gonzalez Martinez, A. Jongeneel, R. van Leeuwen, M.	Sugar – Developments in EU member states	*EU agricultural outlook for markets and income, 2019-2030*. European Commission, DG Agriculture and Rural Development, Brussels. 2019, pp. 28- 29.
(4)	Haß, M.	Coupled support for sugar beet in the European Union: Does it lead to market distortions?	*Journal of Agricultural Economics*, 2022, 73 (1): pp. 86-111. DOI:10.1111/1477-9552.12435
(5)	Haß, M.	Liberalising the EU sugar market: what are the effects on third countries?	*The Australian Journal of Agricultural and Resource Economics,* in press. DOI: 10.1111.1467-8489.12475

* An extended version of article (2) can be found in HAß et al. (2016).

Source: own compilation.

Article (1) provides a comprehensive descriptive analysis of the world and EU sugar market focusing on the market dynamics prevailing in the sugar marketing year 2015/16 (Oct. to Sept.)[2]. Specifically, the analysis highlights the long-term trends observed in the sugar market and describes the key economic fundamentals and policies driving the observed development of the supply, demand and trade of sugar in the short and medium run. Moreover, article (1) identifies the major sugar producing, exporting, importing and consuming countries which are, due to their high market shares, important players in the global and EU sugar market significantly affecting the formation of the EU and world sugar price. For the EU, the article also outlines the situation of the EU isoglucose market. Moreover, the evolution of the EU sugar regime is described in detail. Overall, article (1) provides a comprehensive basic understanding of the functioning of the EU sweetener and global sugar market and thus builds the ground for the subsequent model-based analyses.

Article (2) addresses the first research question raised in section 1.1. The expected consequences of the abolition of the EU quota system in 2017 are examined by a model based ex-ante policy impact assessment focussing on the price and supply changes in EU MS. The changes in EU sugar imports and exports and the resulting effects on the production of sugar in non-EU countries are presented only at the aggregated level of the five continents Africa, Asia, America, Oceania and Non-EU-Europe, but are not analysed in detail for individual countries. The research presented in article (1) was realised as part of a project funded by the Nordzucker company in the period from 2013 to 2015. Moreover, the work received funding in its final stage from the ‘Edmund Rehwinkel Stiftung der Landwirtschaftlichen Rentenbank’. Thus, an extended version of article (2) can be found in the publication series of the ‘Rentenbank’ (HAß et al. 2016) where special focus is given to the competitive position of the German sugar sector relative to other EU MS. Overall, the aim of the research presented in article (1) is to i) identify the most competitive sugar producing EU MS, where EU sugar production is likely to concentrate in the post-quota period and ii) assess the competitiveness of sugar production compared to the production of isoglucose. These two research questions are addressed by applying a revised stand-alone version of the SPE model first developed by NOLTE (2008). Major adjustments compared to previous model versions comprise an update of the model database (market balances, EU policies, EU supply elasticities) and an extension of the model to the EU isoglucose sector. Moreover, EU domestic demand of sweetener (combined demand of sugar and isoglucose) was broken-down to individual EU MS. Unlike previous model versions, the extended model version does therefore cover complete market balances for all EU MS, also allowing intra-EU trade to be simulated. The revised version of the SPE model does therefore better capture the competition among EU MS. Furthermore, the supply functions of EU MS were calibrated to empirical data on production costs. Production costs for both products were obtained from an Excel based tool developed by LMC (2013), which allows to calculate production costs for sugar and isoglucose under different world market price assumptions for

[2] Similar articles were also published in 2018, 2019 and 2020 (see Appendix B – list of publications). The article published in 2017 has been selected to be included in this thesis, because it provides the most detailed description of the EU sugar regime.

crude oil, corn, wheat and rapeseed. In article (2) this feature is used to account for different possible world market price developments until 2020/21, i. e., the expected consequences of the abolition of the EU quota system are examined under three different world market price scenarios.

Article (3) assesses the development of the sugar and isoglucose sector until 2030 under the macro-economic assumptions and policy framework of the EU agricultural outlook 2019-2030 (EC 2019a). The research presented in article (3) has been part of a wider project funded by the EU Commission (SALAMON et al. 2017). The aim of the project is to disaggregate the annually published market projections for the two country blocks EU-15[3] and EU-13[4] to the level of individual member states using the agricultural sector model Agmemod. For that purpose, the representation of the sweetener market in Agmemod was completely revised building on the approach developed in article (2). Appendix A provides a detailed documentation of this approach including all model equations. The new sweetener module developed to generate the market projections described in article (3) is also applied in the policy-impact assessment presented in article (4) and (5). Specifically, all additional scenarios simulated to quantify the effects of changes in the EU sugar regime are derived from the market projections presented in article (3). Thus, article (3) forms the methodological basis for answering research questions (2) and (3). However, the results presented in article (3) for the individual EU MS were scaled to exactly meet the market projections of the EU agricultural outlook for the EU-15 and EU-13, while article (4) and (5) are based on the original model outcome (see Appendix A, section 1.1.7 for details). The results presented in article (4) and (5) do therefore slightly deviate from the market projections described in article (3), even though all three articles apply the identical model version.

Article (4) addresses the second research question raised in section 1.1. Methodologically, the article applies the Agmemod sweetener module developed in article (3). Based on a scenario analysis the market-distorting effects of voluntary coupled support (hereafter, VCS) payments for sugar beet are investigated. These payments were introduced in 2015 in 11 of 19 sugar beet producing EU MS[5] as part of the 2013 CAP reform in order to maintain sugar production in less competitive countries. However, since its introduction these payments are subject to a controversial political debate, as they are likely to hamper the concentration of sugar production in the most competitive regions of the EU. Moreover, these payments can be expected to lead to market-distortions between sugar beet and other arable crops (EC 2019b; SMIT et al. 2017). Article (4) contributes to this political debate by providing quantitative results on the market-distorting effects of VCS payment for sugar beet. In particular, the analysis aims to assess i) the change in production costs caused by VCS payments for sugar beet and the resulting changes in sugar production and sugar prices in EU MS and ii) the change in land allocation caused by VCS payments for sugar beet. Moreover, in order to account for yield uncertainties

[3] The EU-15 includes ‘the old Member States’: AT, BE, DE, DK, ES, FI, FR, GR, IE, IT, LU, NL, PT, SE, UK.

[4] The EU-13 includes ‘the new Member States that acceded to the EU in 2004, 2007 and 2013: BG, CY, CZ, EE, HR, HU, LT, LV, MT, PL, RO, SI, SK.

[5] Please note that in LT voluntary coupled payments were introduced in 2017, i. e., two years later than in the other 10 EU MS.

arising from an application ban on certain insecticides that came into force in the EU in 2018, the analysis is carried out under two different assumptions on the future development of sugar beet yields.

Finally, **Article (5)** addresses the third research question raised in section 1.1. While the previous articles analyse the consequences of changes in the EU sugar regime focussing on the effects within the EU, article (5) sheds light on the trade-distorting effects and the resulting influence on the production of sugar in non-EU countries. Detailed quantitative results are provided for i) the changes in EU sugar imports by country of origin and ii) the resulting changes in sugar production in non-EU countries. These effects are simulated for a set of four scenarios assuming a gradual full liberalisation of the EU sugar regime by phasing-out all domestic support and border protection measures. Methodologically, the analysis builds on articles (2) and (4). To take advantage of both previously developed modelling approaches, the analysis is carried out by applying a combined linked version of the SPE and the Agmemod model. Combining the two models allows to simultaneously i) simulate the supply response of EU MS based on empirical data on production costs taking into account the competitive position of sugar beet in the crop rotation, ii) simulate resulting changes in bilateral global trade flows covering all third countries with preferential access to the EU market, iii) consider regional trade agreements in great detail with all tariff barriers (specific and ad valorem tariffs, bilateral and multilateral tariff-rate-quotas) modelled explicitly.

The reminder of the thesis is structured as follows: The next section presents the five articles listed in Table 1. In addition, Appendix B provides a list of further publications published between 2016 and 2020. These articles were not included in this thesis but contribute to the overall topic of the dissertation. After presenting the individual articles, the thesis concludes with a summary of the key findings, a discussion of major limitations that provide directions for future research and a summary of policy recommendations that can be derived based on the finding of the thesis.

2 ARTICLES INCLUDED AS PART OF THE THESIS

The following sections present the five articles included as part of the thesis. As described in the previous sections, all articles have been published in international peer-reviewed journals, scientific conference proceedings or high impact policy reports.

Article (1):

2.1 Der Markt für Zucker

Marlen Haß

German Journal of Agricultural Economics, 66 (2017), Supplement: pp. 20-43.

Author contributions: All tasks related to research planning, data collection, data analysis and drafting and revising the manuscript were performed by **Marlen Haß**.

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Der Markt für Zucker

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1 Zusammenfassung

Im vergangenen Zuckerwirtschaftsjahr 2015/16 (ZWJ: Okt. bis Sept.) ist der Zuckerpreis auf dem **Weltmarkt** nach einer vier Jahre andauernden Talfahrt deutlich gestiegen. Ursache hierfür war das erste globale Produktionsdefizit seit fünf Jahren. Und auch für das laufende ZWJ 2016/17 rechnen Marktexperten damit, dass der globale Verbrauch von Zucker erneut die weltweite Zuckerproduktion übersteigt. Denn anders als die weltweite Zuckerproduktion, die in den letzten Jahren stagnierte, wächst der globale Zuckerverbrauch kontinuierlich, vor allem in asiatischen und afrikanischen Ländern. Auch im ZWJ 2015/16 bleibt Brasilien der mit Abstand weltweit größte Zuckerproduzent und konnte die Zuckererzeugung gegenüber dem Vorjahr steigern. Aufgrund der positiven Weltmarktpreisentwicklung hat sich die brasilianische Zuckerindustrie dazu entschieden, in der laufenden Kampagne einen geringeren Anteil der Zuckerrohrernte zu Ethanol zu verarbeiten als im Vorjahr. Für die Kampagne 2017/18 wird mit einer Fortsetzung dieses Trends gerechnet (F.O. LICHT, 2017). Auf der Nachfrageseite bleibt Indien hinter China im ZWJ 2015/16 der größte Absatzmarkt für Zucker weltweit. Und auch für das laufende Zuckerwirtschaftsjahr gehen Marktexperten davon aus, dass die indische und chinesische Konsumsteigerung oberhalb des globalen Durchschnitts liegen wird. Indien und China bleiben damit die beiden größten Wachstumsmärkte, wobei der chinesische Zuckerverbrauch noch schneller wächst als der indische Zuckerkonsum. Entsprechend der globalen Produktions- und Verbrauchsentwicklung ist das Handelsvolumen von Zucker im vergangenen Zuckerwirtschaftsjahr weiter gestiegen, wobei der Anteil der Rohzuckerimporte und -exporte am gesamten Handelsvolumen weiter wächst. Global betrachtet dominierte auch im ZWJ 2015/16 Brasilien das Angebot auf den internationalen Zuckermärkten, und Erwartungen über die brasilianische Produktionsentwicklung und Exportstrategie beeinflussten auch im vergangenen Zuckerwirtschaftsjahr stark die Preisbildung auf dem Weltmarkt. Auf der Nachfrageseite war China im ZWJ 2015/16 im dritten Jahr in Folge der weltweit größte (Netto-)Importeur von Zucker. Da die Entwicklung der chinesischen Zuckerproduktion in den letzten Jahren an Dynamik verloren hat, der Zuckerkonsum des Landes jedoch kontinuierlich wächst, ist der Importbedarf Chinas in den letzten zehn Jahren deutlich gestiegen.

Nicht nur auf dem Weltmarkt, sondern auch auf dem **EU-Binnenmarkt** tendierte der Zuckerpreis im ZWJ 2015/16 wieder nach oben. Allerdings war die Preissteigerung weniger stark als auf dem Weltmarkt. Gegenüber der Rekordernte im ZWJ 2014/15 ist die EU-Zuckererzeugung im vergangenen Zuckerwirtschaftsjahr vergleichsweise deutlich gesunken. Denn aufgrund der hohen Übertragungsmengen aus dem Vorjahr haben die EU-Zuckerunternehmen und Rübenbauern die Anbauflächen deutlich reduziert. Gleichzeitig ist der Zuckerverbrauch in der Europäischen Union wie in den Vorjahren auch kaum gewachsen. Nachfragesteigerungen waren in den vergangenen Jahren lediglich in den östlichen und südlichen EU-Mitgliedstaaten zu beobachten, in allen anderen EU-Ländern stagnierte der Zuckerverbrauch oder entwickelte sich sogar rückläufig. Trotzdem bleiben Deutschland, Frankreich und Großbritannien auch im ZWJ 2015/16 die größten Absatzmärkte für Zucker in der Europäischen Union. Auch auf der Angebotsseite ergeben sich keine Änderungen. Frankreich, Deutschland und Polen führen weiterhin die Liste der größten EU-Zuckerproduzenten an und sind darüber hinaus die größten Zucker exportierenden Länder der Gemeinschaft. Auch im ZWJ 2015/16 wurde das WTO-Exportlimit vollständig ausgeschöpft. Dabei bleibt Israel das wichtigste Zielland für EU-Zuckerexporte. Importe aus Drittstaaten gelangen weiterhin nahezu ausschließlich zu einem reduzierten Zollsatz oder zollfrei im Rahmen von Präferenzhandelsregelungen auf den EU-Binnenmarkt. Aufgrund seiner hohen Raffinationskapazitäten bleibt Großbritannien auch im ZWJ 2015/16 der größte EU-Importeur von Zucker aus Drittstaaten. Nach einem Einbruch der brasilianischen Zuckerimporte im vorangegangenen Zuckerwirtschaftsjahr ist Brasilien im ZWJ 2015/16 vor Mauritius wieder der wichtigste Lieferant für Zuckerimporte aus Drittstaaten. Als größte EU-Defizitregion hat Italien weiterhin den größten Anteil an den EU-Gesamtimporten, wobei ein

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Großteil der italienischen Zuckerimporte aus anderen EU-Mitgliedstaaten stammt.

Mit dem **Ende der EU-Quotenregelung** für Zucker und Isoglukose ändern sich die politischen und wirtschaftlichen Rahmenbedingungen für die EU-Zuckerindustrie ab dem ZWJ 2017/18 grundlegend. Zucker, der aus den im Jahr 2017 geernteten Rüben gewonnen wird, kann ab dem 1. Oktober 2017 ohne Mengenbegrenzung auf dem EU-Binnenmarkt abgesetzt werden. Im Zuge des EU-Quotenausstiegs haben die EU-Zuckerunternehmen angekündigt, ihre Produktion im ersten Jahr ohne Quote um 20 % bis 40 % zu steigern. Gleichzeitig werden die gezahlten Rübenpreise deutlich sinken. Marktexperten rechnen außerdem mit einem Rückgang der EU-Importe und einer Steigerung der EU-Isoglukoseerzeugung. Langfristig könnte der Marktanteil von Isoglukose im Zuge des EU-Quotenausstiegs von derzeit 4 % auf maximal 10 % bis 20 % steigen.

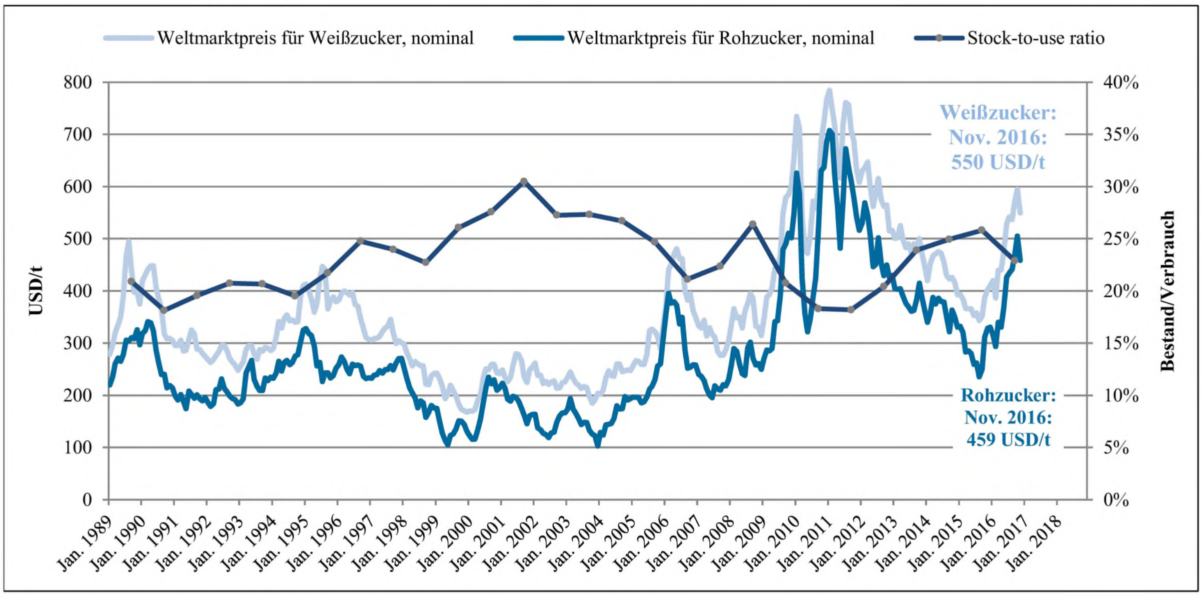
2 Der Weltmarkt für Zucker

2.1 Preise

Das ZWJ 2015/16 begann für die globale Zuckerwirtschaft mit einer guten Nachricht. Die vier Jahre andauernde Talfahrt der Weltmarktpreise für Weiß- und Rohzucker scheint mit dem Ende des ZWJ 2014/15 vorerst gestoppt. Nach dem sechsjährigen Tiefststand der Weltmarktpreise für Weiß- und Rohzucker von 343 USD/t Weißzucker bzw. 235 USD/t Rohzucker im August 2015 tendieren die Weltmarktpreise seit September 2015 wieder nach oben (vgl. Abbildung 1). In der zweiten Februarhälfte 2016 starteten die Futures auf Zucker an den Börsen in London und New York eine regelrechte Preisrallye und notierten nach einem vorläufigen Höchststand im Oktober 2016 von 595 USD/t Weißzucker und 540 USD/t Rohzucker zuletzt etwas schwächer. Gegenüber dem Preistiefststand im August 2015 betrug die Preissteigerung im November aber immer noch 65 % für Weißzucker und 95 % für Rohzucker.

Auslöser für die Preissteigerung im Februar war der Marktausblick der Internationalen Zuckerorganisation (ISO), in dem die Marktexperten ihre Prognose für das globale Produktionsdefizit für das laufende Zuckerwirtschaftsjahr um 1,52 Mio. t auf 5,02 Mio. t nach oben korrigierten. Ursache für die Korrektur waren in erster Line Ernteausfälle in den Hauptproduktionsländern Brasilien, Indien und Thailand durch das Wetterphänomen El Niño (AGRA-EUROPE, 2016d). Mit einem globalen Defizit von 8,2 Mio. t (Czarnikow), 7,2 Mio. t (F.O. Licht) und 6,8 Mio. t (Rabobank) lagen die Prognosen anderer Institutionen sogar noch deutlich über denen der ISO, Kingsman und das US-Landwirtschaftsministerium (USDA) schätzten die Versorgungslage für das ZWJ 2015/16 mit einem globalen Defizit von 5,1 Mio. t und

Abbildung 1. Entwicklung der Zuckerweltmarktpreise und des Stock-to-use ratio 1989-2016 − monatliche Werte



Anm.: Weißzucker: Kontrakt Nr. 407 (aka Nr. 5), Rohzucker: Kontrakt Nr. 11
Quelle: eigene Darstellung, basierend auf USDA (2016d, 2017a, 2017b)

Tabelle 1. Weltzuckerbilanz 2009/10 bis 2016/17 (Mio. t Rw)

	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17[1)]	Δ 2015/16 vs. Vorjahr	Ø Jährliches Wachstum 2005/06-2015/16
Produktion	158,5	165,2	174,6	184,1	181,4	181,7	176,9	177,4	-2,7%	1,6%
Importe	62,7	60,0	60,9	64,3	63,9	63,1	64,3	63,5	1,9%	1,8%
Exporte	62,7	61,2	60,5	66,8	64,5	65,0	66,0	65,4	1,5%	1,7%
Verbrauch	162,6	162,8	168,4	172,5	176,0	178,9	181,7	183,7	1,6%	2,1%
Anfangsbestand	60,0	56,0	57,1	63,7	72,8	77,5	78,4	70,6	1,2 %	2,8 %
Endbestand	56,0	57,1	63,7	72,8	77,5	78,4	72,0	62,5	-8,3%	1,5%
Selbstversorgungsgrad	97,5%	101,5%	103,7%	106,7%	103,1%	101,6%	97,4%	96,6%	–	–
Defizit/Überschuss[2)]	-4,1	1,2	6,6	9,1	4,7	1,0	-6,5	-8,1	–	–
Bestand/Verbrauch	34,4%	35,1%	37,8%	42,2%	44,0%	43,9%	39,6%	34,0%	–	–

Anm.: Rw: Rohzuckerwert; 1) Schätzung; 2) einschließlich statistisch nicht erfasstem Verbrauch (Exporte – Importe)
Quelle: F.O. LICHT (2016a, 2016c); eigene Berechnung

3,8 Mio. t dagegen optimistischer ein (AGRA-EUROPE, 2016c; EU-COM, 2016d). Im Jahresverlauf wurde die Versorgungslage von allen Institutionen zunehmend pessimistischer beurteilt, was den anhaltenden Aufwärtstrend der Zuckerweltmarktpreise an den Börsen in London und New York erklärt. So prognostizierten Czarnikow, ISO und Kingsman zur Jahresmitte ein globales Defizit von 11,4 Mio. t, 6,7 Mio. t und 7,6 Mio. t (EU-COM, 2016e). In ihrer im November veröffentlichten Prognose schätzen die Marktexperten des USDA die globale Versorgungslücke für das ZWJ 2015/16 auf 6,1 Mio. t und auch F.O. LICHT und die Rabobank korrigierten ihre Schätzung zuletzt gegenüber der Prognose zu Jahresbeginn mit 9,5 Mio. t bzw. 7,9 Mio. t deutlich nach oben (USDA, 2016a; AGRA-EUROPE, 2016c; F.O. LICHT, 2016c).

Die Weißzuckerprämie, das heißt die Differenz zwischen dem Weißzucker- und Rohzuckerpreis, lag mit durchschnittlich 95 USD/t im ZWJ 2015/16 nominal leicht über dem 20-Jahres-Durchschnitt von 82 USD/t. Die Prämie spiegelt die Verfügbarkeit von Roh- und Weißzucker wider und kann außerdem als Indikator für die Höhe der Raffinationskosten angesehen werden (AHLFELD, 2007). Nachdem die Weißzuckerprämie zu Beginn des ZWJ 2015/16 zunächst eine steigende Tendenz zeigte und im April einen Jahreshöchststand von 109 USD/t erreichte, haben sich der Weiß- und Rohzuckerpreis im weiteren Jahresverlauf wieder angenähert. Im zweiten Monat des laufenden Zuckerwirtschaftsjahres lag die Prämie mit 51 USD/t wieder auf dem Niveau des Vorjahres.

2.2 Versorgung

Die Entwicklung der Weltmarktpreise wird in erster Line durch die globale Versorgungslage bestimmt. Entscheidender Indikator ist hierbei vor allem das sog. „Stock-to-use-ratio", das heißt das Verhältnis der Lagerbestände zum Verbrauch. Während dieses Verhältnis in den vergangenen Jahren kontinuierlich gestiegen ist (vgl. Abbildung 1), war die globale Zuckerproduktion im ZWJ 2015/16 erstmals seit dem ZWJ 2009/10 wieder geringer als die weltweite Nachfrage nach Zucker (vgl. Tabelle 1). Und auch für das laufende ZWJ 2016/17 prognostiziert F.O. Licht ein globales Defizit von 8,1 Mio. t. Ursache hierfür ist vor allem der kontinuierlich wachsende globale Zuckerverbrauch. Innerhalb der letzten zehn Jahre ist die weltweite Nachfrage nach Zucker um jährlich durchschnittlich 2,1% gestiegen.[1] Im selben Zeitraum konnte auch die globale Zuckerproduktion zunächst deutlich gesteigert werden. In den letzten drei Jahren stagniert das globale Produktionsniveau jedoch bzw. ist leicht rückläufig. Über einen Zeitraum von zehn Jahren betrachtet, liegt das durchschnittliche jährliche Produktionswachstum mit 1,6% daher unterhalb der Wachstumsrate des globalen Zuckerkonsums (vgl. Tabelle 1).

2.3 Erzeugung

Weltweit wird Zucker in Abhängigkeit von den klimatischen Bedingungen aus Zuckerrohr oder Zuckerrüben gewonnen. Dabei ist die Zuckererzeugung auf Zuckerrohrbasis in den vergangen dreißig Jahren kontinuierlich von 60,5 Mio. t Rw (Rw: Rohzuckwert) im Jahr 1986/87 auf voraussichtlich 122,8 Mio. t Rw im Jahr 2016/17 gestiegen (+103%). Im selben Zeitraum lag die Zuckererzeugung auf Rübenbasis dagegen

[1] Die in diesem Artikel ausgewiesenen jährlichen Wachstumsraten wurden nach folgender Formel berechnet:

$$Wachstumsrate = \left[\left(\frac{Endwert}{Anfangswert}\right)^{\left(\frac{1}{Anzahl\ der\ Jahre}\right)} - 1\right] x\ 100.$$

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mehr oder weniger konstant auf einem Produktionsniveau von durchschnittlich 33,5 Mio. t Rw, sodass der Anteil der Rohrzuckerproduktion innerhalb der vergangenen dreißig Jahre stetig von 63,3 % im Jahr 1986/87 auf zuletzt 78,8 % im Jahr 2016/17 gewachsen ist (USDA, 2016d).

Auch im ZWJ 2015/16 bleibt **Brasilien** mit einer Produktion von 38,9 Mio. t Rw und einem Anteil an der globalen Zuckerproduktion von rund 22 % der mit Abstand weltweit größte Zuckerproduzent. Gegenüber dem Vorjahresniveau kann das Land die Erzeugung um 12 % steigern. Für das brasilianische ZWJ 2016/17 (April – März) schätzt F.O. LICHT die Produktion auf 40,3 Mio. t Rw (vgl. Tabelle 2). Damit würde die brasilianische Zuckerwirtschaft die bisher größte Erntemenge erzielen (F.O. LICHT, 2016h). Befürchtungen im August 2016, die brasilianische Ernte könnte aufgrund niedriger Erträge deutlich geringer ausfallen, haben sich damit als unbegründet herausgestellt (F.O. LICHT, 2016f). Gegenüber der Kampagne 2015/16 wird der Anteil der Zuckerrohrernte, der zu Ethanol verarbeitet wird, in der laufenden Kampagne voraussichtlich leicht von knapp 60 % auf 55 % sinken (USDA, 2016a).

Hinter Brasilien ist **Indien** mit einer Erzeugung von 28,3 Mio. t Rw im ZWJ 2015/16 und einem Anteil an der globalen Zuckererzeugung von 16 % der weltweit zweitgrößte Zuckerproduzent (vgl. Tabelle 2). Das Land hat die Zuckererzeugung seit Beginn der 1980er Jahre kontinuierlich gesteigert, wobei die Produktion witterungsbedingt jedoch starken Schwankungen unterliegt. So wird die Zuckererzeugung in der Ernteperiode 2016/17 (Okt. bis Sept.) voraussichtlich mit 24,5 Mio. t Rw deutlich geringer ausfallen als im Vorjahr. Ursache hierfür sind sowohl niedrigere Erträge als auch ein Rückgang der Anbaufläche. Während die Monsunregenfälle in den Anbauregionen Maharashtra und dem nördlichen Karnataka für ausreichend Niederschlag gesorgt haben, lagen die Regenfälle in vielen anderen Regionen unterhalb des Durchschnitts. Zudem rechnen Marktexperten für das ZWJ 2016/17 mit einem Rückgang der Anbaufläche von 5,5 % (F.O. LICHT, 2016f; USDA, 2016a).

China ist auch im ZWJ 2015/16 mit einer Zuckerproduktion von 10,9 Mio. t Rw und einem Anteil an der Weltzuckererzeugung von 6 % der weltweit drittgrößte Zuckerproduzent. Neben den USA, Japan, Ägypten, dem Iran, Pakistan, Marokko und Frankreich gehört China zu den wenigen Länder, in denen Zucker sowohl auf Zuckerrohrbasis als auch auf Basis von Zuckerrüben produziert wird. Für die laufende Ernteperiode 2016/17 (Okt. bis Mai) rechnet F.O. LICHT mit einer Zuckerproduktion von schätzungsweise 10,9 Mio. t Rw (vgl. Tabelle 2). Wie Indien hat auch China die Zuckererzeugung seit Beginn der 1980er-Jahre deutlich steigern können. Nach einer Rekordernte im ZWJ 2007/08 von 16,1 Mio. t Rw hat die chinesische Zuckerproduktion jedoch an Dynamik verloren. Im Zeitraum von 2008/09 bis 2015/16 lag das durchschnittliche Produktionsniveau bei 12,3 Mio. t Rw (F.O. LICHT, 2016a).

Mit einer Produktionsmenge von 10,3 Mio. t Rw erzeugte **Thailand** im ZWJ 2015/16 ebenso wie China rund 6 % der globalen Zuckerproduktion. Damit ist die Produktion gegenüber dem Vorjahr um 11 % gesunken (vgl. Tabelle 2). Hauptursache für den Produk-

Tabelle 2. Top-10 Zucker produzierende Länder weltweit

	Ernte 2016/17			Okt.-Sept. 2015/16			
Rang	**Land**	**Mio. t Rw**	**Anteil**	**Land**	**Mio. t Rw**	**Anteil**	**Δ Vorjahr**
1	Brasilien	40,3	22,5 %	Brasilien	38,9	22,0 %	12,0 %
2	Indien	24,5	13,7 %	Indien	28,3	16,0 %	-8,2 %
3	China	10,9	6,1 %	China	10,9	6,1 %	-5,3 %
4	Thailand	10,0	5,6 %	Thailand	10,3	5,8 %	-11,0 %
5	USA	8,5	4,7 %	USA	8,2	4,6 %	4,1 %
6	Mexiko	6,6	3,7 %	Mexiko	6,3	3,5 %	0,7 %
7	Russland	6,2	3,5 %	Pakistan	5,8	3,3 %	3,5 %
8	Pakistan	6,0	3,4 %	Russland	5,6	3,2 %	14,3 %
9	Australien	5,2	2,9 %	Australien	4,9	2,7 %	-5,2 %
10	Frankreich	4,4	2,5 %	Frankreich	4,1	2,3 %	-13,5 %
(…)	Andere	56,6	31,6 %	Andere	53,8	30,4 %	-8,4 %
	Welt	**179,2**	**100,0 %**	**Welt**	**176,9**	**100,0 %**	**-2,7 %**

Anm.: Rw: Rohzuckerwert. Ernteperiode entspricht nicht in allen Ländern Okt.-Sept.
Die dargestellten Werte für 2015/16 und 2016/17 sind daher nur begrenzt vergleichbar.
Quelle: eigene Berechnung, basierend auf F.O. LICHT (2016a, 2016h)

tionsrückgang ist eine lange Trockenperiode, die im ZWJ 2015/16 sowohl zu niedrigeren Zuckerrohrerträgen als auch zu einem geringeren Zuckergehalt geführt hat. Auch für die laufende Ernteperiode 2016/17 (Nov. bis Juni) gehen Marktexperten übereinstimmend von keiner Erholung der thailändischen Zuckerproduktion aus, denn die lange Trockenperiode im vergangenen Zuckerwirtschaftsjahr hat bereits zu einer Schädigung der neu angelegten Zuckerrohrplantagen geführt (AGRA-EUROPE, 2016b; F.O. LICHT, 2016f; USDA, 2016a). Zudem sind einige Farmer auf den Anbau von Tapioka umgestiegen, da dieser eine höhere Trockenresistenz besitzt als Zuckerrohr (F.O. LICHT, 2016f). Die thailändische Zuckerproduktion wird daher für die Ernteperiode 2016/17 von F.O. LICHT auf rund 10 Mio. t Rw geschätzt (vgl. Tabelle 2). Dieser negative Trend könnte sich allerdings in den kommenden Jahren umkehren, denn nach Informationen der Rabobank wurden in Thailand zuletzt 25 neue Zuckerfabriken genehmigt. Die niederländischen Analysten rechnen daher mit einer deutlichen Ausdehnung des Zuckerrohranbaus auf Kosten des Reisanbaus und einem Anstieg der thailändischen Zuckerproduktion auf 22 Mio. t in den nächsten fünf Jahren (AGRA-EUROPE, 2016b).

2.4 Verbrauch

Getrieben durch das globale Bevölkerungswachstum ist der weltweite Zuckerverbrauch innerhalb der letzten dreißig Jahre stetig mit einer durchschnittlichen jährlichen Wachstumsrate von 1,7% gestiegen. Während die Nachfrage in Europa stagniert, wächst der Zuckerverbrauch vor allem in Afrika und Asien mit einer durchschnittlichen jährlichen Wachstumsrate von 2,7% bzw. 2,4%. In Amerika und Ozeanien lag die Nachfragesteigerung in den vergangenen dreißig Jahren dagegen unterhalb des globalen Durchschnitts (1,4% bzw. 1,1%) (USDA, 2016d). Für das laufende ZWJ 2016/17 erwartet F.O. LICHT einen globalen Konsumanstieg um rund 1,4% bzw. 3 Mio. t Rw (F.O. LICHT, 2016d).

Haupteinflussfaktoren auf den Zuckerkonsum sind neben der bereits genannten Bevölkerungsentwicklung auch die Entwicklung des Pro-Kopf-Einkommens, die Preisentwicklung von Zucker, die Verfügbarkeit von Zuckersubstituten sowie sich ändernde Ernährungsgewohnheiten. In den letzten Jahren beeinflusst darüber hinaus gerade in Europa sowie Nord- und Mittelamerika die gesellschaftliche und politische Diskussion um die Zunahme von ernährungsbedingten Krankheiten in der Bevölkerung, wie Adipositas und Diabetes Typ 2, immer stärker die Nachfrage nach Zucker (F.O. LICHT, 2016d).

Global betrachtet ist **Indien** nicht nur der zweitgrößte Zuckerproduzent, sondern auch der mit Abstand größte Absatzmarkt für Zucker. Im ZWJ 2015/16 lag der Zuckerverbrauch Indiens bei 27,7 Mio. t Rw. Dies entspricht einem Anteil von 15,3% am weltweiten Zuckerkonsum. Pro Kopf wurden in Indien im ZWJ 2015/16 rund 22 kg Rw verbraucht. Damit liegt der Pro-Kopf-Verbrauch Indiens etwas unterhalb des globalen Durchschnitts von 25 kg Rw (vgl. Tabelle 3). Der Gesamtzuckerverbrauch des asiatischen Landes ist seit dem ZWJ 1999/2000 um jährlich durchschnittlich 3% gestiegen (F.O. LICHT, 2016d). Und auch für das laufende ZWJ 2016/17 erwartet F.O. LICHT eine Steigerung des indischen Zuckerkonsums um 1,7% auf dann insgesamt 28,2 Mio. t Rw.

Tabelle 3. Top-10 Zucker konsumierende Länder weltweit

	Okt.-Sept. 2016/17				Okt.-Sept. 2015/16				
Rang	**Land**	**Mio. t Rw**	**Anteil**	**Δ Vorjahr**	**Land**	**Mio. t Rw**	**Anteil**	**Δ Vorjahr**	**kg/Kopf**
1	Indien	28,2	15,3%	1,7%	Indien	27,7	15,3%	1,6%	21,9
2	China	17,6	9,6%	2,9%	China	17,1	9,4%	3,0%	12,5
3	Brasilien	12,2	6,6%	-2,3%	Brasilien	12,5	6,9%	0,2%	60,5
4	USA	11,2	6,1%	1,7%	USA	11,0	6,0%	0,1%	33,9
5	Indonesien	6,9	3,8%	2,3%	Indonesien	6,8	3,7%	3,5%	26,3
6	Russland	6,0	3,3%	1,9%	Russland	5,9	3,2%	0,0%	41,2
7	Pakistan	5,3	2,9%	-0,6%	Pakistan	5,3	2,9%	3,0%	26,1
8	Mexiko	4,9	2,7%	1,1%	Mexiko	4,9	2,7%	2,0%	39,7
9	Ägypten	3,7	2,0%	4,2%	Ägypten	3,6	2,0%	2,9%	39,8
10	Thailand	3,5	1,9%	0,0%	Thailand	3,5	1,9%	0,3%	51,3
(…)	Andere	84,5	45,9%	1,2%	Andere	83,5	46,0%	1,5%	–
	Welt	**184,0**	**100,0%**	**1,3%**	**Welt**	**181,7**	**100,0%**	**1,6%**	**24,8**

Anm.: Rw: Rohzuckerwert
Quelle: eigene Berechnung, basierend auf F.O. LICHT (2016a, 2016d)

Nach Indien ist **China** mit einem Nachfragemenge von 17,1 Mio. Rw im ZWJ 2015/16 der zweitgrößte Absatzmarkt für Zucker weltweit (vgl. Tabelle 3). Seit Beginn des 21. Jahrhunderts ist der chinesische Zuckerverbrauch deutlich angestiegen (F.O. LICHT, 2016d). Mit einer jährlichen Wachstumsrate von durchschnittlich 5,5 % in den letzten 16 Jahren war das Nachfragewachstum sogar noch stärker als in Indien. Trotzdem konsumieren die Chinesen mit 12,5 kg Rw je Kopf immer noch gerade einmal die Hälfte des durchschnittlichen jährlichen Pro-Kopf-Verbrauchs weltweit. Der chinesische Zuckermarkt bleibt daher ein Wachstumsmarkt. Im laufenden ZWJ 2016/17 soll der Zuckerverbrauch um rund 3 % auf 17,6 Mio. t Rw ansteigen. Damit liegt die Steigerung des chinesischen Zuckerkonsums deutlich oberhalb des globalen Durchschnitts von 1,3 % (vgl. Tabelle 3).

Brasilien gehört weltweit zu den Ländern mit dem höchsten Pro-Kopf-Verbrauch von Zucker und ist darüber hinaus global betrachtet der drittgrößte Absatzmarkt für Zucker. Im vergangenen ZWJ 2015/16 betrug der brasilianische Zuckerkonsum 60,5 kg Rw je Kopf der Bevölkerung und 12,5 Mio. t Rw insgesamt, was einem Anteil am Weltzuckerverbrauch von rund 7 % entspricht (vgl. Tabelle 3). Seit Beginn der 90er-Jahre ist der Verbrauch um durchschnittlich 3 % im Jahr gestiegen, wobei die brasilianische Nachfrage jedoch relativ starken Schwankungen unterliegt. Diese werden in erster Linie durch die Preisentwicklung, Politikmaßnahmen und die allgemeine Entwicklung der Volkswirtschaft hervorgerufen. So wird für das laufende ZWJ 2016/17 mit einem Rückgang des brasilianischen Zuckerkonsums um 2,3 % gerechnet, da das Land in einer tiefen ökonomischen Krise steckt und die Nachfrage nach zuckerhaltigen Verarbeitungsprodukten sinken soll (F.O. LICHT, 2016d; USDA, 2016a). Auch im ZWJ 2016/17 bleibt Brasilien jedoch mit einem Verbrauch von 12,2 Mio. t Rw und einem Anteil von 6,6 % am globalen Zuckerkonsum der drittgrößte Absatzmarkt weltweit.

Mit rund 11 Mio. t Rw lag die Zuckernachfrage der **USA** im ZWJ 2015/16 auf einem ähnlichen Niveau wie in Brasilien. Im Vergleich zu dem südamerikanischen Land ist der Pro-Kopf Verbrauch in den USA mit rund 34 kg Rw jedoch deutlich geringer (vgl. Tabelle 3). Dies ist vor allem darauf zurückzuführen, dass in den Vereinigten Staaten Isoglukose, sog. „High-Fructose-Corn-Syrup“ (HFCS), mit rund 40 % einen überdurchschnittlich hohen Marktanteil hat (USDA, 2016a). So beträgt der Marktanteil von Isoglukose in China beispielsweise lediglich rund 10 %. Kanada, Japan, Südkorea und Mexiko erreichen einen Marktanteil von 25 % bis 30 % (LMC, 2013; WHITE, 2008). Rechnet man die Nachfrage für Zucker und Isoglukose zusammen, so ergibt sich für die USA ein durchschnittlicher Pro-Kopf-Verbrauch von rund 55 kg Zucker und Isoglukose pro Jahr.

2.5 Handel

Weltweit werden derzeit rund 65 Mio. t Rw Zucker gehandelt. Dabei ist das Handelsvolumen in den vergangenen zehn Jahren entsprechend der globalen Produktions- und Verbrauchsentwicklung kontinuierlich angestiegen. Im ZWJ 2005/06 wurden weltweit noch rund 53 Mio. t Rw Zucker importiert und exportiert. Das durchschnittliche jährliche Wachstum des weltweiten Zuckerhandels betrug damit in den letzten zehn Jahren rund 2 %, wobei der Anteil der Im- und Exporte am globalen Konsum bzw. der weltweiten Erzeugung auf einem relativ konstantem Niveau zwischen 32 % und 38 % lag (F.O. LICHT, 2016a). Dagegen ist der Anteil der Rohzuckerimporte und -exporte am globalen Zuckerhandel im selben Zeitraum stetig gestiegen. In den Handelsmengen spiegelt sich damit das starke Wachstum der Zuckererzeugung auf Zuckerrohrbasis wider. Denn in vielen Rohrzucker produzierenden Ländern fehlen Raffinationskapazitäten, sodass dieser in der Regel als Rohzucker exportiert und erst im Zielland raffiniert wird. So hat sich das Verhältnis der Weiß- und Rohzuckerimporten von 40 % zu 60 % im Jahr 2006/07 auf zuletzt 30 % zu 70 % im Jahr 2016/17 deutlich in Richtung Rohzuckerhandel verschoben. Und auch auf der Exportseite ist der Anteil der Weißzuckerausfuhren an der globalen Exportmenge in den vergangenen zehn Jahren um rund 10 Prozentpunkte von 45 % auf 35 % gesunken (USDA, 2016d).

Global betrachtet dominiert vor allem **Brasilien** das Angebot auf den internationalen Zuckermärkten. Das Land ist zwar auch die drittgrößte Verbrauchsregion von Zucker, trotzdem übersteigt die brasilianische Zuckererzeugung bei Weitem die inländische Nachfrage, was Brasilien nicht nur zum weltweit größten Zuckerproduzenten, sondern auch zum weltweit größten Netto-Exporteur von Zucker macht (vgl. Tabelle 4). Rund 40 % der globalen Zuckerexporte entfallen auf das südamerikanische Land. Brasilien hat damit im internationalen Zuckerhandel eine Schlüsselfunktion und Erwartungen über die brasilianische Produktionsentwicklung und Exportstrategie beeinflussen stark die Preisbildung auf den internationalen Zuckermärkten. Das Land verarbeitet die inländische Zuckerrohrernte nicht nur zu Zucker für den Export auf den Weltmarkt, sondern in erheblichem Umfang auch zu Ethanol. Das Verhältnis zwischen der Zucker- und Ethanolproduktion lag in der Kampagne 2015/16 (April – März) bei 40% zu 60% und ist damit das dritte Jahr in Folge gesunken (ZWJ 2012/13 50:50) (UNICA, 2016). Für die laufende Kampagne 2016/17 und die darauf folgende Kampagne 2017/18 wird dagegen damit gerechnet, dass der Anteil des Zuckerrohrs, der zu Ethanol verarbeitet wird, sinkt (F.O. LICHT, 2017). Bei hohen Weltmarktpreisen für Zucker verarbeitet Brasilien damit mehr Zuckerrohr zu Exportzucker.

Hinter Brasilien ist **Thailand** der weltweit zweitgrößte (Netto-)Exporteur von Zucker. Mit einer Exportmenge von 8,8 Mio. t Rw erreicht das Land im ZWJ 2015/16 einen Anteil von rund 13% an den globalen Zuckerexporten (vgl. Tabelle 4). Dabei hat Thailand seine Zuckerproduktion und -exporte in den vergangenen zehn Jahren deutlich gesteigert. Im ZWJ 2005/06 lagen die thailändischen Zuckerexporte lediglich bei 2,2 Mio. t Rw, was einem Marktanteil von rund 4% entsprach (F.O. LICHT, 2016a). Zu der starken Expansion des thailändischen Zuckersektors dürfte auch die staatliche Förderung der heimischen Zuckerindustrie beigetragen haben (AGRA-EUROPE, 2016d). Ähnlich wie in der Europäischen Union bis zur Reform der Zuckermarktordnung im Jahr 2006 (vgl. Kapitel 3.1) wird die Zuckermarkt in Thailand durch ein Quotensystem bestehend aus A-, B- und C-Quoten sowie Mindestpreisen und Importzöllen reguliert. In Zeiten niedriger Weltmarktpreise wird Exportzucker damit über die hohen Erlöse auf dem Binnenmarkt quersubventioniert. Nach Auffassung Brasiliens verstößt Thailand damit gegen die Regeln der Welthandelsorganisation (WTO), weshalb das Land im März 2016 Klage bei der WTO eingereicht hat. Unter dem Druck der WTO-Klage denkt die thailändische Regierung derzeit über eine Reform ihrer Zuckerpolitik nach, will am Ausbau des heimischen Zuckersektors aber festhalten (F.O. LICHT, 2016g).

Der weltweit drittgrößte Zuckerexporteur war in den vergangenen vier Zuckerwirtschaftsjahren **Australien**. Mit einer Exportmenge von 3,6 Mio. t Rw erreicht das Land im ZWJ 2015/16 einen Anteil an den globalen Zuckerexporten von rund 5% (vgl. Tabelle 4). Während die Zuckererzeugung und -exporte des Landes bis Mitte der 90er Jahre kontinuierlich gestiegen sind, hat sich der australische Zuckersektor in den vergangenen zwanzig Jahren weniger dynamisch entwickelt. Produktion und Exporte haben sich auf einem durchschnittlichen Niveau von 4,9 Mio. t Rw bzw. 3,8 Mio. t Rw stabilisiert (USDA, 2016d). Für das laufende ZWJ 2016/17 rechnet das US-Landwirtschaftsministeriums mit einem leichten Anstieg der Exporte, da der inländische Verbrauch zum Teil durch einen Abbau der Bestände gedeckt werden kann und zudem die Nachfrage auf potenziellen Exportmärkten, wie beispielsweise Japan und Südkorea, steigen soll und damit zusätzliche Exportmöglichkeiten bietet (USDA, 2016a, 2016b).

Im Vergleich zu den weltweiten Exporten sind die globalen Importe weniger stark konzentriert.

Tabelle 4. Top-10 Export- und Netto-Exportländer von Zucker weltweit

Rang	Exporte Okt.-Sept. 2015/16			Netto-Exporte Okt.-Sept. 2015/16			
	Land	Mio. t. Rw	Anteil	Land	Mio. t. Rw	Ø 3 Jahre[1)]	Δ 2015/16 vs. Ø 3 Jahre
1	Brasilien	25,5	38,6%	Brasilien	25,5	26,0	-2,2%
2	Thailand	8,8	13,4%	Thailand	8,8	6,9	28,6%
3	Australien	3,6	5,5%	Australien	3,5	3,2	8,8%
4	Indien	3,5	5,3%	Guatemala	2,2	2,1	4,9%
5	V Arab Emirate	2,3	3,4%	Indien	2,2	0,7	221,7%
6	Guatemala	2,2	3,4%	Frankreich	1,5	1,6	-8,8%
7	Frankreich	2,0	3,0%	Mexiko	1,4	2,0	-29,7%
8	Mexiko	1,5	2,2%	Kuba	0,8	1,0	-16,8%
9	Deutschland	1,2	1,9%	Kolumbien	0,7	0,6	26,4%
10	Kolumbien	0,8	1,3%	Swasiland	0,7	0,7	3,7%
(…)	Andere	14,6	22,1%	Andere	–	–	–
	Welt	**66,0**	**100,0%**	**Welt**	–	–	–

Anm.: Rw: Rohzuckerwert; 1) Ø 3 Jahre: 2012/13-2014/15
Quelle: eigene Berechnung, basierend auf F.O. LICHT (2016a)

Tabelle 5. Top-10 Import- und Netto-Importländer von Zucker weltweit

Rang	Importe Okt.-Sept. 2015/16			Netto-Importe Okt.-Sept. 2015/16			
	Land	Mio. t. Rw	Anteil	Land	Mio. t. Rw	Ø 3 Jahre[1)]	Δ 2015/16 vs. Ø 3 Jahre
1	China	4,5	7,1 %	China	4,4	4,1	6,6 %
2	Indonesien	4,2	6,6 %	Indonesien	4,2	3,7	12,5 %
3	USA	3,0	4,7 %	USA	2,8	3,0	-5,6 %
4	V Arab Emirat	2,3	3,6 %	Bangladesch	2,1	2,0	7,1 %
5	Bangladesch	2,1	3,3 %	Malaysia	1,7	1,7	2,7 %
6	Algerien	2,0	3,2 %	Algerien	1,7	1,4	21,6 %
7	Malaysia	2,0	3,2 %	Nigeria	1,6	1,5	4,3 %
8	Südkorea	1,9	3,0 %	Italien	1,6	1,6	-0,9 %
9	Nigeria	1,7	2,7 %	Südkorea	1,5	1,5	-2,4 %
10	Italien	1,6	2,6 %	Ägypten	1,4	1,3	13,6 %
(…)	Andere	37,9	60,0 %	Andere	–	–	–
	Welt	**63,1**	**100,0 %**	**Welt**	–	–	–

Anm.: Rw: Rohzuckerwert; 1) Ø 3 Jahre: 2012/13-2014/15
Quelle: eigene Berechnung, basierend auf F.O. LICHT (2016a)

Weltweit größter (Netto-)Importeur von Zucker war im vergangenen ZWJ 2015/16 im dritten Jahr in Folge **China** mit einer Importmenge von 4,5 Mio. t Rw. Dies entspricht einem Anteil an den globalen Zuckerimporten von rund 7 % (vgl. Tabelle 5). Während die chinesische Zuckernachfrage kontinuierlich wächst, hat die chinesische Produktionsentwicklung zuletzt an Dynamik verloren, sodass der Importbedarf Chinas in den letzten zehn Jahren deutlich angestiegen ist. Im ZWJ 2005/06 importierte China noch lediglich 1,2 Mio. t Rw Zucker und damit rund 2 % der globalen Zuckereinfuhren (F.O. LICHT, 2016a). Seitdem ist das Land jedoch von Platz 16 zum weltweit größten Zuckerimporteur herangewachsen. Im ZWJ 2011/12 führte China erstmals die Liste der weltweit größten Zuckerimporteure an.

Auf Platz zwei der weltweit größten Zuckerimporteure lag im vergangenen ZWJ 2015/16 **Indonesien** mit einer Importmenge von 4,2 Mio. t Rw. Damit erreicht das Land einen ähnlich hohen Anteil den globalen Zuckerimporten wie China (vgl. Tabelle 5). Während die Produktion in dem südostasiatischen Land seit Mitte der 90er-Jahre stagniert, wächst die indonesische Zuckernachfrage stetig mit einer durchschnittlichen jährlichen Wachstumsrate von 3,7 % in den letzten dreißig Jahren (USDA, 2016d). Indonesien hat sich daher fest in der Liste der Top 3 der weltweit größten Zuckerimporteure etabliert. In den vergangenen zehn Jahren gehörte das Land immer zu einem der weltweit größten Absatzmärkte für Zuckerexporte.

Ebenfalls fest etabliert in der Liste der Top 3 der weltweit größten Zuckerimporteure sind die **USA** mit einem jährlichen Importbedarf von rund 3 Mio. t Rw. Damit vereinte das Land zuletzt rund 5 % der globalen Zuckerimporte auf sich (vgl. Tabelle 5). Im Vergleich zu China und Indonesien wächst die Zuckernachfrage in den USA jedoch kaum, gleichzeitig werden Zuckerproduktion und -importe über Mengenkontingente politisch reguliert (USDA, 2016c). Setzt sich das Nachfragewachstum im asiatischen und afrikanischen Raum ungehindert fort, könnte die USA daher langfristig als Absatzmarkt für Zuckerexporte an relativer Bedeutung verlieren.

3 Der EU-Zuckermarkt

3.1 Die EU-Zuckermarktpolitik

Der Markt für Zucker gehört weltweit zu einem der am stärksten regulierten Agrarmärkte und auch in der Europäischen Union wird der Zuckermarkt durch die EU-Zuckermarktordnung reguliert. Diese besteht seit 1968 und wurde 2006 erstmals seit ihrem Inkrafttreten grundlegend reformiert und im Jahr 2007 in die gemeinsame Marktorganisation für landwirtschaftliche Erzeugnisse integriert (VO (EG) Nr. 1234/2007). Seit der GAP-Reform 2014 ist die EU-Zuckermarktordnung Bestandteil der Verordnung (EU) Nr. 1308/2013, die die vorherige gemeinsame Marktorganisation für landwirtschaftliche Erzeugnisse ersetzt.

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Bei der Einführung der EU-Zuckermarktordnung war das Kernziel der gemeinsamen Marktorganisation die Gewährleistung einer stabilen Marktlage innerhalb der Europäischen Gemeinschaft (EG) ohne starke Preis- und Mengenschwankungen (Planungssicherheit). Die in der EG erzeugten Mengen sollten die Nachfrage decken (Versorgungssicherheit) und die Einkommen der landwirtschaftlichen Betriebe sollten gestützt und gesichert werden. Um diese Ziele zu erreichen umfasste die EU-Zuckermarktordnung sowohl binnenmarkt- als auch außenhandelspolitische Instrumente. Institutionelle Preise und Produktionsquoten gewährleisteten ein hohes Preisniveau auf dem Binnenmarkt, das durch die Gewährung von Exporterstattungen stabilisiert und mithilfe von Einfuhrzöllen gegenüber dem deutlich geringerem Weltmarktpreisniveau abgesichert wurde.

Zentrales Element der **EU-Zuckermarktordnung bis 2006** war der Interventionspreis. Dieser galt sowohl für Weißzucker (632 €/t) als auch für Rohzucker (524 €/t) und bildete außerdem die Berechnungsgrundlage für den Zuckerrübenmindestpreis (48 €/t). Um den Interventionspreis gegenüber dem wesentlich geringerem Weltmarkpreisniveau durchzusetzen, wurde der EU-Binnenmarkt durch die Erhebung eines Einfuhrzolls gegenüber preiswerten Importen aus Drittländern geschützt. Der Zollsatz setzte sich dabei aus einer fixen Komponente (419 €/t Weißzucker bzw. 339 €/t Rohzucker) und einer variablen Komponente (Zusatzzoll) zusammen, die nur unter bestimmten Bedingungen erhoben werden konnte und deren Höhe in Abhängigkeit vom Weltmarktpreisniveau einmal jährlich festgesetzt wurde. Die Ausgestaltung des Zollsystems auf dem EU-Zuckermarkt entsprach damit dem Prinzip der variablen Importabschöpfung und gewährleistet eine nahezu vollständige Abschottung des EU-Binnenmarktes gegenüber dem Weltmarkt (THOMSEN, 2006). Der über das Zollsystem auf dem EU-Binnenmarkt durchgesetzte Interventionspreis galt jedoch nicht für die gesamte auf dem EU-Binnenmarkt produzierte Menge, sondern nur innerhalb bestimmter Mengenkontingente (Produktionsquoten). Diese orientieren sich an dem EU-internen Verbrauch, sollten also die Selbstversorgung der Gemeinschaft mit Zucker sicherstellen. Unterschieden wurde hierbei zwischen der sog. A-Quote (Grundquote) und B-Quote. Während die A-Quote (14,7 Mio. t) die Nachfrage auf dem EU-Binnenmarkt zum Interventionspreis abdeckte, stellte die B-Quote (2,7 Mio. t) eine Art Schwankungsreserve dar, um die Erfüllung der Grundquote bei witterungs- und ertragsbedingten Produktionsschwankungen zu gewährleisten. Zusammen bildeten A- und B-Quote die sog. Höchstquote (NEUMAIR, 2008). Um den EU-Zuckersektor vor der Konkurrenz mit engen Zuckersubstituten zu schützen, wurden 1977 bzw. 1994 außerdem Produktionsquoten für Isoglukose bzw. Inulin eingeführt (THOMSEN, 2006). Für Quotenzucker, der nicht auf dem EU-Binnenmarkt abgesetzt werden konnte, wurden Exportsubventionen gezahlt, die die Differenz zwischen dem geringen Weltmarktpreisniveau und dem hohem Interventionspreis mindestens ausglichen. Damit wurde der Verkauf an die Interventionsstellen und die Bildung hoher Interventionsbestände innerhalb der EU verhindert (THOMSEN, 2006). Zucker, der über die Quote hinaus produziert wurde (sog. C- oder Überschusszucker), musste auf dem Weltmarkt ohne Exporterstattungen abgesetzt oder auf das nächste Zuckerwirtschaftsjahr übertragen werden. Die Finanzierung der Exporterstattungen für Quotenzucker erfolgt durch die Erhebung einer Produktionsabgabe auf Quotenzucker. Diese war von der Zuckerindustrie zu leisten und wurde zu 58 % auf die Landwirte umgelegt. Die Höhe der Abgabe war innerhalb der A- und B-Quote unterschiedlich. Während auf A-Zucker maximal eine Grundabgabe von 2 % des Interventionspreises erhoben wurde, konnte die B-Abgabe bedarfsabhängig auf bis zu 39,5 % angehoben werden. Reichten die über die regulären Produktionsabgaben erzielten Einnahmen zur Finanzierung der Exporterstattungen nicht aus, so konnte außerdem noch eine Ergänzungsabgabe eingezogen werden. Diese war als Prozentsatz der bereits geleisteten Grund- und B-Abgabe abzuführen (NEUMAIR, 2008). Im Ergebnis führte das Abgabensystem dazu, dass die Zuckerwirtschaft für die Kosten der Marktregulierung weitgehend selbst aufkam, wodurch die Zuckermarktordnung für den EU-Agrarhaushalt haushaltsneutral war. Budgetäre Kosten entstanden lediglich durch den subventionierten Reexport von sog. Präferenzzucker, der im Rahmen von Präferenzhandelsabkommen auf den EU-Binnenmarkt gelangte und reexportiert werden musste, um einen Preisverfall innerhalb der Gemeinschaft durch das zusätzliche Angebot zu verhindern (THOMSEN, 2006). Die Präferenzhandelsabkommen hatte die EG überwiegend aus historischen und entwicklungspolitischen Gründen vor allem mit AKP- und LDC-Ländern geschlossen. Die Kosten für den Reexport von Präferenzzucker wurden daher nicht durch die erhobenen Produktionsabgaben finanziert, sondern als Ausgaben für Entwicklungshilfe über den EU-Entwicklungsfond abgerechnet (NEUMAIR, 2008).

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Wie bereits erwähnt, wurde die EU-Zuckermarktordnung im Jahr 2006 erstmals grundlegend reformiert. Hauptursache für die **EU-Zuckermarktreform 2006** war eine Klage Brasiliens, Thailands und Australiens vor dem WTO-Panel gegen die subventionierten Zuckerexporte der EU. Im Rahmen der Uruguay-Runde hatte sich die Europäische Union verpflichtet, ihre subventionierten Zuckerexporte auf jährlich 1,273 Mio. t Weißzucker zu beschränken und den Export von Zucker mit jährlich nicht mehr als 499 Mio. € zu subventionieren. Während die EU die Auffassung vertrat, dass lediglich der Quotenzucker als direkt subventioniert zu betrachten sei, sahen Brasilien, Thailand und Australien die Einhaltung der vereinbarten Höchstgrenzen durch den uneingeschränkten Export von C- und Präferenzzucker verletzt. Der Klage wurde im Jahr 2005 endgültig durch das WTO-Panel stattgegeben. Dem Urteil zufolge ist Präferenzzucker wie Quotenzucker zu behandeln und fällt daher unter die Exportbeschränkungen, für die neue Obergrenzen von jährlich 1,374 Mio. t Weißzucker bzw. 513,9 Mio. € festgelegt wurden. Außerdem wurde für die Ausfuhr von C-Zucker über die mengenmäßige Obergrenze hinaus ein Exportverbot verhängt, da dieser nach Auffassung des WTO-Panels durch Quersubventionierung[2] von den hohen Preisen für Quotenzucker profitiere. Damit sah sich die Europäische Union der Herausforderung gegenüber, ihre Produktion von Quotenzucker bis zum Inkrafttreten des Urteils am 22. Mai 2006 um den Betrag der bisherigen präferenziellen Import (ca. 1,6 Mio. t) zu senken und außerdem die Produktion und den Export von Überschusszucker zu stoppen (ca. 2-3 Mio. t). Insgesamt wurde damit eine Reduzierung der EU-Produktion um ca. 5 Mio. t ab dem ZWJ 2006/07 erforderlich (NEUMAIR, 2008). Zusätzliches Gewicht bekam die Entscheidung des WTO-Panels bezüglich der präferenziellen Zuckerimporte durch das im Jahr 2001 abgeschlossene Everything-But-Arms-Abkommen, welches die Öffnung des EU-Binnenmarktes für am wenigsten entwickelten Länder (Least Developed Countries, LDC) durch einen schrittweisen Zollabbau und freien Marktzugang ab 2009 vorsah. Nach Schätzungen im Vorfeld der Reform könnten die präferenziellen Importe aus den LDC-Staaten auf bis zu 2,7 Mio. t ansteigen und damit zur Einhaltung der bestehenden WTO-Exportbeschränkungen eine weitere Einschränkung der EU-Quotenproduktion erforderlich machen. Zum Zeitpunkt der EU-Zuckermarktreform 2006 lastete auf der Europäischen Union also aufgrund der aktuellen und bevorstehenden außenhandelspolitischen Verpflichtungen ein erheblicher Reformdruck, der schließlich mit dem Auslaufen der EU-Zuckermarktordnung am 30.06.2006 zur Anpassung der bisherigen Marktorganisation für Zucker an die geänderten Rahmenbedingungen führte. Hierdurch sollte eine weitgehende Destabilisierung (Überangebot, Preisverfall) des EU-Zuckermarktes vermieden werden. Die Kernelemente der Reformmaßnahmen bildeten die Senkung der Interventionspreise für Weißzucker von 632 €/t auf 404 €/t sowie für Rohzucker von 524 €/t auf 335 €/t und des Mindestpreises für Zuckerrüben von 44 €/t auf 26 €/t, die Einführung von entkoppelten Ausgleichszahlungen für Landwirte und die Gründung eines Restrukturierungsfonds, über den die Zuckerquote auf freiwilliger und unternehmensindividueller Basis von 17,5 Mio. t auf 13,3 Mio. t reduziert wurde. Gleichzeitig stieg die Isoglukosequote von 574 Tsd. t auf 690 Tsd. t, da Unternehmen im Zuge der Umstrukturierung auch die Möglichkeit gegeben wurde, über den Restrukturierungsfond Zusatzquote hinzuzukaufen. Die Inulinquote wurde dagegen vollständig in den Restrukturierungsfond abgegeben (WVZ, 2010). Weitere Reformmaßnahmen waren die Zusammenführung der A- und B-Quote zu einer Gesamtquote, die Abschaffung der Intervention und Einführung von Beihilfen für die private Lagerhaltung sowie die Erhebung einer Überschussabgabe auf C-Zucker in Höhe von 500 €/t, sollte dieser nicht auf das nächste Jahr übertragen, vernichtet, im Rahmen einer Ausfuhrlizenz exportiert, zur Versorgung äußerer Randgebiete verwendet oder für industrielle Zwecke eingesetzt werden. Zudem hat sich die EU-Kommission im Jahr 2008 dazu entschieden, die Exportsubventionen für Zucker auszusetzten (VO (EU) Nr. 947/2008). Trotzdem wurde weiterhin die Produktionsabgabe von 12 €/t Quotenzucker und 6 €/t Quotenisoglukose erhoben, die zu 50 % auf die Landwirte umgelegt werden kann (VO (EU) Nr. 1370/2013). Das Zollsystem für EU-Zuckerimporte aus Drittstaaten ohne präferenziellen Marktzugang blieb während der Reform 2006 in unveränderter Form bestehen.

Mit den Beschlüssen zur Gemeinsamen Agrarpolitik für den Zeitraum 2014 bis 2020 hat die EU-Kommission im Jahr 2013 das **Ende der Zucker- und Isoglukosequote ab dem ZWJ 2017/18** beschlossen. Damit wird der mit der EU-Zuckermarktreform 2006 begonnene Reformprozess der EU-Zuckermarktpolitik in Richtung einer stärkeren Markt-

[2] C-Zucker kann nur deshalb gewinnbringend zum Weltmarktpreis abgesetzt werden, weil die Fixkosten über den subventionierten Quotenzucker bereits gedeckt sind.

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orientierung fortgesetzt. Mit dem Wegfall der Produktionsquoten werden auch der innerhalb der Quotenmenge geltende Zuckerrübenmindestpreis sowie die Produktionsabgaben für Zucker und Isoglukose entfallen. Zum Ausgleich für die Aufhebung des Zuckerrübenmindestpreises erhalten Rübenbauern in insgesamt zehn EU-Mitgliedstaaten gekoppelte Direktzahlungen für den Anbau von Zuckerrüben in Höhe von 208 €/ha (Kroatien) bis 645 €/ha (Rumänien) (CEFS, 2014). Der Referenzpreis für Weiß- und Rohzucker bleibt in unveränderter Höhe bestehen, wird jedoch durch den Begriff des Referenzschwellenwertes ersetzt. Damit kann die EU-Kommission auch nach dem Wegfall der Produktionsquoten den EU-Marktpreis unter Berücksichtigung des Referenzschwellenwertes durch die Zahlung von Beihilfen zur privaten Lagerhaltung stützen. Auch die Zahlung von Exporterstattung ist im Fall von Marktstörungen (erhebliche Preissteigerungen oder -rückgänge) und spezifischen Problemen (sehr schnelle Verschlechterung der Erzeugungs- und Marktbedingung) weiterhin möglich. Mit der Aufhebung des EU-Quotensystems wird außerdem aller Voraussicht nach die WTO-Beschränkung für Zuckerexporte der Europäischen Union in Drittstaaten entfallen. Denn nach dem Quotenausstieg werden die EU-Zuckerausfuhren nicht mehr über die hohen Erlöse für Quotenzucker quersubventioniert, womit die Begründung für das WTO-Exportlimit entfallen dürfte. Das Zollsystem für EU-Zuckerimporte aus Drittstaaten ohne präferenziellen Marktzugang zum EU-Binnenmarkt bleibt auch nach dem Ende der Zucker- und Isoglukosequoten in unveränderter Form bestehen. Im Verlauf der letzten Jahre hat die EU-Kommission jedoch immer mehr Handelsabkommen abgeschlossen, die einer immer größer werdenden Anzahl von Ländern einen begrenzten oder unbegrenzten, zollreduzierten oder zollfreien Zugang zum EU-Binnenmarkt gewährt. Eine Übersicht über die bereits in Kraft getretenen Präferenzregelungen für Zucker gibt Tabelle 6. Darüber hinaus werden im laufenden ZWJ 2016/17 voraussichtlich die in Tabelle 7 aufgeführten Präferenzregelungen wirksam werden.

Tabelle 6. Präferenzregelungen der Europäischen Union mit Drittstaaten für Zucker (in Kraft)

Land	Zollquote 2016 - t -	Zollsatz - €/t -	Jährliche Steigerung - t -	VO (EU) Nr.
AKP/LDC[2)]	**unbegrenzt**	**0**		**Abkommen seit 1975/2001**
Westbalkan	**201 167**			**891/2009**
- Albanien	1 000	0	–	891/2009
- Bosnien&Herzegowina	12 000	0	–	891/2009
- Serbien	181 167	0	–	891/2009
- Mazedonien	7 000	0	–	891/2009
CXL	**676 925**			**891/2009**
- Australien	9 925	98	–	891/2009
- Brasilien	334 054	98	–	891/2009
- Kuba	68 969	98	–	891/2009
- Indien	10 000	0	–	891/2009
- Jedes Drittland	253 977	98		891/2009
Kolumbien	**67 580**	**0**	**1 860**	**741/2013**
Peru	**23 980**	**0**	**660**	**405/2013**
Zentralamerika (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua)	**163 500**	**0**	**4 500**	**924/2013**
Panama	**13 080**	**0**	**360**	**923/2013**
Ukraine[4)]	**20 070**	**0**	**–**	**Abkommen seit 2014**
Moldawien[3) 4)]	**unbegrenzt**	**0**		**Abkommen seit 2014**
Georgien[4)]	**unbegrenzt**	**0**		**Abkommen seit 2014**
Jedes Drittland[1)]	**400 000**	**0**	**–**	**635/2014**

Anm.: 1) nur Industriezucker; 2) unbegrenzt seit 2009; 3) bis 2016 Zollquoten (55/2008); 4) Abkommen seit 2014 provisorisch in Kraft, Moldawien und Georgien seit 2016 vollständig in Kraft
Quelle: WVZ (2016), ergänzt

Tabelle 7. Präferenzregelungen der Europäischen Union mit Drittstaaten für Zucker (Verhandlungen abgeschlossen)

Land	Zollquote - t -	Zollsatz - €/t -	Jährliche Steigerung - t -	Inkrafttreten
Ecuador	25 000	0	–	2017
Südafrika	150 000	0	–	ZWJ 2016/17
Kanada	unbegrenzt	Abbau über 7 Jahre		ZWJ 2016/17
Singapur	unbegrenzt	Abbau über 5 Jahre		ZWJ 2016/17
Vietnam	20 400	0	–	2018

Quelle: WVZ (2016), ergänzt

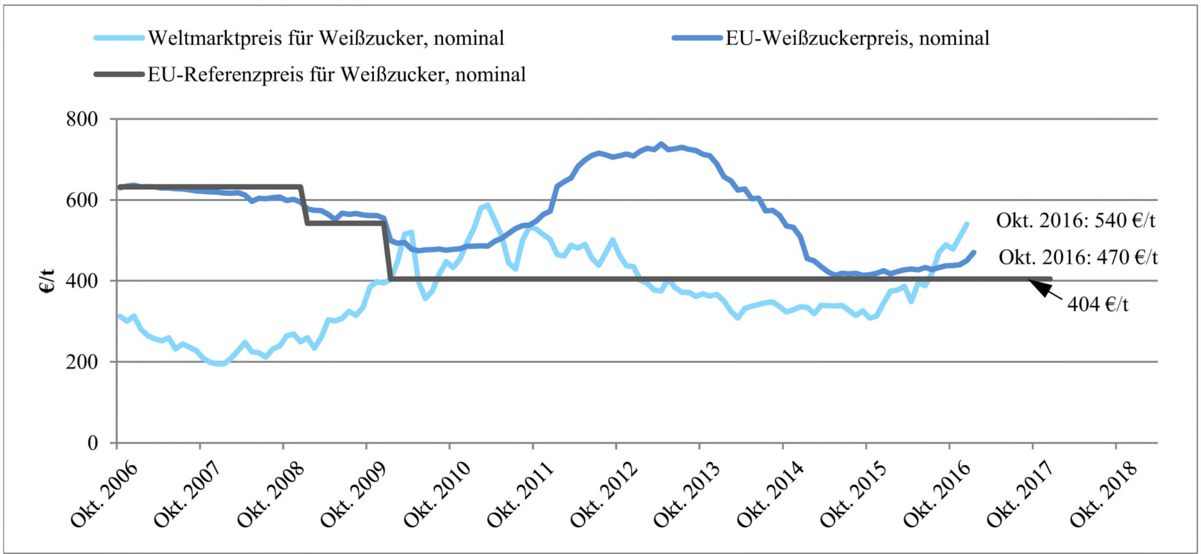
3.2 Preise

Nicht nur auf dem Weltmarkt, sondern auch in der EU tendiert der Weißzuckerpreis seit Beginn des vergangenen ZWJ 2015/16 wieder aufwärts (vgl. Abbildung 2). Allerdings ist der Aufwärtstrend deutlich geringer als auf dem Weltmarkt. Seit Oktober 2015 ist der durchschnittliche Weißzuckerpreis auf dem EU-Binnenmarkt von 417 €/t auf zuletzt 470 €/t gestiegen (+13 %) (Stand Okt. 2016). Im gleichen Zeitraum legte der Weltmarktpreis an der Börse in London um 56 % zu und lag im Oktober mit 540 €/t Weißzucker deutlich über dem durchschnittlichen Weißzuckerpreis in der Europäischen Union. Ursache hierfür könnte ein sich im Zuge des EU-Quotenausstiegs bereits verschärfender Wettbewerb auf dem EU-Binnenmarkt sein. In den kommenden Monaten rechnet die EU-Kommission jedoch mit einem weiteren Anstieg des EU-Zuckerpreises und weist gleichzeitig darauf hin, dass der Marktpreis von Zucker im April 2016 in einzelnen EU-Mitgliedsstaaten mit 550 €/t bereits deutlich oberhalb des EU-Durchschnittspreises lag, in dessen Erhebung nicht nur die aktuellen Marktpreise, sondern auch die zu einem früheren Zeitpunkt in langfristigen Verträgen festgelegten Preise einfließen (AGRA-EUROPE, 2016a; EU-COM, 2016c).

3.3 Versorgung

Tabelle 8 zeigt die EU-Marktbilanz für Zucker und Isoglukose für die beiden letzten und das laufende Zuckerwirtschaftsjahr 2016/17. Unter der Quote werden in der EU jährlich rund 13,5 Mio. t Weißzucker und 0,7 Mio. t Isoglukose erzeugt. Demgegenüber steht ein Bedarf von rund 17 Mio. t Weißzucker und Isoglukose für die Lebensmittelproduktion. Die im Rahmen der Produktionsquoten erzeugten Zucker- und Isoglukosemengen decken damit rund 85 % des

Abbildung 2. Entwicklung der Weißzuckerpreise in der EU und auf dem Weltmarkt 2006-2016 – monatliche Werte



Anm.: Weltmarktpreis: Kontrakt Nr. 407 (aka Nr. 5)
Quelle: eigene Berechnung, basierend auf EU-COM (2017), IMF (2017), USDA (2017)

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Tabelle 8. EU-Zucker- und Isoglukosebilanz (Mio. t Ww)

	2016/17[1]			2015/16[2]			2014/15		
	Quote	Nicht-Quote	Ins-gesamt	Quote	Nicht-Quote	Ins-gesamt	Quote	Nicht-Quote	Ins-gesamt
Produktion	**14,2**	**4,1**	**18,4**	**14,2**	**4,1**	**18,4**	**14,2**	**6,6**	**20,8**
- Zucker	13,5	4,1	17,6	13,5	4,1	17,6	13,5	6,6	20,1
- Isoglukose	0,7	0,0	0,7	0,7	0,1	0,8	0,7	0,0	0,8
Importe	**3,5**	**0,0**	**3,5**	**3,4**	**0,0**	**3,4**	**3,4**	**0,0**	**3,4**
- als solches	2,9	na	–	2,8	na	–	2,8	na	–
- in verarbeiteten Produkten	0,5	na	–	0,5	na	–	0,5	na	–
Exporte	**1,5**	**0,7**	**2,2**	**1,5**	**1,4**	**2,9**	**1,5**	**1,3**	**2,9**
- als solches	0,1	na	–	0,1	na	–	0,1	na	–
- in verarbeiteten Produkten	1,4	na	–	1,4	na	–	1,4	na	–
Verbrauch	**16,7**	**2,2**	**18,9**	**16,7**	**1,8**	**18,6**	**16,8**	**2,6**	**19,4**
Anfangsbestand	**0,7**	**0**	**0,7**	**1,3**	**0**	**1,3**	**2,0**	**0**	**2,0**
Endbestand	**0,2**	**1,3**	**1,5**	**0,7**	**0,9**	**1,6**	**1,3**	**2,7**	**4,0**
Selbstver-sorgungsgrad	**85 %**	**192 %**	**97 %**	**85 %**	**225 %**	**99 %**	**85 %**	**254 %**	**108 %**
Defizit/Überschuss	**-2,5**	**2,0**	**-0,5**	**-2,5**	**2,3**	**-0,2**	**-2,5**	**4,0**	**1,5**
Bestand/Verbrauch	**1 %**	**61 %**	**8 %**	**4 %**	**51 %**	**9 %**	**8 %**	**102 %**	**21 %**

Anm.: Ww: Weißzuckerwert; 1) 2016/17 Schätzung; 2) 2015/16 vorläufig; na: nicht angegeben. Nicht-Quoten-Produktion inkl. Rüben für die Ethanolproduktion und Saldo der Übertragungsmengen aus dem Vor- und Folgejahr.
Quelle: DG AGRI (2016)

EU-Süßungsmittelbedarfs, weshalb die EU zur Deckung ihres Verbrauchs auf Zuckerimporte aus Drittstaaten angewiesen ist. Jährlich werden etwa 3 Mio. t Ww (Ww: Weißzuckerwert) Zucker aus Drittändern in die Europäische Union importiert. Zusätzlich gelangen jährlich 0,5 Mio. t Ww Zucker in verarbeiteten Produkten auf den EU-Binnenmarkt. Über die Quote hinaus produzierte Mengen (sog. Nicht-Quoten- oder Überschusszucker/-rüben/-isoglukose) werden größtenteils innerhalb der Europäischen Union auf dem Nicht-Lebensmittelmarkt zur industriellen Verwertung abgesetzt. Jährlich sind dies 2,0 Mio. t Ww bis 2,5 Mio. t Ww. Hauptabsatzmarkt ist dabei die Bioethanolindustrie mit einem jährlichen Bedarf von 1,0 Mio. t Ww bis 1,7 Mio. t Ww. Darüber hinaus werden jährlich rund 0,8 Mio. t Ww Zucker in anderen industriellen Prozessen eingesetzt (z. B. Hefeherstellung, Pharmaindustrie) (DG AGRI, 2016). Überschusszucker, der nicht auf dem EU-Binnenmarkt abgesetzt werden kann, wird in geringen Mengen im Rahmen der bestehenden WTO-Exportbeschränkung exportiert. Die Einhaltung dieser Exportbeschränkung wird von der EU-Kommission durch die Vergabe von Exportlizenzen gewährleistet. In Abhängigkeit von der Einschätzung der gegenwärtigen Marktlage schreibt die EU-Kommission ein- bis zweimal jährlich Exportlizenzen aus. Für das vergangene ZWJ 2015/16 wurde die erste Tranche in Höhe von 650 Tsd. t Weißzucker und 70 Tsd. t Isoglukose im Juli 2015 freigegeben (DVO (EU) 2015/1164). Im Februar 2016 erhöhte die EU-Kommission die Mengenbegrenzung für Ausfuhren von Nicht-Quotenzucker um 700 Tsd. t auf insgesamt 1,35 Mio. t Weißzucker (DVO (EU) 2016/190). Für das laufende ZWJ 2016/17 stehen derzeit erneut zunächst Exportlizenzen in Höhe von 650 Tsd. t Weißzucker und 70 Tsd. t Isoglukose zur Verfügung (DVO (EU) 2016/1713). Für Zucker, der in verarbeiteten Produkten exportiert wird, besteht keine Exportbeschränkung. In den letzten Jahren wurden im Durchschnitt rund 1,2 Mio. t Ww Zucker in verarbeiteten Produkten exportiert. Überschusszucker, der weder auf den Weltmarkt exportiert, noch auf dem EU-Binnenmarkt zur industriellen Verwertung abgesetzt werden kann, wird von den Zuckerunternehmen auf das nächste Zuckerwirtschaftsjahr übertragen, das heißt auf die Quotenproduktion des Folgejahres angerechnet. In den vergangenen Jahren waren dies zwischen 0,5 Mio. t Ww und 2,7 Mio. t Ww (vgl. Endbestand Nicht-Quotenzucker, Tabelle 8).

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3.4 Erzeugung

In der EU wird Zucker in erster Line aus Zuckerrüben gewonnen. Nur die französischen Überseedepartments Guadeloupe, Martinique und Réunion sowie die portugiesischen Azoren erzeugen Zucker auf Zuckerrohrbasis. Aufgrund der Angebotsregulierung über Produktionsquoten sowie der begrenzten Absatzmöglichkeiten für Überschusszucker ist die EU-Zuckererzeugung relativ stabil. Angebotsänderungen ergeben sich vor allem durch witterungsbedingte Ertragsschwankungen. Gegenüber der Rekordernte im ZWJ 2014/15 ist die EU-Zuckererzeugung im vergangenen ZWJ 2015/16 vergleichsweise deutlich von 19,5 Mio. t Ww auf 15 Mio. t Ww gesunken (-23%), denn aufgrund der hohen Übertragungsmengen aus dem Vorjahr haben die EU-Zuckerunternehmen und Rübenbauern die Anbauflächen deutlich reduziert (-12%). Gleichzeitig lagen die Erträge im ZWJ 2015/16 auf einem durchschnittlichen Niveau von 72 Tonnen Zuckerrüben und 11 t Zucker je Hektar (vgl. Tabelle 9; EU-COM, 2016a). Im Anbaujahr 2016 wurde die EU-Zuckerrübenfläche wieder ausgeweitet, sodass die EU-Kommission für das laufende ZWJ 2016/17 bei einem durchschnittlichen Rübenertrag von 73 t/ha mit einem Anstieg der Zuckererzeugung auf 16,9 Mio. t Ww rechnet. Damit würde die Produktion leicht unterhalb des fünfjährigen Durchschnitts liegen. Da die Rübenerträge und insbesondere der Zuckergehalt sich gegen Ende der Zuckerrübenkampagne aber immer noch ändern können, ist die Schätzung der letztendlichen Höhe der Zuckererzeugung im ZWJ 2016/17 aber mit Unsicherheiten behaftet (EU-COM, 2016b).

Der Schwerpunkt der EU-Zuckererzeugung liegt in Mittel- und Nordwesteuropa. Allein Frankreich, Deutschland und Polen erzeugen zusammen rund 60% der EU-Zuckerproduktion (vgl. Tabelle 9).

Dabei ist **Frankreich** mit einem Anteil von rund 30% an der jährlichen EU-Zuckererzeugung der mit Abstand größte Zuckerproduzent innerhalb der EU. Auf einer Anbaufläche von jährlich rund 350 Tsd. ha erzeugt das Land rund 5 Mio. t Ww Zucker im Jahr. Die französische Zuckererzeugung liegt damit deutlich oberhalb der Zuckerquote von 3,4 Mio. t Ww (vgl. Tabelle 9). Über die Quote hinaus produzierte Mengen werden einerseits exportiert und andererseits auf den Ethanolmarkt abgesetzt. Innerhalb der EU ist Frankreich der größte Bioethanolproduzent und verarbeitet mit Abstand die meisten Rüben zu Bioethanol (MAIER et al., 2016). Im Gegensatz zu anderen EU-Mitgliedstaaten hat Frankreich die Zuckerrübenanbaufläche im Anbaujahr 2015 kaum eingeschränkt (-6%). Der Zuckerertrag lag im ZWJ 2015/16 mit 12,2 t/ha leicht unterhalb des Vorjahresertrags von 12,3 t/ha Zucker, sodass die Zuckererzeugung um 9% gegenüber dem Vorjahr gesunken ist und damit deutlich weniger stark als im EU-Durchschnitt (-23%). Für das laufende ZWJ 2016/17 rechnen Marktexperten übereinstimmend mit einem Rübenertrag leicht unterhalb des fünfjährigen Durchschnitts. Zu feuchtes Wetter im Frühjahr hat in Frankreich im Anbaujahr 2016 die Aussaat verzögert und zu einem hohen Krankheitsdruck geführt. Dagegen herrschten über den Sommer bis zum Beginn der Ernte eher trockene Wetterbedingungen, wodurch der Rübenertrag und auch der Zuckergehalt der Rüben stieg. Gegen Ende der Rübenernte im November nahmen die Niederschläge jedoch wieder zu (EU-COM, 2016a; F.O. LICHT, 2016h). Gleichzeitig hat Frankreich die Anbaufläche im Anbaujahr 2016 um 4% bis 5% ausgedehnt, sodass die Zuckererzeugung im laufenden ZWJ 2016/17 gegenüber dem Vorjahr voraussichtlich leicht ansteigen wird (DG AGRI, 2016; F.O. LICHT, 2016h).

Hinter Frankreich ist **Deutschland** mit einem Anteil von rund 20% an der EU-Zuckererzeugung der zweitgrößte Zuckererzeuger der EU (vgl. Tabelle 9). Wie in Frankreich werden in der Bundesrepublik auf rund 350 Tsd. ha Zuckerrüben angebaut. Allerdings liegt der durchschnittliche Zuckerertrag mit 11,3 t/ha rund eine Tonne unterhalb des Zuckerertrages in Frankreich (12,4 t/ha). Anders als in Frankreich haben sich die deutschen Zuckerrübenanbauer und -unternehmen dazu entschieden, die Zuckerrübenanbaufläche im Anbaujahr deutlich zu reduzieren (-19%). Wie bereits erwähnt, hatten die europaweiten Rekorderträge im Anbaujahr 2014 von in Deutschland 13,8 Tonnen Zucker je Hektar zu hohen Übertragungsmengen geführt und eine Einschränkung der Zuckerrübenfläche erforderlich gemacht. Im Gegensatz zu den Vorjahren, in denen Deutschland seine Zuckerquote um jährlich 18% bis 55% überschritten hatte, entsprach die deutsche Zuckererzeugung im ZWJ 2015/16 mit 2,9 Mio. t Ww der Quote. Für das laufende ZWJ 2016/17 schätzt die EU-Kommission die deutsche Zuckerproduktion auf 3,8 Mio. t Ww, bei einem Zuckerertrag von 12,6 t/ha und einer Anbaufläche von 299 Tsd. ha (DG AGRI, 2016). Die Produktionssteigerung von rund 1 Mio. t Ww Zucker gegenüber dem Vorjahr wäre demnach sowohl auf ein höheres Ertragsniveau (+6%) als auch auf eine Ausweitung der Anbaufläche (+8%) zurückzuführen.

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Tabelle 9. Top-10: Zuckerproduktion, Zuckerrübenanbauflächen und Zuckererträge in der Europäischen Union im ZWJ 2015/16

	Produktion[1]				Anbaufläche				Zuckerertrag			
Rang	Land	Mio. t Ww	Anteil	Quote	Land	1000 ha	Ø 5 Jahre[2]	15/16 vs. Ø 5 Jahre[2]	Land	t/ha	Ø 5 Jahre[2]	15/16 vs. Ø 5 Jahre[2]
1	FR	4,6	31 %	3,4	FR	350	353	-1 %	ES	15,4	13,7	13 %
2	DE	2,9	20 %	2,9	DE	283	348	-19 %	BE	13,6	12,9	6 %
3	PL	1,4	10 %	1,4	PL	172	191	-10 %	NL	13,4	13,4	0 %
4	UK	1,0	7 %	1,1	UK	74	97	-23 %	UK	13,2	12,0	10 %
5	NL	0,8	5 %	0,8	NL	57	70	-19 %	DK	12,5	12,4	1 %
6	BE	0,7	5 %	0,7	BE	54	60	-10 %	FR	12,2	12,4	-1 %
7	ES	0,6	4 %	0,4	CZ	54	57	-6 %	DE	11,7	11,3	3 %
8	IT	0,5	3 %	0,5	AT	45	47	-4 %	SE	10,3	9,9	4 %
9	CZ	0,5	3 %	0,4	IT	38	50	-24 %	AT	9,4	9,9	-5 %
10	AT	0,4	3 %	0,4	ES	37	41	-10 %	CZ	9,3	9,4	-1 %
	EU-28	**14,9**	**100 %**	**13,5**	**EU-28**	**1,035**	**1,491**	**-12 %**	**EU-28**	**11,3**	**11,3**	**-3 %**

Anm.: Ww: Weißzuckerwert; 1) ohne Übertragungsmengen, inkl. Rüben für die Ethanolproduktion; 2) Ø 5 Jahre: 2010/11-2014/15
Quelle: eigene Berechnung, basierend auf DG AGRI (2016)

Polen ist mit einem Anteil von rund 10 % an der EU-Zuckererzeugung das drittgrößte Zucker produzierende Land der EU. Auf einer Fläche von nahezu 200 Tsd. ha erzeugte die polnische Zuckerindustrie in den letzten Jahren knapp 2 Mio. t Ww Zucker im Jahr. Im Vergleich zu Frankreich und Deutschland ist der Zuckerertrag in Polen mit 9,2 t/ha im Durchschnitt der letzten fünf Jahre (2009/10 bis 2014/15) deutlich geringer. Im Anbaujahr 2015 hat Polen wie auch Deutschland die Anbaufläche aufgrund hoher Übertragungsmengen deutlich reduziert (-10 %) (vgl. Tabelle 9). Gleichzeitig war der Zuckerertrag mit 8,5 t/ha vergleichsweise gering, sodass die polnische Zuckerproduktion ebenso wie in Deutschland der Zuckerquote entsprach (1,4 Mio. t Ww). In den letzten vier vorangegangenen Jahren hatte das Land Überschussmengen von 20 % bis 40 % der Quote erzeugt. Im laufenden ZWJ 2016/17 wird die polnische Zuckerproduktion voraussichtlich sogar auf 2,1 Mio. t Ww ansteigen und damit die Produktionsquote um 50 % übersteigen. Ursache für den deutlichen Produktionsanstieg ist einerseits eine deutliche Ausdehnung der Zuckerrübenanbaufläche gegenüber dem Vorjahr (18 %) und andererseits ein sehr gutes Ertragsniveau von voraussichtlich 10,3 Tonnen Zucker pro Hektar (DG AGRI, 2016). Das Anbaujahr 2016 hatte in Polen zwar recht trocken und kühl begonnen, ab Juni haben sich die Witterungsbedingungen jedoch verbessert, sodass der Zuckerertrag deutlich oberhalb des durchschnittlichen Ertragsniveaus liegt (EU-COM, 2016a).

Wie bereits beschrieben, wird in der EU neben Zucker auch Isoglukose erzeugt, etwa 4 % des EU-Süßmittelbedarfs (vgl. Kapitel 3.3). Rohstoff für die Isoglukoseerzeugung ist vor allem Mais, aber auch Weizen. Anders als Zucker wird Isoglukose kaum über die Quote hinaus produziert. In den letzten Jahren lag die Überschussproduktion bei 3 % bis 8 % der Quotenerzeugung (720 Tsd. t) (DG AGRI, 2016).

Während Zucker von insgesamt 20 EU-Mitgliedstaaten erzeugt wird, konzentriert sich die EU-Isoglukoseerzeugung seit dem ZWJ 2010/11 auf nur 9 EU-Länder (vgl. Tabelle 10). Denn während der Restrukturierungsphase der Zuckermarktreform 2006 haben Finnland, Frankreich, Griechenland, Großbritannien, die Niederlande und Rumänien ihre Isoglukosequote vollständig in den Restrukturierungsfond abgegeben (WVZ, 2010). Schwerpunkt der EU-Isoglukoseerzeugung ist Mittel- und vor allem Osteuropa. Zusammen erzeugen die vier osteuropäischen EU-Mitgliedstaaten Ungarn, Bulgarien, Slowakei und Polen durchschnittlich 63 % der EU-Isoglukoseerzeugung (vgl. Tabelle 10). Ein Grund hierfür ist, dass diese Länder erst spät der Europäischen Union beigetreten sind (HU, SK, PL 2004, BG 2007). Vor dem EU-Beitritt war die Erzeugung von Isoglukose in diesen Ländern nicht durch Produktionsquoten begrenzt und mit dem Beitritt zur EU wurde die Höhe der Isoglukosequoten entsprechend der bestehenden Produktionsmengen festgelegt (TODD, 2015).

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Tabelle 10. EU-Isoglukoseerzeugung

Rang	Okt-Sept. 2016/17[1)]				Okt.-Sept. 2015/16[2)]				Okt.-Sept. Ø 5 Jahre[3)]			
	Land	Tsd. t Ww	Anteil	Quote	Land	Tsd. t Ww	Anteil	Quote	Land	Mio. t Ww	Anteil	Quote
1	HU	250	35%	250	HU	250	35%	250	HU	263	35%	250
2	BE	115	16%	115	BE	115	16%	115	BE	115	16%	115
3	BG	89	12%	89	BG	89	12%	89	BG	97	13%	89
4	SK	68	9%	68	SK	68	9%	68	SK	67	9%	68
5	DE	57	8%	57	DE	57	8%	57	DE	58	8%	57
6	ES	54	7%	54	ES	54	7%	54	ES	56	7%	54
7	PL	43	6%	43	PL	43	6%	43	PL	43	6%	43
8	IT	32	5%	32	IT	32	5%	32	IT	33	4%	32
9	PT	13	2%	13	PT	13	2%	13	PT	11	1%	13
	EU-28	**720**	**100%**	**720**	**EU-28**	**720**	**100%**	**720**	**EU-28**	**742**	**100%**	**720**

Anm.: Ww: Weißzuckerwert; 1) 2016/17 Schätzung; 2) 2015/16 vorläufig; 3) Ø 5 Jahre: 2010/11-2014/15
Quelle: eigene Berechnung, basierend auf DG AGRI (2016)

Der mit Abstand größte Isoglukoseerzeuger der EU ist **Ungarn** mit einer jährlichen Produktionsmenge von durchschnittlich 263 Tsd. t. Damit erreicht das Land einen Anteil an der EU-Isoglukoseerzeugung von 35% und produzierte in den vergangenen fünf Jahren durchschnittlich 5% Überschussisoglukose (vgl. Tabelle 10). Im ZWJ 2013/14 hatte Ungarn aufgrund des Beitritts Kroatiens zur Europäischen Union eine zusätzliche Isoglukosequote von 30 Tsd. t erhalten. Seither ist die Überschussproduktion des Landes deutlich gesunken, da nun auch die für den Export nach Kroatien erzeugten Isoglukosemengen unter die Quote fallen.

Hinter Ungarn sind **Belgien** und **Bulgarien** mit einem durchschnittlichen Anteil von 16% und 13% an der EU-Isoglukoseerzeugung die zweit- und drittgrößten Erzeuger von Isoglukose der EU (vgl. Tabelle 10). Während Belgien seine Isoglukosequote in den vergangenen Jahren immer voll ausgeschöpfte, aber nicht überschritten hat, ist die Erzeugung von Überschussisoglukose in Bulgarien zuletzt deutlich angestiegen, was auf einen Ausbau der Isoglukoseerzeugung im Zuge des EU-Quotenausstiegs hindeuten könnte. So lag die bulgarische Isoglukoseerzeugung im ZWJ 2013/14 16% und im Folgejahr 27% über der Quote. Im Durchschnitt der letzten fünf Jahre erzeugte Bulgarien damit rund 9% Überschussisoglukose und erreicht damit noch vor Ungarn den höchsten Wert innerhalb der Europäischen Union. Für das vergangene ZWJ 2015/16 und das laufende ZWJ 2016/17 enthält die vorläufige und geschätzte Zucker- und Isoglukosebilanz der EU-Kommission noch keine Angaben zur Erzeugung von Überschussisoglukose, sodass zum jetzigen Zeitpunkt unklar ist, ob sich der Wachstumstrend der bulgarischen Isoglukoseerzeugung fortsetzt.

3.5 Verbrauch

Während die Zuckernachfrage global betrachtet über die vergangenen dreißig Jahre mit einer durchschnittlichen jährlichen Wachstumsrate von 1,7% gestiegen ist (vgl. Kapitel 2.4), wächst der Zuckerkonsum in der EU kaum. Seit dem ZWJ 1985/86 betrug die durchschnittliche jährliche Nachfragesteigerung lediglich 0,6% (USDA, 2016d). Dabei ist der Zuckerverbrauch in den letzten Jahren vor allem in einigen südlichen und östlichen EU-Mitgliedstaaten gestiegen, in allen anderen EU-Ländern stagniert der Konsum von Zucker dagegen oder entwickelt sich sogar leicht rückläufig. Haupteinflussfaktoren auf die Nachfrageentwicklung sind in Europa die Bevölkerungsentwicklung und eine geringe Einkommenselastizität der Nachfrage (F.O. LICHT, 2016d). Mit dem Ende der EU-Zuckerquote im Oktober 2017 ist davon auszugehen, dass der EU-Zuckerpreis fällt und der Zuckerverbrauch daher leicht ansteigt. Auf der anderen Seite wirken eine rückläufige Bevölkerungsentwicklung und ein zunehmendes Bewusstsein für eine ausgewogene Ernährung in Richtung einer Reduzierung des Zuckerkonsums. Insgesamt gehen die Marktexperten von F.O. LICHT daher davon aus, dass sich das in den vergangenen Jahren beobachtete schwache Wachstum der EU-Zuckernachfrage auch in den kommenden Jahren fortsetzen wird (F.O. LICHT, 2016d).

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Tabelle 11. Top-10 Zucker konsumierende Länder der Europäischen Union

Rang	Okt.-Sept. 2015/16					Okt.-Sept. Ø 5 Jahre[1)]				
	Land	Mio. t Ww	Anteil	Δ Vorjahr	kg/Kopf	Land	Mio. t Ww	Anteil	Δ 2015/16 vs. Ø 5 Jahre	kg/Kopf
1	DE	3,1	17,2%	0,3%	37,9	DE	3,1	17,5%	-0,7%	38,0
2	FR	2,5	13,9%	0,7%	38,1	FR	2,4	13,7%	2,1%	37,8
3	UK	2,0	11,3%	-0,2%	31,1	UK	2,0	11,4%	-0,1%	31,7
4	IT	1,9	10,5%	0,0%	30,2	IT	1,8	10,5%	1,5%	30,0
5	PL	1,6	8,8%	1,1%	41,1	PL	1,5	8,7%	2,0%	40,2
6	ES	1,5	8,5%	0,5%	31,1	ES	1,4	8,1%	5,2%	30,2
7	NL	0,9	4,8%	0,0%	50,6	NL	0,9	4,9%	0,0%	51,2
8	BE	0,6	3,2%	0,0%	52,3	BE	0,6	3,2%	1,1%	51,9
9	RO	0,5	2,8%	0,0%	22,8	RO	0,5	2,8%	0,8%	22,4
10	AT	0,4	2,4%	0,0%	51,5	AT	0,4	2,4%	-0,6%	51,8
(…)	Andere	2,9	16,5%	0,1%	–	Andere	3,0	16,8%	-0,6%	–
	EU-28	**17,8**	**100,0%**	**0,3%**	**37,8**	**EU-28**	**17,6**	**100,0%**	**0,8%**	**37,7**

Anm.: Ww: Weißzuckerwert; 1) Ø 5 Jahre: 2010/11-2014/15
Quelle: eigene Berechnung, basierend auf F.O. LICHT (2016a, 2016d)

Absolut betrachtet haben Deutschland und Frankreich den höchsten Zuckerverbrauch in der Europäischen Union. Zusammen vereinen diese beiden Länder knapp ein Drittel der EU-Zuckernachfrage auf sich (vgl. Tabelle 11). Dabei lag der Pro-Kopf-Verbrauch in den letzten fünf Jahren mit jährlich durchschnittlich 38,0 kg Ww in Deutschland und 37,8 kg Ww in Frankreich etwa auf dem Niveau des EU-Durchschnittsverbrauchs von 37,7 kg Ww je Kopf und Jahr. Dabei stagniert der Zuckerkonsum in Deutschland in den letzten zehn Jahren. Im ZWJ 2015/16 ist der Pro-Kopf-Verbrauch und auch der absolute Zuckerverbrauch der Deutschen im Vergleich zum Durchschnitt der fünf vorangegangenen Zuckerwirtschaftsjahre sogar gesunken. In Frankreich zeigen dagegen sowohl der Verbrauch je Kopf der Bevölkerung als auch der absolute Zuckerverbrauch eine leicht steigende Tendenz. Neben Deutschland und Frankreich erreichen auch Großbritannien und Italien einen Anteil am EU-Zuckerkonsum von mehr als 10%. In beiden Länder lag der Pro-Kopf-Verbrauch mit zuletzt 31,1 kg Ww bzw. 30,2 kg Ww im ZWJ 2015/16 jedoch deutlich unterhalb des durchschnittlichen EU-Verbrauchs. Während der italienische Zuckerverbrauch in den ZWJ 2010/11 und 2011/12 gestiegen ist und seither stagniert, hat sich der Zuckerverbrauch der Briten in den vergangenen Jahren rückläufig entwickelt.

3.6 Handel

Während Zucker auf dem EU-Binnenmarkt frei gehandelt werden kann, unterliegen sowohl die EU-Exporte in Drittstaaten als auch die EU-Importe aus Nicht-EU-Ländern handelspolitischen Restriktionen. Durch eine Handelsbeschränkung der Welthandelsorganisation (WTO) werden die EU-Weißzuckerexporte auf jährlich 1,4 Mio. t Ww begrenzt. Gleichzeitig sind die regulären MFN-Zollsätze[3] für Zuckerimporte aus Nicht-EU-Ländern so hoch, dass Zucker nahezu ausschließlich im Rahmen von Präferenzregelungen in die EU importiert wird (vgl. Kapitel 3.1).

Jährlich werden auf dem EU-Binnenmarkt rund 5 bis 6 Mio. t Ww Zucker gehandelt (Intra-Handel). Darüber hinaus wurde die WTO-Exportbeschränkung in den vergangenen Jahren immer vollständig ausgenutzt und auch im ZWJ 2015/16 erreichten die EU-Exporte in Drittstaaten mit 1,4 Mio. t Ww das WTO-Exportlimit (vgl. Tabelle 12, Extra-Handel). Die Gesamtexporte aller EU-Mitgliedstaaten liegen damit auf einem Niveau von rund 7 Mio. t Ww, wobei etwa 20% der Zuckerausfuhren in Nicht-EU-Länder und 80% der Zuckerexporte in andere EU-Länder abgesetzt werden. Die größten Exportländer der EU sind Frankreich und Deutschland, gefolgt von Belgien, der

[3] MFN: Most Favoured Nations. Zollsatz bei Handel außerhalb von Präferenzreglungen zu WTO-Bedingungen.

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Tabelle 12. Top-10 Export- und Netto-Exportländer von Zucker in der Europäischen Union

Rang	Exporte (1000 t Ww) Okt.-Sept. 2015/16					Netto-Exporte (1000 t Ww) Okt.-Sept. 2015/16			
	Land	Gesamt	Anteil	Intra-EU	Extra-EU	Land	Gesamt	Ø 3 Jahre[1)]	Δ 2015/16 vs. Ø 3 Jahre[1)]
1	FR	2 139	30,4 %	1 845	294	FR	1 806	1 611	12,1 %
2	DE	1 026	14,6 %	878	148	DE	284	330	-13,8 %
3	BE	603	8,6 %	426	176	PL	270	302	-10,8 %
4	NL	475	6,8 %	391	85	CZ	191	210	-9,2 %
5	PL	472	6,7 %	273	199	DK	156	180	-13,4 %
6	CZ	307	4,4 %	155	151	NL	121	97	24,2 %
7	UK	294	4,2 %	248	46	HR	62	22	178,2 %
8	HR	285	4,1 %	248	37	LT	49	68	-27,1 %
9	DK	232	3,3 %	134	98	AT	32	67	-51,7 %
10	ES	221	3,1 %	205	15	SK	21	82	-74,5 %
(…)	Andere	989	14,0 %	829	160	Andere	-4 670	-5 036	-7,3 %
	EU-28	**7 043**	**100,0 %**	**5 633**	**1 410**	**EU-28**	**-1 678**	**-2 066**	**-18,8 %**

Anm.: Ww: Weißzuckerwert; 1) Ø 3 Jahre: 2012/13-2014/15
Quelle: eigene Berechnung, basierend auf EUROSTAT (2016)

Niederlande und Polen. Dabei vereinen allein Frankreich und Deutschland knapp die Hälfte der EU-Exporte auf sich. Wie auch die Niederlande setzen die beiden Länder ihre Zuckerexporte vor allem auf dem EU-Binnenmarkt ab. Dagegen ist der Anteil der Extra-EU-Exporte mit 29 % und 42 % im ZWJ 2015/16 in Belgien und Polen im Vergleich zum EU-Durchschnitt von 20 % vergleichsweise hoch.

Neben der Höhe der EU-Exporte zeigt Tabelle 12 auch die Höhe der EU-Netto-Exporte für das ZWJ 2015/16 und den Durchschnitt der vorangegangenen drei Zuckerwirtschaftsjahre. In der Höhe der Netto-Exporte spiegelt sich die Versorgungslage in den einzelnen EU-Mitgliedstaaten wider. Die größten Überschussregionen und damit Netto-Exporteure der EU sind Frankreich, Deutschland und Polen, das heißt, die drei Länder, die den Schwerpunkt der Zuckererzeugung in der Europäischen Union bilden (vgl. Kapitel 3.4). Großbritannien ist zwar der viertgrößte Zucker erzeugende EU-Mitgliedsstaat, trotzdem übersteigt der Zuckerverbrauch der Briten die inländische Produktion, sodass das Land Netto-Importeur von Zucker ist (vgl. Tabelle 14).

Hauptabsatzmarkt für EU-Zuckerexporte in Drittstaaten sind der Nahe Osten sowie Länder in direkter Nachbarschaft zur EU (vgl. Tabelle 13). Allein nach Israel liefert die EU-Zuckerindustrie jährlich fast 20 % ihrer Drittlandexporte. Aber auch Algerien ist mit einem Exportanteil von nahezu 10 % im ZWJ 2015/16 weiterhin ein wichtiger Absatzmarkt für EU-Zuckerexporte gewesen, auch wenn sich die Ausfuhren in das nordafrikanische Land in den vergangenen vier Jahren rückläufig entwickelt haben. Aufgrund ihrer unmittelbaren Grenzlage gehören außerdem die Schweiz und Norwegen traditionell zu den Top-Exportzielen der EU-Zuckerwirtschaft. Als Absatzmarkt an Bedeutung gewonnen haben im vergangenen ZWJ 2015/16 vor allem die Türkei und Sri Lanka. Dagegen haben sich die EU-Zuckerexporte nach Ägypten, Syrien und Saudi Arabien stark rückläufig entwickelt. Anders als in den vorangegangenen Jahren gehören diese Länder im ZWJ 2015/16 nicht mehr zu den zehn wichtigsten Exportzielen der EU-Zuckerwirtschaft.

Wie zu Beginn des Kapitels 3 bereits erwähnt, wird Zucker nahezu ausschließlich im Rahmen von Präferenzhandelsregelungen in die Europäische Union importiert. Lediglich biologisch erzeugter Zucker gelangt in geringen Mengen zum regulären MFN-Zollsatz auf den EU-Binnenmarkt (LMC, 2013). Während der aus Drittländern importierte Zucker vor allem Rohzucker ist, wird auf dem EU-Binnenmarkt in erster Linie Weißzucker gehandelt. Im ZWJ 2015/16 betrug das Handelsvolumen auf dem EU-Binnenmarkt 5,5 Mio. t Ww. Zusätzlich wurden aus Nicht-EU-Ländern 3,2 Mio. t Ww Zucker importiert, sodass sich für alle EU-Mitgliedstaaten für das vergangene Zuckerwirtschaftsjahr eine Importmenge von insgesamt

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Tabelle 13. Top-10 Exportziele für EU-Zuckerexporte

Rang	Extra-EU-Exporte (1 000 t Ww) Okt.-Sept. 2015/16				Extra-EU-Exporte (1 000 t Ww) Okt.-Sept. Ø 3 Jahre[1)]			
	Land	2015/16	Anteil	Δ 2015/16 vs. Vorjahr	Land	Ø 3 Jahre	Anteil	Δ 2015/16 vs. Ø 3 Jahre
1	Israel	269	19,1 %	-0,6 %	Israel	252	17,4 %	6,7 %
2	Algerien	125	8,8 %	-23,4 %	Algerien	158	10,8 %	-21,0 %
3	Norwegen	119	8,4 %	-0,9 %	Norwegen	120	8,2 %	-0,5 %
4	Schweiz	100	7,1 %	36,3 %	Schweiz	113	7,8 %	-11,5 %
5	Türkei	83	5,9 %	969,8 %	Ägypten	82	5,6 %	-76,0 %
6	Libanon	57	4,0 %	-7,5 %	Libanon	62	4,3 %	-8,6 %
7	Kuwait	49	3,5 %	-3,7 %	Saudi-Arabien	57	3,9 %	-48,7 %
8	Russland	42	3,0 %	-2,7 %	Kuwait	56	3,8 %	-11,6 %
9	Kasachstan	39	2,8 %	-52,4 %	Kasachstan	53	3,6 %	-26,0 %
10	Sri Lanka	37	2,7 %	216 070,9 %	Syrien	46	3,2 %	-54,0 %
(…)	Andere	488	34,6 %	-16,1 %	Andere	454	31,2 %	7,7 %
	Insgesamt	**1 410**	**100,0 %**	**-3,1 %**	**Insgesamt**	**1 452**	**100,0 %**	**-2,9 %**

Anm.: Ww: Weißzuckerwert; 1) Ø 3 JAHRE: 2012/13-2014/15
Quelle: eigene Berechnung, basierend auf EUROSTAT (2016)

8,7 Mio. t Ww ergibt (vgl. Tabelle 14). Die Höhe der Importe der einzelnen EU-Mitgliedstaaten wird einerseits durch die Höhe der vorhandenen Raffinationskapazitäten (Drittlandsimporte) und andererseits durch die Versorgungslage (Intra-EU-Importe) bestimmt. Größter Importeur und auch Netto-Importeur der EU ist Italien. Das Land vereinte im ZWJ 2015/16 fast 20 % der EU-Gesamtimporte auf sich. Hinter Großbritannien und Portugal hat Italien die dritthöchsten Raffinationskapazitäten der EU und war mit einer Importmenge von 0,4 Ww im vergangenen Zuckerwirtschaftsjahr der zweitgrößte Importeur von Zucker aus Drittstaaten (Extra-EU-Importe) (LMC, 2013; vgl. Tabelle 14). Außerdem ist das Land mit rund 1,5 Mio. t Ww noch vor Spanien und Großbritannien die größte EU-Defizitregion und importierte daher im

Tabelle 14. Top-10 Import- und Netto-Importländer von Zucker in der Europäischen Union

Rang	Importe (1 000 t Ww) Okt.-Sept. 2015/16					Netto-Importe (1 000 t Ww) Okt.-Sept. 2015/16			
	Land	Gesamt	Anteil	Intra-EU	Extra-EU	Land	Gesamt	Ø 3 Jahre[1)]	Δ 2015/16 vs. Ø 3 Jahre[1)]
1	IT	1 543	17,7 %	1 148	395	IT	1 458	1 476	-1,2 %
2	UK	1 003	11,5 %	449	554	ES	770	1 028	-25,1 %
3	ES	991	11,4 %	742	249	UK	709	847	-16,3 %
4	DE	742	8,5 %	675	66	RO	371	316	17,6 %
5	BE	596	6,8 %	510	86	GR	302	269	12,4 %
6	RO	460	5,3 %	73	387	PT	252	216	16,7 %
7	PT	443	5,1 %	104	340	BG	243	185	30,9 %
8	NL	355	4,1 %	120	234	HU	186	124	50,6 %
9	FR	334	3,8 %	267	67	IR	147	124	18,3 %
10	GR	326	3,7 %	247	78	FI	102	116	-12,3 %
(…)	Andere	1 929	22,1 %	1 179	750	Andere	-2 863	-2 636	8,6 %
	EU-28	**8 721**	**100,0 %**	**5 513**	**3 207**	**EU-28**	**1 678**	**2 066**	**-18,8 %**

Anm.: Ww: Weißzuckerwert; 1) Ø 3 JAHRE: 2012/13-2014/15
Quelle: eigene Berechnung, basierend auf EUROSTAT (2016)

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ZWJ 2015/16 zusätzlich 1,1 Mio. t Ww Zucker aus anderen EU-Mitgliedstaaten (Intra-EU-Importe) (F.O. LICHT, 2016a, vgl. Tabelle 14).

Die wichtigsten EU-Zuckerlieferanten in die Defizitregionen der Europäischen Union waren im Durchschnitt der vergangenen vier Jahren Frankreich, Belgien, Polen und Deutschland (EUROSTAT, 2016). Die EU-Zuckerimporte aus Drittstaaten stammen vor allem aus Brasilien und Mauritius. Unter der CXL-Quote (vgl. Tabelle 6) lieferte Brasilien im ZWJ 2015/16 und im Durchschnitt der vorangegangenen drei Zuckerwirtschaftsjahre jährlich knapp 0,6 Mio. t Ww Zucker zu einem reduzierten Zollsatz von 98 €/t Rohzucker auf den EU-Binnenmarkt. Damit hatte das Land in den vergangenen Jahren einen Anteil an den EU-Zuckerimporten aus Drittstaaten von knapp 20 % (vgl. Tabelle 15). Aus Mauritius importierten die EU-Mitgliedstaaten in den vergangenen Jahren jährlich insgesamt rund 0,4 Mio. t Ww Zucker, was einem Anteil an den Extra-EU-Zuckereinfuhren von 11 % bis 12 % entspricht. Im Zuge der Zuckermarktreform 2006 hat die Südzucker AG mit dem Land, das zur Gruppe der AKP-Staaten gehört, einen strategischen Partnerschaftsvertrag über die Lieferung von jährlich 0,4 Mio. t Zucker geschlossen, der nun mit Blick auf den bevorstehenden EU-Quotenausstiegs im September 2015 jedoch ausgelaufen ist (SÜDZUCKER AG, 2017). Stattdessen hat Mauritius einen Vertrag mit dem französischen und britischen Unternehmen CristalCo und British Sugar über die Lieferung von insgesamt jährlich 0,2 Mio. t Zucker geschlossen. Die im Vergleich zu dem Vertrag mit der Südzucker AG geringere Liefermenge gibt dem Land die Möglichkeit, Zucker nach dem Ende des EU-Quotensystems und voraussichtlich fallenden EU-Marktpreisen auch in anderen Regionen zu vermarkten (F.O. LICHT, 2016e). Während der Marktanteil Mauritius an den EU-Importen in den letzten Jahren aufgrund der strategischen Partnerschaft mit der Südzucker AG stabil gewesen ist, haben im ZWJ 2015/16 vor allem Kuba, Fidschi und Belize als Herkunftsländer für EU-Importe aus Drittstaaten an Bedeutung gewonnen (vgl. Tabelle 15). Rückläufig waren dagegen die EU-Importe aus Swasiland, das im Durchschnitt der drei vorangegangenen Jahre noch der drittgrößte Lieferant von Zucker in die Europäische Union gewesen ist, im ZWJ 2015/16 jedoch lediglich auf Platz 10 rangiert. Nach Angaben des nationalen Zuckerverbandes bereiten sich die Zuckerproduzenten des Landes bereits auf den EU-Quotenausstieg vor indem sie ihre Exportstrategie stärker auf regionale Märkte ausrichten (F.O. LICHT, 2016e). Auch die EU-Importe aus Mosambik und Guyana sind im vergangenen Zuckerwirtschaftsjahr gegenüber dem Vorjahr deutlich gesunken, was zumindest im Fall von Mosambik auf eine geringe Ernte infolge einer Dürre im Jahr 2015 zurückzuführen ist (F.O. LICHT, 2016e). Anders als Simbabwe und der Sudan schaffen diese beiden Länder es aber auch im ZWJ 2015/16 noch in die Liste der Top-10-Herkunftsländer für EU-Importe aus Drittstaaten. Während in Simbabwe starke Regenfälle zu Ernteausfällen geführt haben, ist der Rück-

Tabelle 15. Top-10 Herkunftsländer von EU-Zuckerimporten aus Drittländern

Rang	Extra-EU-Importe (1 000 t Ww) Okt.-Sept. 2015/16				Extra-EU-Importe (1 000 t Ww) Okt.-Sept. Ø 3 Jahre[1)]			
	Land	2015/16	Anteil	Δ 2015/16 vs. Vorjahr	Land	Ø 3 Jahre	Anteil	Δ 2015/16 vs. Ø 3 Jahre
1	Brasilien	604	18,8 %	166,7 %	Brasilien	614	17,7 %	-1,7 %
2	Mauritius	373	11,6 %	-4,9 %	Mauritius	390	11,2 %	-4,3 %
3	Kuba	346	10,8 %	55,5 %	Swasiland	279	8,0 %	-57,0 %
4	Fidschi	200	6,2 %	32,2 %	Kuba	249	7,2 %	39,1 %
5	Serbien	169	5,3 %	2,3 %	Mosambik	219	6,3 %	-30,3 %
6	Mosambik	153	4,8 %	-40,0 %	Simbabwe	179	5,2 %	-35,1 %
7	Sudan	143	4,5 %	-23,0 %	Serbien	173	5,0 %	-2,2 %
8	Guayana	125	3,9 %	-17,3 %	Fidschi	143	4,1 %	39,5 %
9	Belize	123	3,8 %	54,0 %	Guayana	143	4,1 %	-12,4 %
10	Swasiland	120	3,7 %	-58,4 %	Sudan	140	4,0 %	2,1 %
(…)	Andere	852	26,6 %	-0,4 %	Andere	948	27,3 %	-10,1 %
	Insgesamt	**3 207**	**100,0 %**	**7,9 %**	**Insgesamt**	**3 477**	**100,0 %**	**-7,8 %**

Anm.: Ww: Weißzuckerwert; 1) Ø 3 Jahre: 2012/13-2014/15
Quelle: eigene Berechnung, basierend auf EUROSTAT (2016)

gang der EU-Importe aus dem Sudan vor allem darauf zurückzuführen, dass der Weltmarktpreis im Verlauf des vergangenen Zuckerwirtschaftsjahres deutlich gestiegen ist. Dies verteuert für den Sudan einerseits Importe vom Weltmarkt zur Deckung des inländischen Verbrauchs (F.O. LICHT, 2016e). Steigt der EU-Zuckerpreis weniger stark als der Weltmarktpreis, verringert sich außerdem die Attraktivität des EU-Binnenmarktes gegenüber anderen Absatzmärkten.

3.7 EU-Zuckermarkt nach dem Ende der Quoten

Mit dem Ausstieg aus der EU-Zucker- und Isoglukosequote ändern sich die wirtschaftlichen und politischen Rahmenbedingungen für die EU-Zuckerindustrie ab dem ZWJ 2017/18 grundlegend. Der gesamte in der Europäischen Union produzierte Zucker kann dann auf dem EU-Lebensmittelmarkt abgesetzt werden und die Preisdifferenzierung zwischen Quoten- und Nichtquotenzucker entfällt. Gleichzeitig schützt die Isoglukosequote den EU-Zuckersektor nicht mehr vor der Konkurrenz mit engen Zuckersubstituten. In der Folge wird der Wettbewerbsdruck auf dem EU-Binnenmarkt zwischen inländischen Zuckerproduzenten, aber auch zwischen der EU-Zucker- und Isoglukoseindustrie deutlich ansteigen, denn nach dem Ende des EU-Quotensystems wird die Nachfrage nach Süßungsmitteln durch diejenigen Anbieter von Zucker und Isoglukose gedeckt werden, die ihre Produkte zu den geringsten Kosten anbieten können (HAß und BANSE, 2016).

Im laufenden ZWJ 2016/17 werden Zucker und Isoglukose letztmalig unter der EU-Quotenregelung vermarktet. Zucker, der aus den im Jahr 2017 geernteten Rüben gewonnen wird, kann dann ab dem 1. Oktober 2017 ohne Mengenbegrenzung auf dem EU-Binnenmarkt abgesetzt werden. Die Planung der Rübenmengen für das Anbaujahr 2017 und die Preisverhandlungen zwischen den Zuckerunternehmen über die im kommenden Zuckerwirtschaftsjahr gezahlten Rübenpreise sind daher zum jetzigen Zeitpunkt bereits abgeschlossen. Im Zuge des EU-Quotenausstiegs haben die EU-Zuckerunternehmen angekündigt, ihre Produktion um 20 % bis 40 % zu steigern. Gleichzeitig werden die gezahlten Rübenpreise deutlich sinken (F.O. LICHT, 2016b). Ziel der Unternehmen ist es, in den ersten Jahren nach dem Wegfall des EU-Quotensystems Marktanteile hinzuzugewinnen und wettbewerbsschwache Konkurrenten vom Markt zu verdrängen. Dahinter steht die Strategie, nach dem Ende der Marktbereinigung und Marktkonzentration auf die wettbewerbsfähigsten Produzenten langfristig wieder höhere Preise am Markt durchsetzen zu können (TOP AGRAR, 2016). Um in dem sich verschärfenden Wettbewerb bestehen zu können und möglichst günstig zu produzieren, planen die Zuckerunternehmen die Auslastung der bestehenden Verarbeitungskapazitäten durch eine Ausdehnung der Rübenkampagne auf 120-130 Tage zu erhöhen (TOP AGRAR, 2016). Durch Investitionen in zusätzliche Lagerkapazitäten bereitet sich die Branche außerdem auf eine Verlängerung der Dicksaftkampagne vor und möchte darüber hinaus durch eine gleichmäßigere Marktversorgung einen zu starken Preisverfall durch das zusätzlichen Zuckerangebot vermeiden (F.O. LICHT, 2016b). Die zukünftig gezahlten Rübenpreise orientieren sich nach der Aufhebung des Zuckerrübenmindestpreises an den Deckungsbeiträgen für alternative Konkurrenzkulturen zur Zuckerrübe. Denn die Zuckerunternehmen stehen unter den neuen Rahmenbedingungen vor der Herausforderung, einerseits die Rohstoffversorgung für die Zuckerproduktion sicher zu stellen und andererseits möglichst kostengünstig zu produzieren, um im Wettbewerb bestehen zu können (LMC, 2013; TOP AGRAR, 2016). Zuckerfabriken in Regionen mit schwachen Konkurrenzkulturen zur Zuckerrübe haben daher Wettbewerbsvorteile. Außerdem erhöht eine hohe Eigenkapitalquote und eine diversifizierte Konzernstruktur, in der geringe Zuckererlöse durch hohe Umsätze in anderen Segmenten ausgeglichen werden können, die Chancen, die Konsolidierungsphase nach dem Ende des EU-Quotensystems zu überstehen (TOP AGRAR, 2016).

Für das kommende Anbaujahr 2017 haben die Rübenanbauverbände die neuen Lieferbedingungen der Zuckerunternehmen weitgehend akzeptiert. Trotz deutlich geringer Rübenpreise sind die EU-Rübenbauern bereit, im laufenden Zuckerwirtschaftsjahr eine deutlich höhere Menge an Zuckerrüben anzubauen. Ein Grund hierfür dürfte die seit Jahrzehnten enge, durch Vertrauen geprägte Beziehung zwischen den Rübenbauern und Zuckerunternehmen sein. In vielen EU-Ländern besitzen die Rübenanbauer Firmenanteile an den Zuckerunternehmen, die mit Lieferrechten verbunden sind. Zudem bleibt die Zuckerrübe unter den ausgehandelten Vertragsbedingungen weiterhin konkurrenzfähig und der kurzfristige Ausstieg aus dem Zuckerrübenanbau würde zu hohen versunkenen Kosten für Spezialmaschinen führen, die ausschließlich im Zuckerrübenanbau eingesetzt werden können. Nicht zuletzt dürfte die positive Weltmarktpreisentwicklung im vergangenen Zuckerwirtschaftsjahr die Zuckerbranche optimistisch in die Zukunft blicken lassen, da der Rübenpreis zukünftig je nach gewähltem Preismodell vom erzielbaren Zuckerpreis abhängt und sich darüber hinaus nach der Aufhebung der WTO-Beschränkung Exportchancen auf dem Weltmarkt ergeben (F.O. LICHT, 2016b; SCHMITZ und TSCHOEP, 2016).

Im Vorfeld des EU-Quotenausstiegs schwer abschätzbar ist der zukünftige Marktanteil von Isoglukose in der EU. Dieser hängt einerseits von der Wettbewerbsposition der Isoglukose- gegenüber der Zuckerindustrie ab, also davon, ob Isoglukose in der EU günstiger produziert und zum Verbrauchsort transportiert werden kann als Zucker. Andererseits entscheidet aber auch das technisch mögliche Substitutionspotenzial und die Bereitschaft der verarbeitenden Industrie, ihre Produktionsprozesse von Zucker auf Isoglukose umzustellen, darüber, welchen Marktanteil Isoglukose auf dem EU-Binnenmarkt nach der Aufhebung des EU-Quotensystems erreichen kann. Anders als Zucker ist Isoglukose in der üblichen Handelsform ein flüssiger Sirup. Der Transport von Isoglukose ist daher im Vergleich zu Zucker mit höheren Kosten verbunden (BAHNDORF und KIENLE, 2004). Zudem ist die Verwendung von Isoglukose nicht in allen Produkten möglich, die gegenwärtig mit Zucker gesüßt werden. In bestimmten Produkten hat die Verwendung von Isoglukose aber auch produktionstechnische Vorteile und führt zu einer Verbesserung der Produkteigenschaften wie beispielsweise der Textur und Stabilität. So kann Isoglukose verhindern, dass Produkte an der Verpackung kleben, die Saftigkeit von Gebäck erhalten und hat eine hohe Stabilität in säurehaltigen Lebensmitteln wie Softdrinks. Hauptabsatzmarkt für Isoglukose ist die Getränkeindustrie. Darüber hinaus kann Isoglukose aber auch in Dosenprodukten und Eingemachtem, wie beispielsweise Obstkonserven und Marmeladen, sowie in Milchprodukten, wie beispielsweise Eiscreme und Joghurts mit Fruchtzubereitung, eingesetzt werden. Auch in Süßwaren, Frühstückscerealien, Würzen und anderen Fertigprodukten ist die Verwendung von Isoglukose möglich (LMC, 2013; STARCH EUROPE, 2016). Letztlich wird auch die zukünftige Entwicklung des Zucker- und Energiepreises sowie der Rohstoffpreise für die Isoglukoseherstellung (Mais, Weizen) über die Höhe des Marktanteils von Isoglukose in der EU entscheiden. Denn je höher der Zuckerpreis ist, desto stärker ist der Anreiz für die verarbeitende Industrie, Zucker durch Isoglukose zu ersetzten. Gleichzeitig wird die Höhe der Produktionskosten von Isoglukose deutlich stärker durch Rohstoff- und Energiepreisänderungen beeinflusst, als die Kosten der Zuckerproduktion, sodass sich bei Weltmarktpreisänderungen die Wettbewerbsverhältnisse zwischen der Zucker- und Isoglukoseindustrie verschieben (HAß und BANSE, 2016). Grundsätzlich ist davon auszugehen, dass die Isoglukoseproduktion nach dem Ende des EU-Quotenausstiegs vor allem in EU-Mitgliedstaaten steigen wird, die gleichzeitig Getreideüberschuss- und Zuckerdefizitregionen sind (z.B. HU, BG, SK). Anders als die Zuckerproduktion erfordert eine deutliche Steigerung der Isoglukoseproduktion jedoch Investitionen in zusätzliche Verarbeitungskapazitäten (TODD, 2015). Im Vorfeld des EU-Quotenausstiegs werden die Isoglukosefabriken gegenwärtig insbesondere in Ungarn ausgebaut (F.O. LICHT, 2016b). Zum jetzigen Zeitpunkt gehen Marktexperten davon aus, dass der Marktanteil von Isoglukose in der Europäischen Union nach dem Ende des EU-Quotensystems auf maximal 10% bis 20% steigen wird (TOP AGRAR, 2016).

Während die Abschätzung der zukünftigen Marktentwicklung des EU-Isoglukosesektors mit hohen Unsicherheiten behaftet ist, sind sich Marktexperten darüber einig, dass der EU-Quotenausstieg für Drittländer, die den EU-Binnenmarkt traditionell mit Zucker beliefern, negative Folgen haben wird (F.O. LICHT, 2016e; HAß, 2016; TOP AGRAR, 2016). Denn einerseits ist davon auszugehen, dass der EU-Marktpreis im Zuge der Aufhebung des EU-Quotensystems fallen wird und damit der Wert der EU-Importe sinkt. Außerdem haben viele Länder mit präferenziellem Marktzugang zum EU-Binnenmarkt hohe Produktionskosten. In dem sich nach dem Ende der Quoten verschärfenden Wettbewerb auf dem EU-Binnenmarkt werden sich diese Länder daher nur schwer behaupten können, das heißt, sie werden durch die Angebotssteigerung der EU-Produzenten aus dem Markt verdrängt (F.O. LICHT, 2016e; HAß, 2016). Da der aus diesen Ländern importierte Zucker überwiegend Rohzucker ist, der in der EU vor dem Verkauf an den Endverbraucher noch raffiniert werden muss, könnte der EU-Quotenausstieg auch den EU-Raffinationssektor, und hier insbesondere Vollzeitraffinerien, in wirtschaftliche Schwierigkeiten bringen (LMC, 2013; NOLTE und GRETHE, 2012).

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Article (2):

2.2 Der Zuckermarkt im Wandel: Was passiert nach dem EU-Quotenende?

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DER ZUCKERMARKT IM WANDEL: WAS PASSIERT NACH DEM EU-QUOTENENDE?

Zusammenfassung

Im Zuge der GAP-Reform 2014 werden die Produktionsquoten für Zucker und Isoglukose zum Ende des Zuckerwirtschaftsjahres 2016/17 auslaufen. Ziel der Studie ist es, die Auswirkungen des EU-Quotenausstiegs auf den Zucker- und Isoglukosemarkt quantitativ abzuschätzen. Dazu werden die Markteffekte einer Aufhebung der Produktionsquoten mithilfe eines räumlichen Preisgleichgewichtsmodells für drei Weltmarktpreisszenarien analysiert. Die Ergebnisse zeigen, dass in einigen EU-Mitgliedstaaten die zukünftige Weltmarktpreisentwicklung darüber entscheidet, ob die Produktion infolge des Quotenausstiegs steigt oder fällt. Bei einer Aufhebung der Quoten wird die EU-Zucker- und Isoglukoseerzeugung überwiegend auf dem EU-Binnenmarkt abgesetzt und führt zu einer Verdrängung von Importen aus Ländern mit präferenziellem Zugang zum EU-Binnenmarkt und zu einem Preisverfall innerhalb der EU-28. Hierdurch sinkt die Zuckerproduktion Drittländern, insbesondere in Afrika. Bei hohen Weltmarktpreisen wechselt die EU-28 ihren Handelsstatus vom Netto-Importeur zum Netto-Exporteur. Der zukünftige Marktanteil von Isoglukose in der EU-28 wird stark durch die Weltmarktpreisverhältnisse beeinflusst. Je niedriger das Weltmarktpreisniveau ist, desto stärker steigen Isoglukoseperzeugung und -verbrauch im Zuge des EU-Quotenausstiegs.

Keywords

Gemeinsame Agrarpolitik, Zuckermarktreform, Quotenausstieg, Isoglukose, Zucker.

1. Einleitung

Innerhalb der Agrar- und Ernährungswirtschaft ist der Zuckersektor einer der am stärksten geschützten Märkte. Doch im Zuge der GAP Reform stehen dem EU-Zuckersektor tiefgreifende Reformschritte bevor. Die Produktionsquoten für Zucker und Isoglukose werden zum Ende des Zuckerwirtschaftsjahres 2016/17 auslaufen. Gleichzeitig fällt damit zum 1. Oktober 2017 auch der innerhalb der Quotenmenge geltende Zuckerrübenmindestpreis. Nach dem Ende der Quotenregelung verbleiben auf dem europäischen Zuckermarkt damit lediglich die Außenhandelsregelungen – Importzölle – als wesentliches Instrument, um die Preise zu stützen. Ziel der Studie ist es, die Auswirkungen des EU-Quotenausstiegs auf den Zucker- und Isoglukosemarkt quantitativ abzuschätzen. Die Ergebnisse der Studie sollen insbesondere Antworten auf die Fragen geben: 1) Wie sich Produktion und Verbrauch, Handelsströme und Preise von Zucker und Isoglukose in der Europäischen Union und in Drittländern infolge einer Aufhebung der Produktionsquoten entwickeln. 2) Wie konkurrenzfähig die Zuckererzeugung gegenüber der Isoglukoseherstellung ist.

2. Theoretische Analyse des Quotenausstiegs auf dem Zuckermarkt

Bevor im nachfolgenden Kapitel eigene Simulationsergebnisse zur Beantwortung der genannten Forschungsfragen vorgestellt werden, analysiert dieses Kapitel die grundsätzlichen Effekte einer Aufhebung der Zucker- und Isoglukosequote. Zudem werden die wesentlichen Ergebnisse anderer quantitativer Analysen zusammengefasst, die den im Rahmen der GAP-Reform 2014 beschlossenen Quotenausstieg auf dem EU-Zuckermarkt untersuchen.

2.1. Wirkungsweise der bisherigen Zuckermarktordnung mit Quoten

Durch die Festlegung von Produktionsquoten für Zucker und Isoglukose beschränkt die bisherige Zuckermarktordnung den Absatz beider Produkte für die Lebensmittelherstellung innerhalb der EU-28 auf 80% des EU-Verbrauchs. Zur Deckung ihres Bedarfs ist die EU-28 daher auf Einfuhren aus Drittstaaten angewiesen. Da der EU-Außenschutz mit einem regulären Zollsatz von 419 €/t Weißzucker (Ww) und 339 €/t Rohzucker (Rw) prohibitiv hoch ist, gelangen Zuckerimporte ausschließlich im Rahmen von Präferenzregelungen in die EU-28. Diese gewährleisten bestimmten Ländern einen nahezu unbegrenzten zollfreien Zugang zum EU-Binnenmarkt oder erlauben den Import von Zucker im Rahmen zollreduzierter oder zollfreier Importquoten. Zucker, der in der EU-28 über die Quote hinaus produziert wird, kann für industrielle Zwecke verwendet oder in Drittstaaten exportiert werden. Jedoch gilt für EU-Zuckerexporte aufgrund der EU-Quotenregelung eine durch die WTO festgelegte Obergrenze von jährlich 1,4 Mio. t. Da die Produktion von Isoglukose und Inulin ebenfalls einer Quote unterliegt, ist der EU-Zuckersektor weitgehend vor der Konkurrenz mit Substituten geschützt.

Durch die Beschränkung der Absatzmenge innerhalb der EU-28 gewährleisten die Produktionsquoten einerseits ein hohes inländisches Preisniveau, das mithilfe von Einfuhrzöllen gegenüber dem i.d.R. deutlich geringeren Weltmarktpreis abgesichert wird. Andererseits führen die Quoten aber auch zu hohen Produktionskosten und einer starken Wettbewerbsverzerrung innerhalb der EU-28. Denn die Kontingentierung der Absatzmenge je Unternehmen hindert wettbewerbsstarke Erzeuger mit geringen Produktionskosten daran, ihre Produktion auszuweiten und wettbewerbsschwache Erzeuger vom Markt zu verdrängen. Die Quote führt damit zu einer aus marktwirtschaftlicher Sicht ineffizienten Produktionsstruktur, bei der die Grenzkosten der Erzeuger unterschiedlich hoch sind (BUREAU 1997; RÉQUILLART et al. 2008).

2.2. Markteffekte einer Aufhebung der Zucker- und Isoglukosequoten

Mit der Aufhebung der Produktionsquoten fällt auch die WTO-Exportbeschränkung und EU-Produzenten können Zucker und Isoglukose unbegrenzt auf dem auf dem Weltmarkt und EU-Binnenmarkt absetzen. Nach dem EU-Quotenausstieg wird der EU-Bedarf an Süßungsmitteln daher durch diejenigen Anbieter von Zucker und Isoglukose gedeckt werden, die ihre Produkte zu dem geringsten Preis anbieten können. Hierdurch steigt der Wettbewerbsdruck auf dem EU-Binnenmarkt, indem sich auch Drittanbieter mit präferenziellem Marktzugang behaupten müssen.

Neben der Höhe der Produktionskosten kann auch die Entfernung zu den Hauptabsatzmärkten und die damit verbundenen Transportkostenunterschiede zwischen den Ländern ein entscheidender Wettbewerbsvorteil bzw. –nachteil sein (CUNI 2014). Denn der von den Produzenten erzielte Preis muss nicht nur die Produktionskosten, sondern auch die Transportkosten zum Absatzmarkt decken. Damit haben Produzenten in Überschussregionen, die zusätzlich produzierte Mengen exportieren müssen, einen Transportkostennachteil gegenüber Produzenten in Defizitregionen.

Vor diesem Hintergrund lassen sich die wahrscheinlichen Markteffekte des EU-Quotenausstiegs wie folgt zusammenfassen:

- Wettbewerbsstarke EU-Produzenten mit geringen Produktionskosten und niedrigen Transportkosten zu den Hauptabsatzmärkten werden ihre Produktion ausweiten.
- Durch die steigende Angebotsmenge der wettbewerbsfähigen Produzenten wird der Marktpreis von Zucker und Isoglukose in der EU-28 fallen.
- Wettbewerbsschwache EU-Produzenten mit hohen Produktions- und Transportkosten sind bei einem deutlich geringeren Preisniveau innerhalb der EU-28 nicht mehr konkurrenzfähig und werden ihre Produktion reduzieren.
- Die EU-Zuckerimporte werden sinken, da vor allem Entwicklungsländer mit hohen Produktionskosten einen zollfreien Zugang zum EU-Binnenmarkt haben. Gleichzeitig haben EU-Produzenten gegenüber Drittländern einen Transportkostenvorteil.

- Durch das geringere Preisniveau wird der Gesamtverbrauch von Zucker und Isoglukose leicht steigen.
- Produzenten in Defizitregionen haben einen Transportkostenvorteil und steigern die Produktion eher als Produzenten in Überschussregionen mit ähnlich hohen Produktionskosten.

2.3. Stand der Literatur

Die Folgen des EU-Quotenausstiegs wurden bereits in anderen Studien quantitativ mithilfe unterschiedlicher ökonomischer Modelle untersucht (EU-COM 2011; SMIT et al. 2012; NOLTE et al. 2012, LMC 2013, BURRELL et al. 2014, OECD/FAO 2014a). Die Ergebnisse sind aufgrund der unterschiedlichen Modellansätze und -spezifizierungen sowie Annahmen hinsichtlich der zukünftigen Entwicklung der wirtschaftlichen und politischen Rahmenbedingungen nur begrenzt vergleichbar. Dennoch lassen sich einige grundlegende Entwicklungen erkennten. Alle Modellsimulationen zeigen einen Anstieg der EU-Zuckerproduktion und eine Verringerung des EU-Zuckerpreises infolge des EU-Quotenausstiegs. Die Produktion wird überwiegend auf dem EU-Binnenmarkt abgesetzt und der Handelssaldo der Europäischen Union steigt deutlich an. Die Europäische Union bleibt jedoch auch nach dem Quotenausstieg Netto-Importeur von Zucker. Auf Ebene der EU-Mitgliedstaaten zeigen die Ergebnisse, dass der Erhalt der Zuckerproduktion vor allem in den südlichen EU-Mitgliedstaaten (GR, IT, ES, PT) sowie Finnland gefährdet ist.

Nur das in den Studien der EU-Kommission und der OECD/FAO verwendete Modell AGLINK-COSIMO und der Modellansatz von LMC bilden auch den Isoglukosesektor der EU-28 ab, jedoch nicht auf Ebene der EU-Mitgliedstaaten. In den unterschiedlichen Studien steigt die Isoglukoseerzeugung infolge des Quotenausstiegs um 2,3% bis 234% (EU-COM 2011; OECD/FAO 2014a). Die Effekte einer Aufhebung der Produktionsquoten auf den EU-Isoglukosesektor unterscheiden sich zwischen den Studien damit erheblich.

3. Quantitative Analyse des Quotenausstiegs auf dem EU-Zuckermarkt

Nachfolgend werden die Methodik und Ergebnisse einer eigenen quantitativen Analyse vorgestellt, die auf den Modellansätzen bisher veröffentlichter Studien aufbaut.

3.1. Methodik

Für die quantitative Analyse des Quotenausstiegs auf dem EU-Zuckermarkt werden Modellansätze von LMC (2013) und NOLTE et al. (2012) genutzt. Beide Modelle werden daher nachfolgend kurz beschrieben. Eine detaillierte Modellbeschreibung ist in LMC (2013) bzw. NOLTE (2008) zu finden.

Im Modell von LMC werden für Länder und Regionen der Europäischen Union Preise für Zucker, Isoglukose und Zuckerimporte berechnet, die mindestens erzielt werden müssen, um eine bestimmte (maximale) Menge des jeweiligen Produktes auf dem EU-Binnenmarkt anzubieten. Diese Preis-Mengen-Kombinationen werden horizontal zu einer EU-Angebotsfunktion aggregiert. An dieser lässt sich ablesen, zu welchem Marktpreis die EU-Nachfrage gedeckt werden kann und welche Produktionsländer bzw. -regionen diese Menge bereitstellen. Für EU-Zuckerimporte berechnet sich der Importpreis als Summe der Opportunitäts-, Transport- und Raffinationskosten sowie Zöllen. Die Angebotspreise für EU-Zucker und EU-Isoglukose sind die Summe aus Rohstoff-, Verarbeitungs- und Transportkosten abzüglich Nebenprodukterlösen. Um eine Vergleichbarkeit der Preise für beide Produkte zu gewährleisten, erfolgt die Berechnung der Preise für Isoglukose auf Trockensubstanzbasis[1]. Für die Rübenkosten

[1] Bei gleichem Trockensubstanzgehalt ist die Süßkraft von Isoglukose mit einem Fruktosegehalt von 55 % mit Weißzucker (Saccharose) vergleichbar (HANOVER u.WHITE 1993).

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wird derjenige Preis kalkuliert, der von der Zuckerindustrie mindestens gezahlt werden muss, um die Rübe in der Fruchtfolge zu halten. Der gezahlte Rübenpreis gewährleistet demnach, dass mit dem Anbau von Zuckerrüben ein gleich hoher Deckungsbeitrag erzielt wird, wie mit dem Anbau der jeweils wettbewerbsfähigsten Konkurrenzkultur (Weizen, Mais, Raps).

Das in NOLTE et al. (2012) verwendet Modell ist ein räumliches Preisgleichgewichtsmodell für den globalen Zuckersektor, das im Jahr 2008 erstmals publiziert worden ist (NOLTE 2008). Es bildet die Zuckerproduktion und den –verbrauch sowie bilaterale Handelsströme und –preise ab und umfasst einschließlich der EU-Mitgliedstaaten rund 120 Länder. Alle Mengen werden in Euro je Tonne Weißzuckerwert (Ww) gehandelt. Handel zwischen Ländern findet statt, wenn der Marktpreis in einem Importland den Angebotspreis im Exportland zuzüglich Transport- und Transaktionskosten sowie Zöllen deckt. Nationale Zuckermarktpolitiken (Mindestpreise, Produktionsquoten, Subventionen, Zölle) sowie präferenzielle Handelsabkommen (zollfreier Marktzugang bzw. zollreduzierte oder zollfreie Importquoten) sind im Modell detailliert berücksichtigt. Das Modell ist in GAMS (General Algebraic Modeling System) als MCP (Mixed Complementarity Problem) programmiert und wird mit dem PATH Solver gelöst.

Die Stärke des Modells von LMC liegt in der genauen Schätzung der Produktionskosten von Zucker und Isoglukose in Abhängigkeit von der Weltmarktpreisentwicklung für die Konkurrenzkulturen der Zuckerrübe (Weizen, Mais, Raps) bzw. den Rohstoffpreisen für die Isoglukoseerzeugung (Mais, Weizen) sowie der Entwicklung des Erdölpreises. Im Gegensatz zu dem in NOLTE et al. (2012) verwendeten räumlichen Preisgleichgewichtsmodell basiert das Modell von LMC jedoch auf einem kalkulatorischen Ansatz und keinem Optimierungsansatz. In der Berechnung des Marktgleichgewichtes für die EU-28 sind alle Preise und Mengen exogen vorgegeben. Damit kann das Modell von LMC weder preisabhängige Änderungen der Produktions- und Verbrauchsmengen noch preisabhängige Änderungen der globalen Handelsströme abbilden.

Um die Stärken beider Ansätze zu nutzen, werden in der vorliegenden Studie beide beschriebenen Modelle miteinander verknüpft. Dazu wird das räumliche Preisgleichgewichtsmodell um den Isoglukosesektor der Europäischen Union erweitert und die EU-Angebotsfunktionen von Zucker und Isoglukose auf die mithilfe des Modells von LMC geschätzten Produktionskosten kalibriert. Abweichend von den in andren Versionen des Modells verwendeten Angebotsfunktionen werden für die EU-Mitgliedstaaten folgende Funktionsformen unterstellt:

Zucker: $$QA_j = Max\left\{0, \alpha_j * \left(PA_j + S_j - KV_j\right)^{\varepsilon_j} - QE_j\right\} \quad (1)$$

Isoglukose: $$QA_j = \alpha_j * \left(PA_j - KV_j\right)^{\varepsilon_j} \quad (2)$$

wobei QA die Angebotsmenge, PA den Angebotspreis, S die Höhe der gegebenenfalls gezahlten Subventionen und KV die Verarbeitungskosten von Zucker bzw. Isoglukose im jeweiligen Land j darstellen. Diese Funktionsform gewährleistet, dass in einem Land nur dann Zucker oder Isoglukose produziert wird, wenn der erzielte Preis (Marktpreis im Zielland zuzüglich Subventionen, abzüglich Transportkosten und Zoll) die Verarbeitungskosten übersteigt. Der Parameter ε bestimmt die Steigung der Funktion und liegt je nach EU-Mitgliedsland zwischen 0,7 und 1,9. Dabei werden für die EU-Zuckerrübenangebotsfunktionen die Angebotselastizitäten aus GRETHE et al. (2012) übernommen und für die EU-Isoglukoseangebotsfunktionen entsprechend der Annahme in TANYERI-ABUR et al. (1993) ein Wert von 1 unterstellt. QE ist ein fixer Wert und entspricht der für die Ethanolherstellung erforderlichen Rübenmenge. Mithilfe des Parameters α werden die Angebotsfunktionen auf das Produktionsniveau eines bestimmten Jahres kalibriert. Ebenso wie die Zuckerproduktion wird auch die Isoglukoseerzeugung in Weißzuckerwert (Trockensubstanzbasis) abgebildet, sodass Zucker- und Isoglukose perfekte Substitute sind und die Gesamtnachfrage nach Süßungsmitteln durch beide Produkte gedeckt werden kann. Eine zusätzliche Restriktion im Modell gewährleistet, dass der aus technischer Sicht maximal mögliche Marktanteil von Isoglukose nicht überschritten wird.

Mit Ausnahme der EU-Angebotspreise im Ausstiegsszenario stammen die Preise für alle anderen Modellfunktionen wie in NOLTE (2008) auch aus einem endogenen Kalibrierungslauf mit fixen Angebots- und Nachfragemengen und dem in Tabelle 1 dargestellten Zuckerweltmarktpreis als Referenzpreisniveau.

Für die im Rahmen dieser Studie durchgeführten Simulationen wurde die Datenbasis des räumlichen Preisgleichgewichtsmodells aktualisiert und erweitert. Basisjahr der Simulation ist der Dreijahresdurchschnitt der Zuckerwirtschaftsjahre 2009/10 bis 2011/12. Die Projektion erfolgt bis zum Zieljahr 2020/21. Datengrundlage der Basisjahre sind die Marktbilanzen von F.O. LICHT (2014), LMC (2013) und dem USDA (2015). Auch für die Projektion bis zum Zieljahr nutzt das Modell externe Daten (OECD/FAO 2014b; OECD/FAO 2015; EU-COM 2015), die durch Trendanalysen ergänzt werden. Die Erweiterung der Datenbasis umfasst insbesondere eine Schätzung der Transportkosten[2] von Zucker und Isoglukose innerhalb der EU-28 und die Abbildung der Nachfrage auf Ebene der EU-Mitgliedstaaten. Diese Änderungen ermöglichen es den Intra-EU-Handel von Zucker und Isoglukose im Modell abzubilden und vollständige Marktbilanzen einschließlich Marktpreisen für die EU-Mitgliedstaaten zu berechnen.

3.2. Szenarien

Die Folgen des EU-Quotenausstiegs werden für drei Weltmarktpreisszenarien berechenet, die eine unterschiedliche Entwicklung der Weltmarktpeise bis zum Zieljahr annehmen. Das Referenzpreisszenario bildet eine Entwicklung aller im Modell berücksichtigten Weltmarktpreise entsprechend den Projektionen der OECD-FAO (2015) und EU-Kommission (2015) ab. Im Hochpreisszenario werden alle Weltmarktpreise um 60% gegenüber diesen Projektionen erhöht und im Niedrigpreisszenario um 30% verringert (vgl. Tabelle 1).

Für jedes Weltmarktpreisszenario wird ein Quoten- und ein Ausstiegsszenario simuliert und die Ergebnisse miteinander verglichen.

Tabelle 1: Weltmarktpreisannahmen für das Jahr 2020/21

Produkt	Einheit	**Referenz WMP** Alle Preise: OECD-FAO/EU-KOM	**Hohe WMP** Alle Preise: +60%	**Niedrige WMP** Alle Preise: -30%
Rohöl[1)]	USD/Barrel	77	124	54
Weizen[2)]	€/t	200	312	140
Mais[2)]	€/t	146	233	102
Raps[2)]	€/t	337	540	236
Rohzucker[2)]	€/t Ww	303	485	212
Prämie[2)]	€/t Ww	59	59	59
Weißzucker[2)]	€/t Ww	362	544	271

1) EU-COM (2015).

2) OECD/FAO (2015): Umgerechnet mit einem Wechselkurs von 1,29 USD/EUR (OECD/FAO (2014b)) und 1 t Rw = 0,92 t Ww. Ww: Weißzuckerwert, Rw: Rohzuckerwert.

Anm.: Weißzuckerpreis im Ausstiegsszenario endogen. Alle anderen WMP im Quoten- und Ausstiegsszenario exogen.

Quelle: Eigene Darstellung.

[2] Einfache lineare Regression mit der Entfernung zwischen den Ländern als unabhängige Variable (n=14, R^2=0,61). Für Isoglukose wird mit einem Transportkostenaufschlag von 10 % gerechnet.

Das Quotenszenario basiert auf der Annahme einer Fortsetzung der bisherigen Politik bis zum Zieljahr 2020/21, d. h. es bildet die zukünftige Entwicklung des globalen Zuckermarktes unter Beibehaltung des EU-Quotensystems ab und dient als Vergleichszenario für die Analyse des Ausstiegsszenarios. Die EU-Produktionsquoten und –abgaben sowie die Höhe der im Rahmen der GAP 2006-2013 gezahlten gekoppelten Direktzahlungen für den Anbau von Zuckerrüben bleiben bestehen und die WTO-Obergrenze für Zuckerexporte in Höhe von 1,4 Mio. t wird beibehalten.

Im Ausstiegsszenario werden die EU-Produktionsquoten und -abgaben für Zucker und Isoglukose sowie die WTO-Beschränkung für EU-Zuckerexporte zum Zuckerwirtschaftsjahr 2017/18 aufgehoben und die Höhe der gekoppelten Direktzahlungen für Zuckerrüben angepasst. Nach dem Wegfall der Zuckerquote beschränkt lediglich die maximale Verarbeitungskapazität der bestehenden Fabriken die Höhe der Zuckerproduktion in den EU-Mitgliedstaaten. Gleichzeitig wird angenommen, dass die Produktionskapazitäten von Isoglukose ausgebaut werden. Dabei wird in Zuckerdefizit- und Getreideüberschussregionen (BG, SK, HU) ab dem Jahr 2017/18 eine jährliche Wachstumsrate von 30%, in allen anderen isoglukoseproduzierenden EU-Ländern (PL, DE, BE, IT, PT, ES) eine jährliche Wachstumsrate von 15% unterstellt.

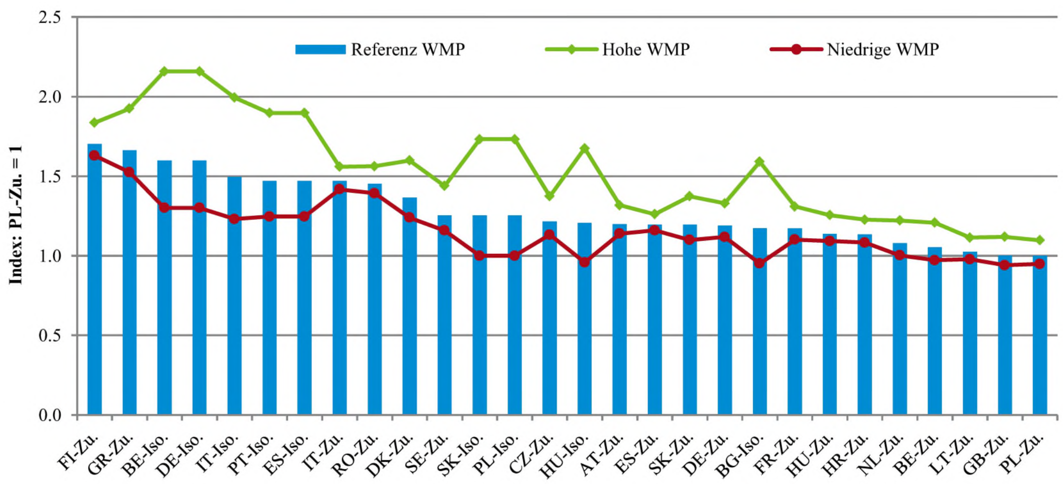
4. Ergebnisse

Nachfolgend werden zunächst kurz die Ergebnisse der mithilfe des Modells von LMC durchgeführten Berechnung der Produktionskotsen vorgestellt. Es folgt die Darstellung der mithilfe des räumlichen Preisgleichgewichtsmodells berechneten Simulationsergebnisse.

4.1. Produktionskosten von Zucker und Isoglukose

Abbildung 1 zeigt die Höhe der Produktionskosten in Euro je Tonne Ww für Zucker und Isoglukose in den EU-Mitgliedstaaten als Index. Die Basis des dargestellten Indexes bilden die niedrigsten Produktionskosten im Referenzpreisszenario, d. h. die Kosten der Zuckerproduktion in Polen. Wie das Diagramm zeigt bestehen innerhalb der EU-28 deutliche Produktionskostenunterschiede von bis zu 70%.

Abbildung 1: Produktionskosten von Zucker und Isoglukose in den EU-Mitgliedstaaten



Zu.: Zucker (€/t Ww); Iso.: Isoglukose (€/t Ww).

Quelle: Eigene Berechnung auf Basis von LMC (2013).

Weltmarktpreisänderungen beeinflussen die Höhe der Produktionskosten von Zucker und Isoglukose in gleicher Weise, jedoch sind die Effekte unterschiedlich stark. In beiden Produktionsprozessen bewirken steigende Weltmarktpreise einerseits eine Erhöhung der Rohstoff- und Energiekosten, andererseits steigt aber auch der Wert der Nebenprodukte. Während eine Weltmarktpreissteigerung von 60% - wie im Hochpreisszenario angenommen - in der Zuckerproduktion je nach EU-Land lediglich zu einer Produktionskostensteigerung von 5% bis 17% führt, erhöhen sich die Produktionskosten von Isoglukose in den EU-Ländern zwischen 29% und 39%. Bei einer Reduzierung der Weltmarktpreise um 30% - wie im Niedrigpreisszenario angenommen – verringern sich die Produktionskosten von Isoglukose je nach EU-Mitgliedstaat um 15% bis 21%, die Produktionskosten von Zucker dagegen nur um 3% bis 9%. Weltmarktpreisänderungen beeinflussen die Höhe der Produktionskosten von Isoglukose damit deutlich stärker als die Kosten der Zuckerproduktion, sodass sich bei steigenden oder fallenden Weltmarktpreisen das Wettbewerbsverhältnis zwischen der Zucker- und Isoglukoseindustrie verschiebt. Gleichzeitig ist aber auch die Isoglukose- und Zuckerproduktion in den EU-Mitgliedstaaten unterschiedlich stark von Weltmarktpreisänderungen betroffen, sodass sich bei steigenden oder fallenden Weltmarktpreisen die Wettbewerbsposition einzelner EU-Mitgliedstaaten innerhalb der EU-Zucker- bzw. EU-Isoglukoseindustrie ändert.

4.2. Markteffekte einer Aufhebung der Zucker- und Isoglukosequote

Im Folgenden werden zunächst die Ergebnisse für die EU-28 dargestellt. Es folgt eine Beschreibung der Effekte des EU-Quotenausstiegs auf die Zucker- und Isoglukoseerzeugung in den EU-Mitgliedstaaten und die Zuckerproduktion in Drittstaaten.

4.2.1. EU-28

Tabelle 2 zeigt die Effekte des EU-Quotenausstiegs auf die Marktbilanz der EU-28 im Jahr 2020/21 für die unterschiedlichen Weltmarktpreisszenarien.

Tabelle 2: EU-Marktbilanz im Jahr 2020/21 in den unterschiedlichen Szenarien

	Referenz WMP			Hohe WMP			Niedrige WMP		
Mio. t Ww €/t Ww	Mit Quote	Ohne Quote	Effekt (%)	Mit Quote	Ohne Quote	Effekt (%)	Mit Quote	Ohne Quote	Effekt (%)
Produktion	16,4	17,2	+5	16,4	19,3	+18	16,4	16,2	-1
- Zucker	15,6	15,9	+2	15,7	18,3	+17	15,7	14,3	-9
- Isoglukose	0,7	1,3	+77	0,7	1,0	+43	0,7	2,0	+174
Verbrauch	18,8	18,9	+1	18,6	18,8	+1	18,9	18,9	0
- LM-Zucker	17,2	16,8	-2	17,0	16,9	-1	17,4	16,2	-7
- Industriezucker[1)]	0,8	0,8	–	0,8	0,8	–	0,8	0,8	–
- Isoglukose	0,7	1,3	+77	0,7	1,0	+43	0,7	2,0	+174
Handelssaldo	-2,5	-1,8	-27	-2,2	0,4	-120	-2,7	-2,8	+5
- Exporte	1,4	0,1	-93	1,4	0,6	-55	1,3	0,0	-100
- Importe	3,9	1,9	-50	3,6	0,2	-95	4,0	2,8	-30
Δ Bestand	0,1	0,1	+21	0,1	0,1	+69	0,2	0,1	-16
EU-Preis[2)]	516	423	-18	704	510	-28	425	406	-5
WM-Preis[3)]	362	362	0	544	530	-3	271	273	+1

1) Zucker für die Verwendung in der chemischen Industrie (ohne Ethanolherstellung). 2) Mit den Verbrauchsmengen gewichteter Durchschnittspreis. 3) Weißzucker.

Quelle: Eigene Simulation.

Im Referenzpreisszenario, das eine Weltmarktpreisentwicklung entsprechend der OECD-FAO Projektion 2015 abbildet, steigt die EU-Zuckerproduktion bei einem Wegfall der Produktionsquoten von 15,7 Mio. t Ww auf 15,9 Mio. t Ww (+2%), die Isoglukoseproduktion von 0,7 Mio. t Ww auf 1,3 Mio. t Ww (+77%). Mit der Aufhebung der Produktionsquoten wird die Zuckerproduktion nahezu ausschließlich auf dem EU-Binnenmarkt abgesetzt und verdrängt Importe aus Drittländern mit präferenziellem Marktzugang in die EU-28 (-50%).

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Gleichzeitig stellen EU-Produzenten den Export von Zucker in Drittländer nahezu ein, sodass die EU-28 auch bei einem Wegfall der Produktionsquoten Netto-Importeur von Zucker bleibt. Der EU-Marktpreis fällt von 516 €/t Ww auf 423 €/t Ww (-18%). Durch den sinkenden Preis steigt der Gesamtverbrauch von Zucker und Isoglukose leicht von 18,8 Mio. t Ww auf 18,9 Mio. t Ww (+1%). Dabei erhöht sich der Marktanteil von Isoglukose von 4% auf 7%.

Die beiden anderen in Tabelle 2 dargestellten Szenarien zeigen die Effekte von Weltmarktpreisänderungen. Bei hohen Weltmarktpreisen ist der Produktionsanstieg auf dem Zuckermarkt deutlich stärker und auf dem Isoglukosemarkt deutlich geringer als im Referenzpreisszenario. Der EU-Zuckersektor profitiert demnach von einem hohen Weltmarktpreisniveau, da sich seine relative Wettbewerbsposition gegenüber dem Isoglukosesektor und Importen aus Drittstaaten verbessert. Bei hohen Weltmarktpreisen wird der EU-Bedarf nahezu ausschließlich durch die inländische Produktion gedeckt und der Produktionsüberschuss auf dem Weltmarkt abgesetzt, sodass die EU-28 infolge des Wegfalls der Produktionsquoten ihren Handelsstatus vom Netto-Importeuer zum Netto-Exporteur wechselt und der EU-Zuckerpreis auf die Höhe des Weltmarktpreises fällt.

Im Vergleich zu Weltmarktpreissteigerungen haben sinkende Weltmarktpreise genau den gegenteiligen Effekt. Im Niedrigpreisszenario steigt die Isoglukoseerzeugung bei einer Aufhebung der Produktionsquoten deutlich stärker als im Referenzpreisszenario, die Zuckerproduktion sinkt dagegen infolge des Quotenausstiegs. Bei niedrigen Weltmarktpreisen wird Zucker damit deutlich stärker durch Isoglukose substituiert als im Referenzpreisszenario. Gleichzeitig werden bei einem Zuckerweltmarktpreis von 273 €/t Ww nach dem EU-Quotenausstieg weiterhin knapp 3 Mio. t Zucker aus Ländern mit präferenziellem Marktzugang in die EU-28 importiert. Anders als im Referenzszenario bleibt die EU-28 damit einer der weltweit größten Netto-Importeure von Zucker. Auch nach Aufhebung der Produktionsquoten gewährleistet der EU-Zollschutz in einer Situation niedriger Weltmarktpreise einen deutlichen Preisabstand zwischen dem EU-Binnenmarkt und dem Weltmarkt.

4.2.2. EU-Mitgliedstaaten

Tabelle 3 fast die Effekte des EU-Quotenausstiegs auf die Zucker- und Isoglukoseproduktion in den EU-Mitgliedstaaten zusammen.

Tabelle 3: Änderung der Zucker- und Isoglukoseproduktion infolge des EU-Quotenausstiegs in den EU-Mitgliedstaaten (2020/21)

	Land	Effekt	
Zucker-industrie	PL*, GB, NL, BE, HR*, HU*, LT	Steigerung oder Erhalt der Produktion in allen WMP-Szenarien	0% bis + 31%
	FR, DE, ES*, AT, CZ*, SE, SK*, RO*, PT	Steigerung/Reduzierung der Produktion in den WMP-Szenarien	-44% bis +33%
	IT*, DK, GR*, FI*	Reduzierung der Produktion in allen WMP-Szenarien	-2% bis -59%
Isoglukose-industrie	HU, BG, SK, ES, PL, PT	Steigerung der Produktion in allen WMP-Szenarien	6% bis 336%
	IT, BE, DE	Steigerung/Reduzierung der Produktion in den WMP-Szenarien	-56% bis +38%
	–	Reduzierung der Produktion in allen WMP-Szenarien	

* Länder mit gekoppelten Direktzahlungen für Zuckerrüben.

Quelle: Eigene Darstellung.

Polen, Großbritannien, die Niederlande, Belgien, Kroatien, Ungarn und Litauen steigern ihre Zuckerproduktion unabhängig von der Weltmarktpreisentwicklung im Zuge des Quotenausstiegs oder können ihr Produktionsniveau zumindest halten. Dabei lasten Polen, die Niederlande, Belgien, Großbritannien und Litauen ihre Produktionskapazitäten auch bei niedrigen Weltmarktpreisen vollständig aus. Italien, Dänemark, Griechenland und Finnland reduzieren die Zuckerproduktion in allen Weltmarktpreisszenarien bei einer Aufhebung der Produktionsquoten. In Frankreich, Deutschland, Spanien, Österreich, Tschechien, Schweden, der Slowakei, Rumänien und Portugal entscheidet die zukünftige Entwicklung des Weltmarktpreisniveaus darüber, ob die Zuckerproduktion im Zuge des Quotenausstiegs steigt oder fällt. So reduzieren beispielsweise Frankreich, Spanien, Österreich, Schweden und die Slowakei ihre Zuckererzeugung bei niedrigen Weltmarktpreisen, bei hohen Weltmarktpreisen steigern diese Länder ihre Produktion dagegen bis an die Kapazitätsgrenze.

Auch die Höhe der Isoglukoseerzeugung wir nach dem Quotenausstieg stark durch die Weltmarktpreisverhältnisse beeinflusst. So reduzieren Italien, Belgien und Deutschland ihre Produktion bei hohen Weltmarktpreisen nach dem Ende der Quote, können diese bei niedrigen Weltmarkpreisen dagegen steigern. In Ungarn, Bulgarien, der Slowakei, Spanien, Polen und Portugal steigt die Isoglukoseerzeugung in allen Weltmarktpreisszenarien infolge des Quotenausstiegs, jedoch ist die Produktionssteigerung auch in diesen Ländern bei hohen Weltmarktpreisen deutlich geringer.

4.2.3. Drittländer

In Kapitel 4.2.1 wurde bereits dargestellt, dass die Aufhebung der EU-Produktionsquoten zu einer Verdrängung von Importen vom EU-Binnenmarkt führt. Bestimmte Drittländer mit präferenziellem Zugang zum EU-Binnenmarkt verlieren demnach die EU-28 als Absatzmarkt. Sind diese Länder auf dem Weltmarkt nicht wettbewerbsfähig, sinkt die Zuckerproduktion in diesen Drittländern. Tabelle 4 zeigt die Änderung der Zuckerproduktion für die unterschiedlichen Weltmarktpreisszenarien je Kontinent.

Tabelle 4: Änderung der Zuckerproduktion infolge des EU-Quotenausstiegs nach Kontinent (2020/21)

Kontinent	**Referenz WMP** Alle Preise: OECD-FAO/EU-KOM	**Hohe WMP** Alle Preise: +60%	**Niedrige WMP** Alle Preise: -30%
EU-28	**+1,7%**	**+16,7%**	**-8,8%**
Drittländer	**-0,3%**	**-1,3%**	**+0,1%**
- Afrika	-1,8%	-2,1%	-0,5%
- Amerika	-0,4%	-1,6%	0,0%
- Asien	-0,1%	-0,8%	+0,2%
- Ozeanien	-0,5%	-1,9%	+0,2%
- Europa (nicht EU-28)	-0,2%	-2,1%	+0,5%
Welt	**-0,2%**	**+0,2%**	**-0,6%**

Quelle: Eigene Darstellung.

Je stärker die EU-Importe infolge des EU-Quotenausstiegs sinken, desto höher ist der Rückgang der Zuckerproduktion in Ländern außerhalb der EU-28. Insbesondere die Zuckerproduktion in Afrika sinkt im Zuge des EU-Quotenausstiegs, da viele afrikanische Länder einen präferenziellen Zugang zum EU-Binnenmarkt haben, diese Länder auf dem Weltmarkt aber nicht wettbewerbsfähig sind. Bei einem niedrigen Weltmarktpreisniveau steigt der Zuckerweltmarktpreis im Zuge des EU-Quotenausstiegs und Länder in Amerika, Ozeanien und Europa steigern ihre Zuckerproduktion und profitieren somit vom Wegfall der Produktionsquoten in der EU-28.

5. Diskussion

Aus theoretischen Analyse ist deutlich geworden, dass nach dem Quotenausstieg die Entwicklung des EU-Zucker- und Isoglukosemarktes entscheidend von der Höhe der Produktions- und Transportkosten in den EU-Mitgliedstaaten abhängt. Denn bei einer Aufhebung der Produktionsquoten entscheiden vor allem die Kostenunterschiede zwischen den Ländern darüber, in welchen EU-Mitgliedstaaten die Zucker- bzw. Isoglukoseindustrie ihre Produktion nach dem Quotenausstieg steigern kann und in welchen EU-Ländern Produzenten vom Markt verdrängt werden. Der für die quantitative Analyse des EU-Quotenausstiegs gewählte Modellansatz sollte daher nach Möglichkeit sowohl die Produktions- als auch die Transportkostenunterschiede zwischen den EU-Mitgliedstaaten abbilden. Dies wurde in dieser Analyse durch die Verknüpfung eines räumlichen Preisgleichgewichtsmodells mit einem Modell von LMC erreicht. Dabei ermöglicht das Modell von LMC die Berechnung der Produktionskosten von Zucker und Isoglukose in Abhängigkeit von der Höhe der Weltmarktpreise für Weizen, Mais, Raps und Erdöl. Das räumliche Preisgleichgewichtsmodell simuliert den globalen Zuckerhandel sowie Intra-EU-Handel mit Zucker und Isoglukose auf Basis der Höhe der Produktions- und Transportkosten in rund 120 Ländern.

Die mithilfe dieses Modellansatzes berechneten Ergebnisse stimmen grundsätzlich mit den Ergebnissen anderer Studien überein. Diese zeigen, dass das Ende der EU-Produktionsquoten zu einer Steigerung der Zucker- und Isoglukoseerzeugung, einem Rückgang der Importe, einem Preisverfall auf dem EU-Binnenmarkt sowie einem leicht steigenden Gesamtverbrauch von Zucker und Isoglukose führen wird. Darüber hinaus bestätigen die in dieser Analyse vorgestellten Ergebnisse, dass die Zuckerproduktion bei einer Aufhebung der Produktionsquoten vor allem in Griechenland, Italien und Finnland sinkt. Im Gegensatz zu den Ergebnissen anderer Studien fällt die Zuckerproduktion aber auch in Dänemark und in Abhängigkeit vom Weltmarktpreisniveau auch in anderen EU-Ländern.

Anders als die in bisherigen Studien verwendeten Modellansätze, bildet der entwickelte Modellansatz auch die preisabhängige Konkurrenzbeziehung zwischen dem Zucker- und Isoglukosesektor auf Ebene der EU-Mitgliedstaaten ab. Bei der Interpretation der Ergebnisse ist jedoch zu berücksichtigen, dass die zukünftige Entwicklung des Isoglukosesektors entscheidend von den Annahmen über den Ausbau der Produktionskapazitäten und damit der Annahmen über die Höhe der jährlichen Wachstumsraten abhängt. In der Simulation wurden für den Isoglukosesektor in den Szenarien, in denen die Isoglukosequoten aufgehoben werden, je nach EU-Mitgliedstaat jährliche Wachstumsraten zwischen 15% und 30% angenommen. Höhere oder geringere Wachstumsraten würden die Höhe der Isoglukoseproduktion deutlich beeinflussen. Zudem berücksichtigt die Simulation nicht, dass im Zuge des Quotenausstiegs auch EU-Mitgliedstaaten in die Isoglukoseerzeugung einsteigen können, die gegenwärtig über keine Produktionsquoten verfügen.

In methodischer Hinsicht besteht eine Einschränkung des vorgestellten Modellansatzes darin, dass das verwendete Modell von LMC keine Berechnung der Grenzkosten ermöglicht, sondern nur die Berechnung der durchschnittlichen Produktionskosten. Darüber hinaus sind in dem für die Simulation verwendeten räumlichen Preisgleichgewichtsmodell die Wechselwirkungen zwischen der Zucker- und Isoglukoseindustrie und anderen Wirtschaftssektoren nicht abgebildet. Dies ist vor allem für die Szenarien relevant, in denen die Isoglukoseerzeugung deutlich steigt, da der Effekt steigender Getreidepreise auf die Produktionskosten von Zucker- und Isoglukose im Modell nicht endogen abgebildet wird. Bei der Interpretation der Effekte in Drittländern ist zu berücksichtigen, dass das Modell nicht auf die realen Handelsströme kalibriert ist. Zudem werden die Angebots- und Nachfragereaktionen im räumlichen Preisgleichgewichtsmodell stark durch die Wahl der Angebots- und Nachfragefunktionen sowie durch die Annahmen über die Höhe der Angebots- und Nachfrageelastizitäten bestimmt.

6. Schlussfolgerungen

Ziel der Studie war es, die Auswirkungen des EU-Quotenausstiegs auf den Zucker- und Isoglukosemarkt quantitativ abzuschätzen. Dazu wurden die Markteffekte einer Aufhebung der Zucker- und Isoglukosequote mithilfe eines räumlichen Preisgleichgewichtsmodells für drei Weltmarktpreisszenarien analysiert. Die Szenarien zeigen einen Ergebniskorridor für die potenziellen Markteffekte des EU-Quotenausstiegs auf und ermöglichen die Beantwortung der in der Einleitung aufgeworfenen Forschungsfragen:

Wie werden sich Produktion und Verbrauch, Handelsströme und Preise von Zucker und Isoglukose in der Europäischen Union und in Drittländern infolge einer Aufhebung der Produktionsquoten entwickeln?

Die Ergebnisse der simulierten Weltmarktpreisszenarien zeigen, dass die EU-Zuckerproduktion infolge des Quotenausstiegs in Abhängigkeit von den Weltmarktpreisverhältnissen leicht bis deutlich steigt (+2% bis +17%), bei niedrigen Weltmarktpreisen jedoch fällt (-9%). Die EU-Isoglukoseerzeugung steigt dagegen in allen simulierten Szenarien (+43% bis +174%). Dabei steigern die wettbewerbsfähigsten EU-Mitgliedstaaten ihre Erzeugung unabhängig von den Weltmarktpreisverhältnissen, wenig wettbewerbsfähige EU-Länder reduzieren die Produktion dagegen auch bei hohen Weltmarkpreisen. In einigen EU-Mitgliedstaaten entscheidet die zukünftige Weltmarktpreisentwicklung darüber, ob die Produktion infolge des Quotenausstiegs steigt oder fällt. Mit der Aufhebung der Produktionsquoten wird die Zuckerproduktion nahezu ausschließlich auf dem EU-Binnenmarkt abgesetzt und verdrängt Importe aus Drittländern mit einem präferenziellen Zugang zum EU-Binnenmarkt. Hierdurch sinkt die Zuckerproduktion in Ländern außerhalb der EU, insbesondere in Afrika. Bei hohen Weltmarktpreisen wechselt die EU-28 ihren Handelsstatus vom Netto-Importeur zum Netto-Exporteur. Im Zuge des Ausstiegs aus der Zucker- und Isoglukosequote fällt der Preis auf dem EU-Binnenmarkt stark und stabilisiert sich in Abhängigkeit vom Weltmarktpreisniveau in einem Preiskorridor von 406 €/t Ww bis 510 €/t Ww. Durch das geringere Preisniveau innerhalb der EU-28 steigt der Gesamtverbrauch von Zucker und Isoglukose leicht um bis zu 1%. Dabei erhöht sich der Marktanteil von Isoglukose auf bis zu 10%. Bei niedrigen Weltmarktpreisen gewährleistet der EU-Zollschutz auch nach dem Quotenausstieg einen deutlichen Preisabstand zwischen dem EU-Binnenmarktpreis und dem Weltmarktpreis. Zudem steigt bei einem niedrigen Weltmarktpreisniveau der Zuckerweltmarktpreis im Zuge des EU-Quotenausstiegs. Länder in Amerika, Ozeanien und Europa steigern ihre Zuckerproduktion und profitieren somit vom Wegfall der EU-Produktionsquoten.

Wie konkurrenzfähig ist die Zuckererzeugung gegenüber der Isoglukoseherstellung?

Die Wettbewerbsfähigkeit der Zuckerproduktion gegenüber der Isoglukoseerzeugung wird stark durch die Entwicklung der Weltmarktpreise von Getreide, Raps und Erdöl beeinflusst. Denn Weltmarktpreisänderungen beeinflussen die Höhe der Produktionskosten von Isoglukose deutlich stärker als die Kosten der Zuckerproduktion. Dies führt im Fall steigender Weltmarktpreise zu einer Verbesserung und im Fall sinkender Weltmarktpreise zu einer Verschlechterung der Wettbewerbsposition der Zuckerindustrie gegenüber der Isoglukoseindustrie. In der Simulation des Quotenausstiegs wird Zucker daher vor allem bei niedrigen Weltmarktpreisen durch Isoglukose substituiert und erreicht in der EU-28 einen Marktanteil von bis zu 10%. Die Simulationsergebnisse zeigen jedoch auch, dass insbesondere bei hohen Weltmarktpreisen nicht alle EU-Mitgliedstaaten die Isoglukoseerzeugung im Zuge des Quotenausstiegs steigern. In diesen Ländern kann sich die Isoglukoseindustrie demnach nicht im Wettbewerb durchsetzen und verliert Absatzmärkte an den Zuckersektor.

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Article (3):

2.3 Sugar – Developments in EU member states

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In: EC (ed.): *EU agricultural outlook for markets and income*, 2019-2030. European Commission, DG Agriculture and Rural Development, Brussels, 2019, pp. 28- 29.[6]

Author contributions: Martin Banse coordinated the overall project. **Marlen Haß** developed the model approach, compiled the model database, implemented the model equations, performed the model simulations, analysed the model outcome and drafted and revised the manuscript. Max-Emanuel Zirngibl implemented the sweetener module for France supervised by **Marlen Haß**. Petra Salamon, Max-Emanuel Zirngibl, Ana Gonzalez Martinez, Roel Jongeneel und Myrna van Leeuwen contributed to the overall model version. All authors discussed the results.

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6 Appendix A provides a detailed documentation of the model approach developed to derive the market projections described in this article.

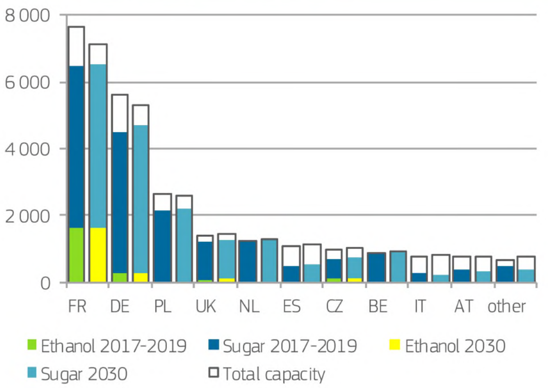
SUGAR – DEVELOPMENTS IN EU MEMBER STATES

Stable sugar production in major producing EU Member States, despite factory closures

Following the abolition of the quota regime in 2017, the EU sugar sector is currently undergoing a consolidation phase. Over the outlook period, this process is expected to continue, leading to a concentration of sugar and isoglucose production in the most competitive EU Member States. In the first years of the post-quota period, domestic sugar prices have dropped sharply in the EU because of a production surplus and intensive competition among EU sugar producers fighting for market shares on the EU single market. Moreover, the world market price of sugar has also been on a declining trend since 2017 due to a global production surplus.

Consequently, factory closures have been announced by Südzucker AG and Cristal Union. By 2020, four factories will shut down in France and two in Germany, with a combined total processing capacity of about 800 000 t of sugar. In addition, one factory has been closed in Poland in 2019. This may come as a surprise as these three countries are the largest EU sugar producers, located in the 'beet belt' and considered as being the most competitive, apart from Belgium and the Netherlands. In addition, France, Germany and Poland are among the EU Member States that expanded the beet area most significantly following the abolition of the quota system (France: +19%, Germany: +21%, Poland: +22%; average 2017-2019 compared to the average 2014-2016). However, to reduce fixed costs and increase competitiveness, sugar companies seek to run existing factories at their capacity limit. Therefore, factory closures will not necessarily lead to a decline in sugar production. Instead, the reduction in processing capacities may only result in a higher capacity utilisation rate for the remaining factories.

GRAPH 3.19 Beet slicing capacity utilisation in selected Member States, 2017-2019 and 2030 (1 000 t w.s.e.)



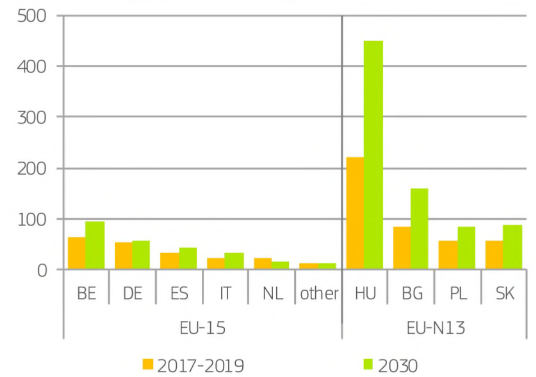
Source: AGMEMOD simulation.

Among the major sugar producing EU Member States, only the Netherlands and Belgium are producing at their estimated capacity limit. They are also expected to continue to produce to capacity until 2030. In France, Germany and Poland sugar production is projected to remain stable, despite factory closures, leading to a higher capacity utilisation rate in 2030. Moreover, sugar production in other smaller sugar producing EU Member States is expected to decline. The strongest decline in relative terms is projected for Greece (-47%), Italy (-21%) and Romania (-19%) as these three countries are among the EU sugar producers with the highest production costs.

Only moderate growth of isoglucose production concentrated in eastern European Member States

In contrast to sugar production, which can be increased by lengthening the beet processing campaign, a substantial increase in isoglucose production requires investments in additional production capacities. Before the abolition of the quota system, investments were made in Hungary and Bulgaria. However, most recent developments have shown a decline in isoglucose production in most EU Member States. This might be explained by the sharp drop in sugar prices, at which isoglucose production and investments in additional production capacities are no longer profitable. Furthermore, health concerns linked to isoglucose may discourage food processors to switch from sugar to isoglucose, even in market situations where isoglucose has a price advantage over sugar. Against this background, EU isoglucose production is expected to increase only moderately over the outlook period.

GRAPH 3.20 Isoglucose production in selected Member States, 2017-2019 and 2030 (1 000 t dry weight)



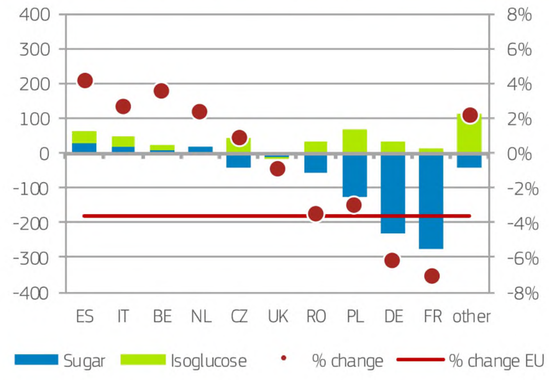
Source: AGMEMOD simulation.

Growth of isoglucose production is concentrated in eastern European countries, while production levels in EU-15 Member States are only expected to recover from the decline observed in the first two years following the abolition of the quota system given the price recovery.

Overall negative trend in total sweetener consumption, limited growth in some southern EU Member States

Over the past decades, sugar consumption has been stagnating in the EU at a high level. However, in recent years, consumption of sugar has been subject of public debate and several EU Member States have introduced policy measures to reduce sugar consumption through, e.g. taxes, reformulation strategies or nutritional labelling. These policy measures as well as shifting consumer preferences due to health concerns linked to high levels of sugar intake (obesity, non-communicable diseases such as type-2-diabetes, cardiovascular diseases, etc.) are expected to result in a negative trend in total sweetener consumption in most EU Member States.

GRAPH 3.21 Change in domestic sweetener use in selected Member States, 2017-2019 compared to 2030 (1 000 t w.s.e and %)



Source: AGMEMOD simulation.

Total EU sweetener demand is expected to decline by 4% between 2017-2019 and 2030. At EU Member State level, relative changes among the major sweetener consuming countries range from an increase of 4% in Spain to a decline of 7% in France. While in the Netherlands, Belgium and Czechia the slight increase in total sweetener consumption can only be attributed to population growth, in Spain and Italy a slight increase in per capita consumption is expected as this trend has already been observed in the past. The strongest decline in total sweetener demand is expected for the top 3 sweetener consuming EU Member States that are France, Germany and Poland, as well as for Romania. While the decline in Poland and Romania is a result of a negative trend in population, in France and Germany per capita consumption is expected to decline as both countries have introduced policies to reduce sweetener consumption.

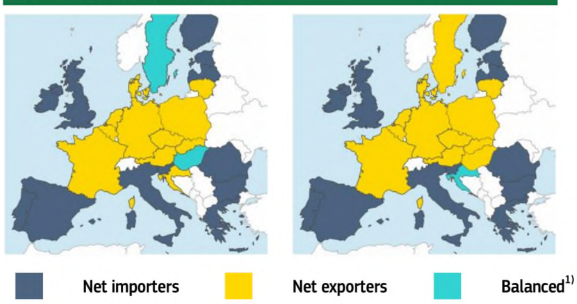
In contrast to the negative trend in total sweetener consumption projected for most EU Member States, isoglucose consumption is expected to grow. However, at aggregated EU level the share of isoglucose in total sweetener consumption remains at a rather low level of 5% by 2030. At EU Member State level, growth of isoglucose consumption is concentrated in eastern European countries, namely Poland, Czechia, Hungary, Romania, Slovakia and Bulgaria. Among the EU-15 Member States, the strongest increase in absolute terms is expected for Spain, Germany, Italy and Greece. This regional pattern of growth in isoglucose consumption can be explained by the fact that isoglucose as a liquid sweetener is not transported over long distances and therefore consumed domestically or exported to neighbouring countries only.

No significant changes in regional net trade pattern at EU Member State level

Before the abolition of the quota system, the EU was a net importer of sweetener as production quotas were set at a level below EU sweetener consumption and sugar exports were restricted to 1.4 million t due to WTO commitments. In the first year following the abolition of the quota system, the EU increased exports significantly and became a net exporter. However, over the outlook period the EU sweetener market is expected to be broadly balanced as net exports are expected to not exceed 0.8 million t.

The traditional net exporting countries of sweetener are mostly central European Member States, whereas the large net importing countries are mainly located in the south of the EU, except the UK. Over the outlook period, these regional net trade patterns are not expected to change significantly as only three countries are projected to change their net trade position. Due to the growth of isoglucose production Hungary is expected to switch from a broadly balanced market to a net exporter of sweetener. Also Sweden would move to a net exporting position, whereas Croatia would turn from a net exporter to a broadly balanced market as a consequence of a decline in sugar production.

MAP 3.1 Sweetener net trade position of Member States, 2017-2019 (left) and 2030 (right)



Source: AGMEMOD simulation.
[1)] Net trade volume < 10% of production.

Article (4):

2.4 Coupled support for sugar beet in the European Union: Does it lead to market distortions?

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Coupled support for sugar beet in the European Union: Does it lead to market distortions?

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Abstract

Under the EU Common Agriculture Policy, only 11 of 19 sugar beet producing EU Member States provide coupled direct payments for sugar beet. This paper analyses the market effects of this uneven implementation of an agricultural policy instrument along the sugar supply chain, focusing in particular on changes in sugar production in individual EU Member States. In addition to previous literature, the effects on the production of competing crops to sugar beet are also presented. Moreover, the effects of coupled support are investigated under two different yield levels to account for yield uncertainties arising from an application ban on certain insecticides that came into force in the EU in 2018. The simulation was carried out using the partial equilibrium model AGMEMOD. Results suggest that the market-distorting effect of coupled support for sugar beet remains limited and tends to be higher under an optimistic yield development. Assuming unchanged yield growth, the simulated increase in sugar production of EU countries providing coupled support totals 258,000 tonnes of sugar (+5.7%), while sugar production in EU countries without coupled payments declines by only 21,000 tonnes (−0.2%) resulting in an overall increase in EU sugar production of 236,000 tonnes (+1.3%). Despite these rather limited market-distorting effects, providing coupled support to sugar beet cannot be supported from an economic point of view because it contradicts the objective of a stronger market-orientation of EU agricultural production.

KEYWORDS

AGMEMOD, common agricultural policy, coupled direct payments, partial equilibrium model, sugar

JEL CLASSIFICATION

C6; O13; O52; Q13

1 | INTRODUCTION

The European Union's Common Agricultural Policy (CAP) is subject to a systematic reform process. Between 1992 and 2012, income support for farmers was gradually decoupled from production. In a first step, direct price support measures were abolished. Instead, farmers received coupled direct payments still linked to the production level of a specific crop. Later, these coupled direct payments were converted into decoupled direct payments, granted independently of the production level of a specific crop (Matthews, 2018; World Bank, 2018). By the end of this reform period the share of coupled direct payments in the total EU budget for direct payments had been reduced to only 7% (Matthews, 2015). However, as part of the last major CAP reform in 2013 and in contrast to previous reforms, the EU Commission has recently expanded the legal scope for the provision of coupled direct payments. This applies to both the maximum share of coupled direct payments in the total budget for direct payments as well as to the list of products eligible for coupled support (Matthews, 2018). Since 2015, coupled direct payments can also be granted for sugar beet to give EU Member States (EU-MS) the opportunity to support sugar beet growers following the abolition of the quota system. Under the CAP financial period 2014–2020, 11 EU-MS decided to provide coupled support to their sugar beet sector. Per hectare payment rates range from €67 in Finland to €630 in Romania (EC, 2017a). Thus, rates per hectare differ considerably among EU-MS, raising the question as to what extent these payments lead to market distortion within the EU, as coupled support payments for sugar beet are likely to result in: (1) a regional shift of sugar beet production to those EU-MS granting high per hectare premiums for sugar beet, and (2) a shift in cropping patterns at EU-MS level from crops not benefiting from coupled payments to sugar beet (EC, 2019c; Smit et al., 2017). Apart from these market distorting effects within the EU, coupled payments for sugar beet may also increase the competitiveness of the EU sugar sector on the international market with potentially adverse effect on third countries, in particular developing countries. Against this background this paper aims to analyse the market distorting effects of EU coupled support for sugar beet, focusing mainly on the market distortions within the EU; the effects of coupled support to EU sugar beet production at the international level are not analysed in detail. In addition to previous literature, the effects on the production of competing crops to sugar beet are also presented. Moreover, the analysis investigates the effects of coupled support to sugar beet under two different assumptions regarding the future development of EU sugar beet yield to account for yield uncertainties arising from an application ban on certain insecticides that came into force in the EU in 2018. In particular, the paper addresses the following questions: (i) How do coupled direct payments for sugar beet affect sugar production and sugar prices at EU-MS level? (ii) How do coupled direct payments for sugar beet affect the production of competing products? (iii) What is the overall effect on the aggregated EU level and on EU net trade? In order to answer these questions, the paper is structured as follows.

Section 2 gives a brief overview of coupled direct payments under the CAP. Section 3 briefly outlines the effects of coupled direct payments for sugar beet that can be expected on the basis of economic theory, summarises the main findings of previous studies and identifies literature gaps. Section 4 constitutes the main body of this paper and provides the quantitative analysis of the market effect of coupled direct payments for sugar beet. The paper ends with a summary of the main findings and critical discussion of the results and the methodology applied.

2 | COUPLED SUPPORT UNDER THE CAP

Starting with the MacSharry reform in 1992, the EU Commission has initiated a fundamental reform process of the CAP towards a stronger market orientation of agricultural production, which was subsequently pursued with the Agenda 2000, the Fischler Reform of 2003 and the Health Check decisions of 2008. As part of the reform measures, direct market support instruments (intervention prices, export refunds, etc.) were gradually abolished for most agricultural products. To compensate producers for income losses, farmers were initially supported by product specific compensatory payments, later called 'direct payments', which were gradually decoupled from production from 2005 onwards (Matthews, 2018). By the end of the implementation period of the Health Check decisions (2008–2012), the share of coupled direct payments in the total EU budget for direct payments had been reduced to only 7% (Matthews, 2015). At national level, the share of coupled direct payments (so-called 'special support') was limited to a maximum of 10% of the national annual budget for direct payments—so-called 'national ceilings' (REG (EC) No 73/2009, Art. 69(1)). In particular, coupled direct payments were targeted at supporting production in the dairy and beef sectors, as the budget available to support other sectors was capped at a maximum of 3.5% of the annual national ceiling (REG (EC) No 73/2009, Art. 69(5)).

However, as part of the 2013 CAP reform, the EU Commission altered the legal framework and relaxed the conditions for coupled support. This applies to both the maximum share of coupled direct payments in the total budget for direct payments as well as to the list of products eligible for coupled support.

In principle, the current direct payments regulation (REG (EU) No. 1307/2013), limits the share of coupled direct payments (so-called 'voluntary coupled support', VCS) to a maximum of 8% of the annual national ceiling, but there are a number of exceptions. First, under certain conditions, EU-MS are allowed to increase their budget for the VCS scheme to 13% of the national ceiling (Art. 53(2)) and, after approval by the EU Commission, even further (Art. 53(4)). Second, there is a general derogation which allows EU-MS to allocate up to €3 million per year to the VCS scheme, irrespective of whether this exceeds the maximum percentage of voluntary coupled support in the national ceiling for direct payments (Art. 53(5)). Finally, the protein crop sector has an exceptional role in the current VCS scheme. If EU-MS use at least 2% of their annual national VCS budget to support the production of protein crops, they are allowed to increase the maximum percentage of voluntary coupled support in the national ceiling for direct payments by 2 percentage points (Art. 53(3)).

Moreover, since the 2013 CAP reform, a larger number of sectors can be supported by VCS payments. Whereas in the previous financing period of the CAP only the dairy, beef and veal, sheep- and goat-meat, as well as the rice sector, were eligible for VCS payments (REG (EC) No 73/2009, Art. 68(1b)), in the current regulation the list has been extended to 19 crop sectors, but the list of livestock sectors eligible for VCS payments remains unchanged (REG (EU) No 1307/2013, Art. 52(2)). In particular, the sugar beet was added to the list to give EU-MS the opportunity to support their sugar sector following the abolition of the quota system.

In principle, under the current regulation VCS payments may only be granted to agricultural sectors that undergo certain difficulties and those sectors that are of particular importance due to economic, social or environmental reasons (Art. 52(3)). Also, the VCS scheme was originally designed as a production-limiting scheme to ensure that coupled direct payments comply with the rules of the World Trade Organization (WTO), as production-limiting schemes are classified as WTO blue box measures. Therefore, the initial text of Article 5 of regulation (EU) No 1307/2013 explicitly mentions that VCS payments are not intended to provide an incentive to increase production, but only to maintain the current level of production. Thus, VCS payments were initially only granted within defined quantitative limits based on fixed areas and yields or on a fixed number of animals (Art. 51(5f.)). However, in 2018 these quantitative limits were removed from the regulation in order to reflect the current practice since 1 January 2015 (REG (EU) No 2017/2393) (Matthews, 2018).

With respect to sugar beet, so far 11 out of 19 sugar beet producing EU-MS have decided to provide coupled support to beet growers. In 2017, about 486,000 hectares were supported by VCS payments accounting for roughly 30% in the total EU sugar beet area harvested (EC, 2019c, 2019d). On average EU-MS decided to allocate 10% of their national ceiling to the VCS scheme and used 4% of the VCS budget to support their sugar beet sector (EC, 2017b). In particular smaller sugar beet producing EU-MS located in the eastern and southern part of the EU decided to provide coupled support for sugar beet. Moreover, in these countries the percentage of VCS in the national ceiling for direct payments ranges between 8% and 16%, clearly exceeding the EU average of 4%. In contrast, beet growers in most large sugar beet producing EU-MS—that is, France, Germany, the United Kingdom, the Netherlands and Belgium—do not receive VCS payments and Germany even decided completely against supporting its agricultural sector by VCS payments. However, Poland, the EU's third largest sugar beet producing country, provides coupled support for sugar beet, accounting alone for almost 50% of the subsidised sugar beet area in the EU.

Table 1 shows the amount of aid paid per hectare (so called 'premiums') in the 11 EU-MS currently providing coupled support for sugar beet. In the table, premiums are calculated by dividing the available budget for 2020 by the quantitative hectare limit that was initially in place. As the sugar beet area harvested in a specific year usually differs from the quantitative hectare limit, premiums actually paid may differ from the calculated premiums given in Table 1 (EC, 2019c). Furthermore, premiums per tonne of beet or tonne of sugar are sensitive to the beet yield and sugar content in the respective year. In the table, average yields for the period 2014–2016 are applied.

The average EU premium granted for sugar beet equals €331 per hectare, which corresponds to a payment of about €5 per tonne of beet and a payment of about €30 per tonne of sugar. However, as Table 1 indicates, there are large differences among EU-MS regarding the amount of aid per hectare. Romania grants by far the highest rate of VCS, followed by Greece and Spain, but also in Slovakia, Hungary and Poland beet growers receive above EU average per hectare premiums. For most countries, this is also the case, if compared on a per tonne of sugar basis. The only exception is Spain, where comparatively high beet yields result in a below-average premium per tonne of sugar, despite above-average premiums per hectare.

3 | ECONOMIC THEORY AND LITERATURE REVIEW

From economic theory the effects of coupled subsidies are well known. Figure 1 illustrates the effects of VCS payments on prices as well as supply and demand compared to a market situation without any policy intervention. For the sake of simplicity, the figure assumes a two-country model and ignores the existence of competing crops. In the initial situation without any policy intervention—shown in blue—the quantity q_0^T is traded between the two countries at the market price p_0^M. The introduction of VCS payments—shown in red—in one of the two countries (hereafter called 'VCS-MS') results in a downward shift of the supply function

TABLE 1 Voluntary coupled support (VCS) for sugar beet by Member State

	VCS 2020		Quantitative limit[b]	Premium	Yield[c]	Premium	Sugar content[c]	Premium
MS	€m	Share %[a]	1,000 ha	€/ha	t/ha	€/t beet	%	€/t sugar
RO	19	8	29	645	41	16	17	91
GR	7	4	13	500	58	9	14	60
ES	14	2	33	445	95	5	17	27
SK	7	12	20	351	65	5	16	34
HU	8	4	20	374	66	6	16	36
PL	74	15	211	352	62	6	18	32
CZ	17	13	62	267	66	4	17	23
IT	16	4	62	262	64	4	15	27
HR	4	10	23	157	65	2	15	16
LT	2	2	19	86	57	1	18	8
FI[d]	1	1	15	67	39	2	17	10
EU–28	168	4	509	331	66	5	17	30

[a]Share of VCS for sugar beet in national ceiling for VCS.

[b]Abolished in 2018.

[c] Avg. 2014–16, EU-28 yield represents average of MS granting VCS weighted by production quantities.

[d]Finland additionally grants a hectare premium of €350/ha financed from national funds.

Source: EC (2017a, 2019d), Maier et al. (2018), REG (EU) No. 2017/1272.

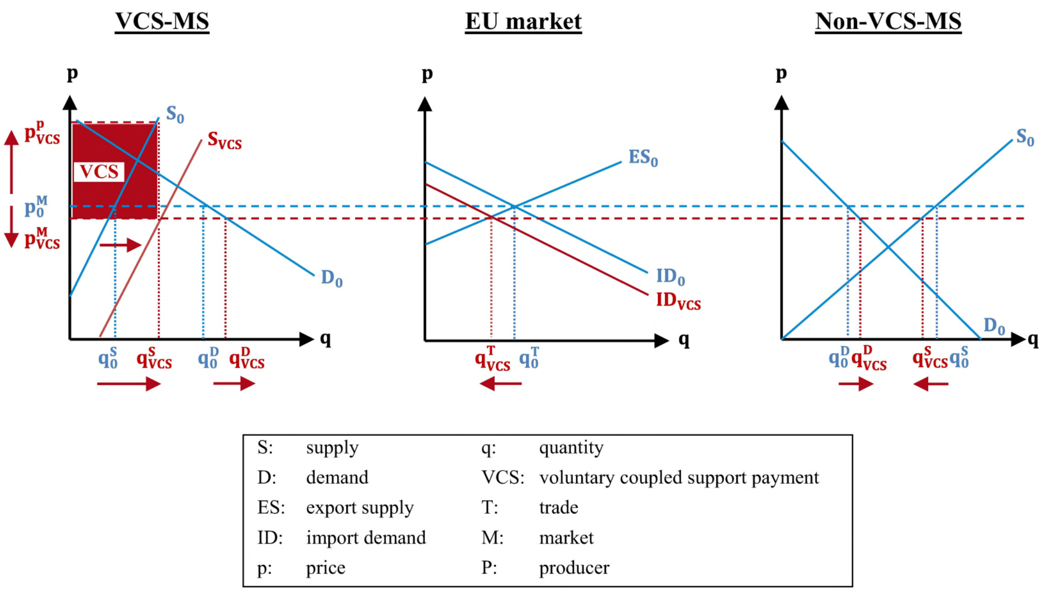

FIGURE 1 Price and quantity effects of VCS payments (reference situation: unregulated market). Source: Own figure [Colour figure can be viewed at wileyonlinelibrary.com]

($S_0 \rightarrow S_{VCS}$) as VCS payments can be considered as direct subsidies reducing the marginal cost of production. Supply in the VCS-MS increases and import demand declines ($ID_0 \rightarrow ID_{VCS}$). In the new market equilibrium, a lower quantity is traded ($q_0{}^T \rightarrow q_{VCS}{}^T$) and the market price falls from $p_0{}^M$ to $p_{VCS}{}^M$. However, in the VCS-MS the coupled payment more than offsets the decline in the market price, that is, the producer price including VCS payments rises from p_0^M to p_{VCS}^P. In the other EU-MS, where no VCS scheme is implemented (hereafter called 'non-VCS-MS'), the drop in the market price results in a decline in production.

However, the implementation of VCS schemes for sugar beet does not only affect the level playing field among countries, it also changes the competitive position of sugar beet relative to other crops (Dwivedi, 2012; Gandolfo, 2013; Hill, 2014). While the producer price for sugar beet increases in the VCS-MS, the sugar beet price falls in the non-VCS-MS. Thus, ceteris paribus, producers in VCS-MS will increase sugar beet production at the expense of other crops, while producers in non-VCS-MS are expected to reduce sugar beet production and expand the production of other crops.

In conclusion, from economic theory the following effects of the VCS payments for sugar beet can be summarised:

- In countries where VCS payments for sugar beet are introduced, production costs of sugar beet decline leading to an increase in sugar beet production at the expense of competing crops and a decline in the market price of sugar beet, while the producer price (incl. VCS) of sugar beet as well as the demand for sugar beet increases.
- In countries where beet growers do not receive coupled support for sugar beet, the decline in the market price results in a reduction of sugar beet production and an increase in the production of competing crops.

At the processing stage of the supply chain similar effects can be expected as sugar beets are grown almost exclusively under contracts with regionally based and often grower-owned sugar processing companies.

Moreover, changes in relative market prices caused by the introduction of VCS payments for sugar beet affect the market of competing products at the processing stage, such as isoglucose.[1] While changes in the price for corn and wheat directly result in higher or lower production costs of isoglucose, changes in the price ratio between sugar and isoglucose affect the demand behaviour of consumers. Due to space constraints, this is not discussed in detail here. However, the implicit market effects on the isoglucose sector are described in the quantitative analysis in Section 4.4.

Over time, an extensive literature has developed on the effect of decoupling, reducing or even abolishing direct payments in the EU (Binfield et al., 2003; Boulanger & Philippidis, 2015; Erjavec et al., 2011; Uthes et al., 2011; Weinmann et al., 2006). However, there is a lack of recent studies quantitatively examining the effects of re-coupling EU direct payments introduced by the 2013 CAP reform. The EU Commission impact assessment of its legislative proposal for the CAP post-2020 reports the supply effect of removing VCS payments currently in place for dairy, beef and sugar beet. However, results are only presented at the aggregated EU level. According to the simulation, carried out using the CAPRI model, removing VCS for sugar beet leads to an overall decline in EU beet production of 2.8% resulting in a 3.9% increase of the EU sugar beet price. The reduction in the beet area harvested is simulated to be even larger than the decline in production (−4.9%), as beet production shifts to more competitive regions, leading to an increase in the average EU beet yield of 2.2% (EC, 2019b). A second CAPRI-based analysis, published in 2015, reports results not only for the EU in total, but also for selected EU-MS (Offermann et al., 2015). The scenario investigated in the study of Offermann et al., (2015) assumes the abolition of VCS payments in all sectors, which results in a decline in EU sugar beet production of 0.9%, with effects on beet production at MS-level varying between +0.7% (France) and −7.1% (Poland). Given the overall decline in EU production the EU sugar

[1]Isoglucose (which is also widely referred to as high fructose corn syrup, HFCS) is a liquid sweetener produced from wheat or corn starch.

price is simulated to increase by 0.8%. However, to the best of the authors' knowledge, so far only the study of Smit et al., (2017) analyses the effects of VCS payments for sugar beet in detail for all sugar beet producing EU-MS. According to the results, which were simulated by applying an Equilibrium Displacement Model (EDM) approach, VCS payments lead to an increase in sugar beet production in particular in Poland (+1.2 mill. t). In other EU-MS with VCS payments for sugar beet in place, the increase in production remains rather limited in absolute terms, despite relatively high payment rates per hectare granted in some EU-MS. This can be explained by the fact that these countries, unlike Poland, only account for a small share of EU sugar beet production. Similarly, when looking at the absolute effects in non-VCS-MS, sugar beet production declines most strongly in the large sugar beet producing countries, namely in France (0.25 mill. t), Germany (0.184 mill. t) and the Netherlands (0.074 mill. t). However, in relative terms, the decline in sugar beet production in these countries is less than 1%. Also, the decline in sugar beet prices does not exceed 5.5%.

A closer look to the study of Smit et al., (2017), however, reveals a number of gaps and shortcomings. First, the study exclusively focuses on the effects on the sugar beet sector, neglecting the price, volume and revenue effects at the sugar processing stage and for competing crops as well as the interactions between the different crop sectors. Second, the EDM model was calibrated to 2016/17 base year data, that is, the last marketing year, where the EU quota system was still in place. However, as during the quota-period market price did not reflect marginal cost of production, supply functions were calibrated to expected sugar beet prices for 2017—that is, the first year of quota abolition—ranging between €26 and €56 per tonne including VCS payments. While the study clearly discloses the data used to calibrate the supply functions, the approach of how exactly sugar beet prices were estimated remains unclear.

4 | MODELLING THE EFFECT OF COUPLED SUPPORT FOR SUGAR BEET

This section provides a quantitative analysis of the market effect of coupled direct payments for sugar beet based on the partial equilibrium model AGMEMOD (Agricultural Member State Modelling). Before presenting results, the model approach as well as the scenarios simulated are briefly described.

4.1 | Method

AGMEMOD is a recursive dynamic partial equilibrium model for the agricultural sector of the EU. A detailed model description can be found in Chantreuil et al., (2012). In addition to the EU-MS, Russia, Ukraine and Turkey are also represented in the model as individual countries, whereas all other regions of the world are grouped in one 'Rest of the World' aggregate. In recent years, the AGMEMOD model has been intensively used to generate medium-term baseline projections for key agricultural markets at EU-MS level (Haß et al., 2020; Offermann et al., 2018; Salputra et al., 2017). In particular, AGMEMOD has been used to break down the baseline projections of the Aglink-Cosimo model, which only includes two country aggregates for the EU, to the individual EU-MS level. Thus, baseline results of both models are closely aligned and projections are based on the same macroeconomic assumptions (EC, 2017a, 2018a, 2019b). In addition, AGMEMOD has also been applied for policy-impact assessment, in particular for the analysis of different direct payments schemes and changes in the CAP budget for direct payments (Chantreuil et al., 2012; Erjavec et al., 2011; Salputra et al., 2011). The model version used for this analysis covers 32 crop and 21 livestock products (primary and processed). For each sector and country, the model endogenously determines on a yearly basis market prices, production, consumption, stocks, exports and imports. Market equilibrium for individual commodities is determined by defining one position of the market balance as a model-closure variable. In the sugar and isoglucose market, exports or imports are chosen as the model-closure variable, whereas in the sugar beet market, consumption represents the closing variable. Because AGMEMOD is a partial equilibrium model, certain variables are assumed to be exogenous. Exogenous variables in AGMEMOD are in particular macroeconomic variables (GDP, inflation rate, population, exchange rates, etc.) and policy variables (subsidies, tariff rates, tariff rate quotas, etc.). The values of endogenous variables are determined by behavioural equations whose intercepts and coefficients are estimated by econometric methods, that is, using linear ordinary least squares (OLS) regression. However, the equation system of AGMEMOD also comprises behavioural equations, where a given functional form is specified and the intercept is calibrated to an observed base year using literature-based elasticities. Calibrated equations are applied in particular due to data constraints, that is, if the quality of the data and length of the data series required for the estimation proves to be insufficient (Chantreuil et al., 2012; Erjavec et al., 2011). By applying flexible functional forms, AGMEMOD captures region and product specificities to a large degree. Moreover, most model functions used in simulation are rooted in observed behaviour as they are directly estimated from the model database and regularly updated. However, the functional forms are not necessarily consistent with profit and utility maximization behaviour of producers and consumers and the resulting required microeconomic restriction, such as homogeneity of degree zero in prices, symmetry and correct curvature. Consequently, AGMEMOD does not allow for the calculation of welfare changes of producers and consumers.

As long as the EU sugar market was regulated by a quota system, the sugar and sugar beet sector in AGMEMOD was modelled by a simplified approach, where production quantities were fixed to the quota level. However, the abolition of the quota system in 2017 required a complete revision of this approach. Modelling supply behaviour of EU sugar processors and beet growers in the post-quota period poses methodological challenges, as with binding production quotas in place historically observed market prices incorporate the quota rent and do thus not represent marginal cost of production. Therefore, either information on the size of the quota rent or empirical data on production costs is needed to properly calibrate the supply functions of the model (Frandsen et al., 2003; Gohin & Bureau, 2006; Jensen & Pohl Nielsen, 2004; Jongeneel & Tonini, 2009). In this paper we opt for the second approach and calibrate the sugar supply function of AGMEMOD to per unit production costs of sugar endogenously calculated within the model.

Equation (1) shows the applied functional form for sugar (*su*) supply SPR_{su}.[2] The first part of the equation limits sugar supply to the existing processing capacity available for sugar production. This capacity is calculated as the daily sugar beet (*st*) slicing capacity bsc_{st} multiplied by the maximum length of the sugar processing campaign loc_{st} corrected for the quantity of sugar beet processed into ethanol (UOD_{st}). Multiplying by the sugar extraction rate XTR_{su} converts the available processing capacity from beet quantity into white sugar equivalent. The second part of the equation determines the level of sugar supply. Sugar processors react to the processing margin, that is, the producer price of sugar PS less processing cost CPO_{su} plus by-product values of sugar processing BPV_{su} (beet pulp, molasses). This formulation of the supply function ensures that sugar processors will cease production, if the market price of sugar falls below the net processing costs (CPO_{su} – BPV_{su}). All values are expressed in real value terms, that is, deflated by the GDP deflator *gdpd*. The parameter ε determines how sensitive sugar processors react to changes in the processing margin. Finally, the sugar supply function is

[2]Please note that endogenous variables are written in capital letters, exogenous variables in lowercase letters.

shifted by the quantity of sugar beet processed into ethanol expressed in white sugar equivalent. Thus, an increase (decrease) in the use of sugar beet for ethanol effectively reduces (increases) the quantity of sugar beet available for processing into sugar, resulting in a decline (increase) in sugar production.

4.1.1 | Supply function

$$\mathrm{SPR_{su}} = \mathrm{Min}\left\{ \left(\mathrm{bsc_{st}} * \mathrm{loc_{st}} - \mathrm{UOD_{st}}\right) * \mathrm{XTR_{su}},\ \mathrm{Max}\left\{0,\ \alpha_{su} * \left(\frac{\mathrm{PFN_{su}} + \mathrm{BPV_{su}} - \mathrm{CPO_{su}}}{\mathrm{gdpd}}\right)^{\varepsilon_{su}} - \mathrm{UOD_{st}} * \mathrm{XTR_{su}}\right\}\right\} \tag{1}$$

As already mentioned above, calibrating the supply function to market prices observed during the quota period would lead to a misspecification of the position of the supply curve as these market prices do not represent marginal cost of production. Therefore, the intercept parameter α is not derived based on observed market prices PFN_{su}. Instead, the supply function is calibrated to given base quantities based on average production cost per tonne of sugar (PFE_{su}) endogenously determined within the model:

4.1.2 | Calibration of supply function

$$\alpha_{su} = \left(\overline{\mathrm{spr\_0_{su}}} + \left(\overline{\mathrm{uod\_0_{st}}}\right) * \overline{\mathrm{xtr\_0_{su}}}\right) * \left(\frac{\mathrm{PFE_{su}} + \mathrm{BPV_{su}} - \mathrm{CPO_{su}}}{\mathrm{gdpd}}\right)^{(-\varepsilon_{su})} \tag{2}$$

Thus, Equation (2) implies that a given base quantity—indicated by an overline (¯) and a zero suffix (_0)—can be produced at production cost of PFE_{su}. As the supply function itself reacts to the sugar market price PFN_{su}, supply of sugar will equal the base quantity, if $PFN_{su} = PFE_{su}$, whereas sugar production will start to decline (increase) compared to the production level of the base year $\overline{spr\_0_{su}}$, if the market price falls below (exceeds) the average per unit production costs.

The base quantity used for calibrating the supply function is the average of the sugar marketing years 2010/11 to 2012/13 (see Table A1 in the Appendix S1). This base year was chosen mainly because of data availability with respect to certain variables not modelled time depended, as for example fixed cost components needed to derive per unit production costs PFE_{su}. However, all cost components entering the model as constant parameters have been adjusted compared to the actual average cost in 2010/11 to 2012/13, to take into account that sugar processors have optimised the length of the beet processing campaign following the abolition of the quota system and factories are thus operating closer to their capacity limit. Moreover, important cost components are modelled dependent on input prices, such as energy costs that are a function of the crude oil price. Furthermore, under the quota system production quantities were rather stable, in particular because in 2006 EU sugar exports to third countries were limited to 1.4 million tonnes by the WTO. The effect of changing the base year can therefore be expected to be limited. Moreover, calibrating the supply function to a higher or lower base quantity mainly affects the supply level projected over the simulation period, which is not the focus of this analysis, as the paper aims to quantify the effects of VCS payments, that is, the relative and absolute differences between scenarios.

Production costs per tonne of sugar are influenced by a number of factors as for example beet prices, which are in turn affected by the prices of competing crops, as well as energy prices and the prices of by-products. As a result, changes in these variables shift the supply curve of sugar. The intercept parameter α is therefore recalculated each year based on the prevailing market price environment. Thus, the intercept parameter α implicitly accounts for effects on the supply of sugar other than the direct effect of the sugar market price.

Domestic prices of sugar are modelled by a linear function depending on a representative price $\mathrm{PFN}_{\mathrm{su,FR}}$ (price of France), the respective domestic self-sufficiency rate $\left(\frac{\mathrm{SPR}_{\mathrm{su}}}{\mathrm{UDC}_{\mathrm{su}}}\right)$ and the domestic market price of the previous year $\mathrm{PFN}_{\mathrm{su,t-1}}$. The intercept parameter α_{su} as wells as all β-coefficients are estimated by linear ordinary least squares regression:

4.1.3 | Sugar price

$$\mathrm{PFN}_{\mathrm{su}} = \alpha_{\mathrm{su}} + \beta^1_{\mathrm{su}} * \mathrm{PFN}_{\mathrm{su,FR}} - \beta^2_{\mathrm{su}} * \left(\frac{\mathrm{SPR}_{\mathrm{su}}}{\mathrm{UDC}_{\mathrm{su}}}\right) \pm \beta^3_{\mathrm{su}} * \mathrm{PFN}_{\mathrm{su,t-1}} \quad (3)$$

Production costs PFE_{su} are calculated following the approach of LMC (2013), that is, total production costs per tonne of sugar are the sum of raw material cost SCF_{su} and processing cost CPO_{su} less by-product value BPV_{su}:

4.1.4 | Production costs

$$\mathrm{PFE}_{\mathrm{su}} = \mathrm{SCF}_{\mathrm{su}} + \mathrm{CPO}_{\mathrm{su}} - \mathrm{BPV}_{\mathrm{su}} \quad (4)$$

The total by-product value per tonne of sugar BPV_{su} is calculated as the sum of by-product credits from beet pulp and molasses, with the by-product values for beet pulp and molasses being calculated by multiplying the respective by-product price by the respective by-product yield. Processing costs per tonne of sugar CPO_{su} are the sum of fixed costs, variable costs and administration costs, with variable costs depending on the price of crude oil. Raw material costs of sugar production SCF_{su} are equivalent to the sugar beet price PFN_{st} paid by sugar processors multiplied by the sugar extraction rate XTR_{su} (Equation 6).

Sugar beet prices are calculated according to Equation (5). The equation reflects the fact that after the abolition of the quota system and minimum prices for sugar beet, sugar producers are aiming to increase competitiveness by reducing beet costs to the lowest level possible, while at the same time they have to ensure that farmers include sugar beet in their crop rotation. Therefore, beet prices paid by sugar processors need to ensure that sugar beets achieve the same gross margin as the most competitive alternative crop. Thus, Equation (5) determines in a first step the maximum alternative gross margin $EGG_{ws/\mathrm{co/rs}}$ of the competing crops wheat (*ws*), corn (*co*) or rapeseed (*rs*). In addition to that gross margin the beet price paid by sugar processors also has to cover the costs for growing sugar beet GCO_{st} corrected for the amount of voluntary coupled support VCS_{st}. The whole term is divided by the expected beet yield YHT_{st} to obtain the beet price that yields the same gross margin as the most competitive alternative crop. Finally, as beet growers are usually compensated by sugar processors for the cost of beet haulage and a lower sugar content at the end of the sugar processing campaign, cost of transporting beets to the factory bgh_{st} and a late delivery premium ldp_{st} are added.

4.1.5 | Beet price

$$PFN_{st} = \left(Max\left\{EGG_{ws}, EGG_{co}, EGG_{rs}\right\} + GCO_{st} - VSC_{st}\right) * YHT_{st}^{-1} + bgh_{st} + ldp_{st} \quad (5)$$

4.1.6 | Sugar equivalent beet costs

$$SCF_{su} = PFN_{st} * XTR_{su}^{-1} \quad (6)$$

As Equation (5) shows, VCS payments enter the model as a per hectare premium. The amount of the applied premium is calculated by dividing the available budget by the sugar beet area harvested in the previous year. Hence, premiums per hectare may be higher or lower compared to the premiums listed in Table 1, as these premiums are calculated based on the available budget and the hectare limit that was initially in place. To avoid unrealistic high hectare premiums in countries, where production declines substantially over the projection period, the applied hectare premium is limited to the maximum premium paid between 2015 and 2017, reported in EC (2019c). From Equations (5) and (6) it also becomes obvious that with VCS payments in place sugar beets remain competitive in the crop rotation at a lower beet price as the VCS payment reduces the raw material costs of sugar processors. Consequently, the sugar supply function in VCS-MS shifts downwards, that is, the supply response induced by VCS payments is modelled in AGMEMOD at the sugar processing stage of the supply chain. To ensure a consistent development between sugar and sugar beet, beet quantities are derived from sugar production. This reflects the fact that sugar beets are produced domestically near to the sugar factory and rarely traded, that is, a higher demand of sugar processors for sugar beet can only be met by expanding domestic sugar beet production.

4.2 | Data

The modelling approach for the sugar market requires a comprehensive database as not only consistent market balances for sugar beet and sugar are needed, but also data on growing costs, processing costs, by-product prices and so on. In particular, data on prices and costs are scarce. The parameters required for the calculation of production costs are mainly based on LMC (2013). Market balances for sugar are taken from F.O. Licht (2018) supplemented by national statistics and FAO data (Agreste, 2019; Croatian Bureau of Statistics, 2018; FAOSTAT, 2018; SI-STAT, 2018). As prices of sugar are not published at national level due to the high market concentration in the sugar sector, EU import or export unit values for the marketing year (October–September) have been calculated from Eurostat (2019b)[3] intra-EU trade flows as a proxy for domestic prices. Also sugar beet prices, import and export quantities of sugar beet as well as the sugar beet area harvested were extracted from the Eurostat database (Eurostat, 2018, 2019a, 2019b). To ensure consistency between the market balance for sugar beet and refined sugar, sugar beet production is calculated in the AGMEMOD database as a derived variable describing the quantity of sugar beet required for the production of refined sugar and other uses (feed, bioethanol) plus net imports. Extraction rates and processing capacities are based on CEFS (2017). Supply elasticities applied to calibrate the supply function

[3]For some large producing countries export unit values have been used.

at EU-MS level range between 0.11 and 0.90.[4] Most supply elasticities are taken from Smit et al., (2017). For France and Greece the supply elasticities estimated by Poonyth et al., (2000), which are higher compared to Smit et al., (2017), are applied to reflect the strong supply response in these two countries in the first 2 years following the abolition of the quota system. In addition to the modelling of the sugar sector, the AGMEMOD model has also been extended to the isoglucose sector. Supply behaviour of isoglucose producers is modelled in a similar way as in the sugar sector, that is, supply functions are calibrated to net production costs endogenously calculated within the model assuming an own price elasticity of 0.12 (Tanyeri-Abur et al., 1993). On the demand side, cross-price elasticities are applied to model substitution between sugar and isoglucose. As data on elasticities for the EU isoglucose sector are not available, isoglucose demand functions of all EU-MS are calibrated to an own-price elasticity of −0.48 and cross-price elasticity of 0.27 estimated by Miao et al., (2010) and Uri (1994) for the United States. Isoglucose market balances and prices are derived based on production quantities published by the EU Commission and trade figures extracted from Eurostat (EC, 2019a; Eurostat, 2019b). The main data source for all other required parameters is again LMC (2013). Due to space constraints and the fact that the interlinkages of the sugar and isoglucose markets are not the main focus of this analysis, the approach for the modelling of the isoglucose sector is not explained in detail in this paper.

4.3 | Scenarios

The effects of VCS payments are investigated under two different assumptions on the future development of sugar beet yields to account for yield uncertainties arising from the ban on the use of neonicotinoids (hereafter: neonics)[5] in sugar beet, which came into force in the EU in 2018. For both yield developments, two policy scenarios are simulated to quantify the effects of VCS payments, resulting in a total of four scenarios.

The *optimistic yield development* scenario assumes yield growth of sugar beet to continue as observed in the past effectively ignoring potential yield losses that might occur due to the application ban on neonics. Thus, the scenario is based on the assumption that EU-MS with high pest pressure put emergency authorisations for use of neonics in place, as happened in the past,[6] until new viable alternatives to neonics or resistant sugar beet varieties are available.

The *pessimistic yield development* scenario assumes a drop in sugar beet yields and is based on the assumption that emergency authorisations for the use of neonics are no longer granted in the EU, while biological-technical progress cannot fully compensate for yield losses. Under similar conditions, yield losses of the 2020 sugar beet harvest in France have been estimated at 6.5% to 26.5% (EC, 2020) or—according to earlier estimates—even at 30% to 50% (Audran, 2020). Thus, the potential yield losses due to the application ban on neonics are highly uncertain, even more in the long term. In our analysis we assume a decline in sugar beet yields in all EU-MS of 15% in the pessimistic yield scenario compared to the optimistic development, which is implemented by applying a shifter to the yield function of 0.85.

The *VCS* scenario assumes under both yield developments the maintenance of VCS payments for sugar beet in 11 EU-MS until 2030. Thus, the total budget available for coupled

[4]It should be mentioned that the supply functions as defined in this analysis are not isoelastic. The assumed functional form of the supply equations implies that the function becomes more elastic at lower supply quantities.

[5]Neonics are active substances used in plant protection products to control harmful insects. Before the application ban came into force, neonics were widely used in the EU as seed coating. However, in 2018 the EU completely banned the outdoor uses of three active substances (clothianidin, imidacloprid, thiamethoxam), as they are considered harmful to pollinators.

[6]Since the application ban came into force, 10 EU-MS have repeatedly granted emergency authorisations for the use of neonics in sugar beets.

TABLE 2 EU sweetener market balance under VCS and VCS-ABOL scenario, changes relative to VCS-ABOL

		Optimistic yield development			Pessimistic yield development		
	Base year Avg. 2014–2016[b]	With VCS 2030	VCS-ABOL 2030	Abs diff. (% diff.) 2030	With VCS 2030	VCS-ABOL 2030	Abs diff. (% diff.) 2030
Sugar beet							
Area harvested (1,000 ha)	1,514	1,420	1,395	24.9 (1.8)	1,608	1,581	26.8 (1.7)
Beet yield (t/ha)	74	80	81	−0.4 (−0.4)	69	70	−0.3 (−0.5)
Production (1,000 t)	112,292	114,304	112,802	1501.4 (1.3)	111,326	109,966	1,360.4 (1.2)
Market price[a] (€/t)	31	30	31	−1.2 (−3.9)	34	36	−1.3 (−3.6)
Sugar							
Production (1,000 t)	15,930	17,857	17,621	236.4 (1.3)	17,381	17,167	213.8 (1.2)
Consumption (1,000 t)	17,334	16,931	16,922	8.5 (0.1)	16,909	16,902	7.7 (0.0)
Net exports (1,000 t)	−1,384	924	696	227.9 (32.7)	469	263	206.1 (78.3)
Ending stocks (1,000 t)	10,366	9,873	9,873	0.0 (0.0)	9,873	9,873	0.1 (0.0)
Market price[a] (€/t)	478	402	405	−3.2 (−0.8)	409	412	−2.8 (−0.7)
Isoglucose							
Production (1,000 t)	775	1,055	1,055	−0.2 (−0.0)	1,055	1,056	−0.2 (−0.0)

(Continues)

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TABLE 2 (Continued)

		Optimistic yield development			Pessimistic yield development		
	Base year Avg. 2014–2016[b]	**With VCS 2030**	**VCS-ABOL 2030**	**Abs diff. (% diff.) 2030**	**With VCS 2030**	**VCS-ABOL 2030**	**Abs diff. (% diff.) 2030**
Consumption (1,000 t)	797	900	901	−2.0 (−0.2)	902	904	−1.8 (−0.2)
Net exports (1,000 t)	−22	156	154	1.8 (1.1)	153	152	1.6 (1.0)
Market price[a] (€/t)	460	429	429	−0.5 (−0.1)	429	430	−0.4 (−0.1)

[a]Weighted by production quantities, excluding subsidies and taxes, simulated beet prices including transportation costs and late delivery premiums.
[b]Average of last 3 years before end of EU sugar quota system.
Source: Own simulation.

support to sugar beet remains unchanged at the level of 2020 (see Table 1) during simulation. Beet growers in VCS-MS receive a fixed per hectare payment rate as long as the total amount of premiums does not exceed the total budget. However, in case of budget exceeding, hectare premiums are reduced, that is, the hectare premium is recalculated based on the total budget and the beet area harvested.

The *VCS-ABOL* scenario assumes under both yield developments the abolition of VCS payments for sugar beet by the end of the current CAP financial period, that is, from 2021 onwards. This means that the available budget for supporting the sugar beet sector is set to zero without any substitution, that is, the funds previously used to subsidise the sugar beet sector are not reallocated to other sectors.

Apart from the scenario specific assumptions described above, all scenarios are based on the same macroeconomic and policy assumptions. Current agricultural policies are maintained and already decided policy changes are implemented. However, as negotiations on the terms of the United Kingdom's withdrawal from the EU had not been concluded at the time of writing this paper, the United Kingdom is still considered a Member State of the EU. With regard to the development of macroeconomic variables (GDP, inflation rate, population growth, exchange rates, etc.) and world market prices, a development according to the medium-term projection of the EU Commission is assumed (EC, 2018a; Zaitegui Perez, 2018). According to this projection, nominal world market prices of white sugar and crude oil are projected to range at a level of €363 per tonne and €76 per barrel Brent, respectively, in 2030. The exchange rate of the US dollar against the euro is expected to reach 1.20 by 2030. Regarding the development of population and income, within the period of 2014–16 to 2030 annual growth in real GDP per capita at the EU-MS level is assumed to be highest in Finland (2.3%) and lowest in Italy (1.1%).

4.4 | Results

The effect of VCS payments is calculated as the result of the VCS scenario minus the result of the VCS-ABOL scenario. Thus, calculated differences between the scenarios can be interpreted as the effects of introducing VCS payments for sugar beet.[7] Results are presented for the end of the projection period, that is, the year 2030. First, the overall effect on the EU sweetener market is illustrated, followed by a detailed description of the change in sugar production at EU-MS level. Finally, this section also presents the effects of VCS payments for sugar beet on competing crops.

Section 3 already outlined the basic economic effects of VCS payments that can be expected according to economic theory. As a direct subsidy to sugar beet VCS payments are expected to increase production in VCS-MS resulting in a fall in the market price and a decline in production in non-VCS-MS. Furthermore, consumption of sugar is likely to increase due to lower market price.

Table 2 shows the magnitude of these effects according to our simulation. Under the optimistic yield development, the market price of sugar declines by €3.2 per tonne or 0.8%, leading to an increase in sugar consumption of 8,500 tonnes or 0.1%. In total, EU sugar production increases by 236,000 tonnes or 1.3%, that is, the aggregated increase in sugar production of VCS-MS more than offsets the aggregated decline in sugar production in non-VCS-MS. Under the pessimistic yield scenario, the resulting effects of VCS payments are slightly lower, both in

[7]AGMEMOD does not consider adjustment behaviour of producers triggered by the introduction of VCS payments, for example, strategic investment decisions or the strategic decision to operate a factory until assets are fully depreciated. Under this assumption there is no difference in the size of the effect of an introduction or abolition of coupled direct payments for sugar beet and symmetric effect can be assumed.

TABLE 3 Change in sugar production, prices and production costs at Member State level, relative to VCS-ABOL, 2030.

	Optimistic yield development			Pessimistic yield development		
	Production	Prices	Costs	Production	Prices	Costs
Country	1,000 t (%) 2030	EUR/t (%) 2030	EUR/t (%) 2030	1,000 t (%) 2030	EUR/t (%) 2030	EUR/t (%) 2030
VCS-MS						
PL*	154.35	−13.70	−31.83	136.86	−12.21	−33.57
	(7.07)	(−3.44)	(−10.40)	(6.59)	(−2.98)	(−10.07)
CZ*	29.13	−5.17	−20.44	25.64	−4.62	−21.00
	(5.16)	(−1.29)	(−5.32)	(4.79)	(−1.13)	(−5.12)
IT	17.18	−1.99	−56.12	16.33	−1.83	−65.31
	(14.87)	(−0.46)	(−8.25)	(15.48)	(−0.42)	(−8.95)
HU*	12.00	−3.85	−47.13	10.36	−3.39	−48.97
	(10.63)	(−0.99)	(−11.60)	(9.67)	(−0.86)	(−11.19)
RO	11.05	−14.09	−112.54	11.07	−13.94	−130.81
	(11.12)	(−2.91)	(−22.26)	(11.42)	(−2.84)	(−23.94)
HR	10.26	−1.95	−21.18	9.96	−1.77	−24.78
	(5.02)	(−0.46)	(−5.59)	(5.18)	(−0.41)	(−6.05)
ES*	9.33	−1.49	−22.92	8.09	−1.34	−22.99
	(1.59)	(−0.35)	(−5.58)	(1.40)	(−0.32)	(−5.26)
SK	6.26	−7.67	−38.42	6.36	−7.61	−45.00
	(3.97)	(−1.76)	(−10.20)	(4.13)	(−1.72)	(−11.06)
GR	6.20	−4.81	−92.50	5.75	−4.43	−108.38
	(23.39)	(−1.05)	(−14.00)	(24.05)	(−0.95)	(−15.03)
LT	1.45	−2.37	−6.22	1.47	−2.19	−7.08
	(0.85)	(−0.51)	(−1.95)	(0.88)	(−0.47)	(−2.10)

(Continues)

TABLE 3 (Continued)

	Optimistic yield development			Pessimistic yield development		
	Production	Prices	Costs	Production	Prices	Costs
Country	1,000 t (%) 2030	EUR/t (%) 2030	EUR/t (%) 2030	1,000 t (%) 2030	EUR/t (%) 2030	EUR/t (%) 2030
FI	0.48	−2.68	−11.65	0.53	−2.50	−13.35
	(0.72)	(−0.67)	(−2.30)	(0.80)	(−0.62)	(−2.50)
Total[a]	257.70	−8.96	−30.57	232.41	−7.96	−32.60
	(5.67)	(−2.14)	(−8.49)	(5.36)	(−1.87)	(−8.40)
Non-VCS-MS						
FR	−10.08	−1.64	0.00	−8.80	−1.48	0.00
	(−0.21)	(−0.41)	(0.00)	(−0.19)	(−0.37)	(0.00)
DE	−5.80	−1.34	0.01	−5.04	−1.23	0.02
	(−0.14)	(−0.34)	(0.00)	(−0.12)	(−0.30)	(0.00)
NL	−2.17	−1.61	0.00	−1.87	−1.49	0.00
	(−0.18)	(−0.39)	(−0.00)	(−0.16)	(−0.35)	(−0.00)
AT	−0.98	−1.71	0.01	−0.85	−1.57	0.01
	(−0.19)	(−0.43)	(0.00)	(−0.17)	(−0.38)	(0.00)
DK	−0.95	−2.11	0.00	−0.82	−1.93	0.00
	(−0.23)	(−0.51)	(0.00)	(−0.21)	(−0.46)	(0.00)
UK	−0.60	−1.30	0.01	−0.53	−1.18	0.02
	(−0.05)	(−0.32)	(0.00)	(−0.05)	(−0.29)	(0.01)
SE	−0.45	−1.53	0.00	−0.39	−1.39	0.00
	(−0.14)	(−0.38)	(0.00)	(−0.13)	(−0.34)	(0.00)
BE	−0.29	−1.62	0.00	−0.26	−1.47	0.00
	(−0.04)	(−0.41)	(0.00)	(−0.03)	(−0.37)	(0.00)

(Continues)

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TABLE 3 (Continued)

Country	Optimistic yield development			Pessimistic yield development		
	Production	**Prices**	**Costs**	**Production**	**Prices**	**Costs**
	1,000 t (%) 2030	**EUR/t (%) 2030**	**EUR/t (%) 2030**	**1,000 t (%) 2030**	**EUR/t (%) 2030**	**EUR/t (%) 2030**
Total[a]	−21.33	−1.53	0.00	−18.58	−1.39	0.00
	(−0.16)	(−0.38)	(−0.00)	(−0.14)	(−0.34)	(0.00)
EU−28[a]	236.37	−3.22	−7.86	213.83	−2.83	−8.16
	(1.34)	(−0.79)	(−2.15)	(1.25)	(−0.69)	(−2.09)

[a]Average prices and costs of aggregates weighted by production quantities. Prices refer to market prices.

*Countries that need to cut their per hectare payment under the pessimistic yield scenario to ensure compliance with the national ceilings on VCS for sugar beet.

Source: Own simulation.

relative as well as in absolute terms. Overall, production declines compared to the optimistic yield development as with lower sugar beet yields sugar processors have to pay a higher beet price to ensure that sugar beets remain competitive in the crop rotation leading to an increase in beet costs. Also, the sugar beet area needs to be expanded to source enough sugar beet. Moreover, model results under both yield developments reveal that providing coupled support for sugar beet has a negative effect on the average yield level in the EU. This can be explained by the fact that VCS payments are granted mainly in less competitive countries with below-average yields. Thus, providing coupled support for sugar beet hampers the reallocation of sugar production to the most efficient regions of the EU following the abolition of the quota system by maintaining or even increasing the production level in less competitive regions.

In addition, the simulation results also reveal that the isoglucose sector is negatively affected by VCS payments for sugar beet. The effects are most pronounced with respect to consumption. Given the decline in the market price of sugar, more sugar and less isoglucose is consumed within the EU, that is, consumers substitute isoglucose by sugar. This results mainly in lower imports of isoglucose, while isoglucose production and also the market price of isoglucose decline only marginally.

Moreover, results suggest that third countries are negatively affected by VCS for sugar beet as EU net exports of sugar increase. Although the relative change in net exports appears to be large, an increase of 206,000 to 228,000 tonnes in EU net exports is unlikely to be large enough to substantially reduce the world market price of sugar, as more than 20 million tonnes of white sugar and 35 million tonnes of raw sugar are traded annually on the global sugar market (USDA, 2019). Thus, the relative change in the global trade volume resulting from EU VCS support for sugar beet is only marginal and can be easily compensated by large sugar exporters, such as Brazil, exporting annually about 5 million tonnes of white sugar and 18 million tonnes of raw sugar (USDA, 2019). However, individual third countries, in particular smaller producers, may still lose an important outlet for their sugar sale[8] as these countries might be displaced from the market by higher EU sugar sales.

Looking more closely at the change in sugar production at EU-MS level, Table 3 shows that driven by the decline in production costs VCS-MS increase sugar production, while sugar production in non-VCS-MS declines due to the fall in the market price. Under the optimistic yield development, the aggregated increase in sugar production of VCS-MS totals to 258,000 tonnes (+5.7%), while sugar production in non-VCS-MS declines by only 21,000 tonnes (−0.2%) resulting in an overall increase in EU sugar production of 236,000 tonnes (+1.3%). Under the pessimistic yield development, the absolute as well as relative effects of VCS payments on production are slightly lower compared to the optimistic yield development, at least at the aggregated levels for VCS-MS and non-VCS-MS. This seems to be rather counterintuitive, as a decline in sugar beet yield inflates the coupled premium per tonne of sugar beet and sugar leading to a stronger absolute reduction in production costs. Thus, ceteris paribus, the effect of VCS on production can be expected to be larger, at least in relative terms. However, under the pessimistic yield development the expansion in the area harvested results in a cut of the per hectare premium in some VCS-MS to ensure compliance with the national ceilings on VCS for sugar beet. Besides Hungary, in particular the large sugar producing VCS-MS Poland, the Czech Republic and Spain need to cut their hectare premium compared to the optimistic yield development. As a consequence, the absolute changes in production costs is similar in these countries under both yield scenarios, while the relative change in production costs is lower under the pessimistic yield development due to the increase in total production costs driven by

[8]In the first 2 years following the abolition of the quota system the EU has imported sugar from on average 84 countries with individual import volumes ranging from 272,000 tonnes (Brazil) to only 46 kg (Sri Lanka). In particular, developing countries export a high share of their production to the EU market as, for example, Belize (81%), Mauritius (55%), Guyana (50%), Fiji (36%), and Mozambique (23%) (avg. 2017–18, based on Eurostat (2019b), USDA (2019), converted into white sugar equivalent).

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TABLE 4 Change in area harvested in hectares, relative to VCS-ABOL scenario, 2030.

	Optimistic yield development					Pessimistic yield development				
Country	Grains	Oilseeds	Sugar beet	Protein crops[a]	Other crops[b]	Grains	Oilseeds	Sugar beet	Protein crops[a]	Other crops[b]
VCS-MS										
PL	−12,072	−1,375	13,400	−234	280	−12,597	−1,436	13,985	−244	292
CZ	−2,574	−888	3,746	−92	−192	−2,671	−921	3,887	−96	−200
IT	−1608	−163	1,993	−34	−188	−1798	−182	2,228	−38	−210
RO	−1,454	−429	1,907	−14	−10	−1,730	−524	2,283	−17	−11
HU	−942	−549	1,513	–	−22	−962	−571	1,555	–	−23
HR	−762	−281	1,082	–	−40	−869	−320	1,235	–	−47
ES	−837	−114	1,040	−61	−27	−885	−122	1,101	−65	−29
GR	−712	−97	813	–	−5	−777	−106	887	–	−5
SK	−400	−272	687	–	−15	−480	−328	826	–	−18
LT	−141	−48	202	−14	1	−172	−59	246	−17	1
FI	−113	−3	125	–	−9	−144	−5	160	–	−11
Total	−21,615	−4,218	26,508	−449	−227	−23,085	−4,574	28,395	−476	−261
Non-VCS-MS										
FR	449	168	−724	104	2	449	172	−731	108	2
DE	230	211	−449	8	0	230	217	−455	9	0
NL	134	0	−147	0	13	135	0	−148	0	13
AT	65	6	−72	1	0	65	6	−72	1	0
DK	18	55	−70	0	−3	17	57	−71	0	−3
UK	−22	71	−45	3	−3	−24	74	−46	3	−3
SE	45	−2	−40	1	−3	43	0	−41	1	−3
BE	20	1	−21	0	0	20	1	−21	0	0
Other	**3**	**7**	**−2**	**0**	**−7**	**6**	**6**	**−2**	**0**	**−7**
Total	940	516	−1,569	118	0	941	532	−1,589	122	−1
EU−28	−20,675	−3,702	24,940	−331	−227	−22,144	−4,042	26,806	−354	−261

[a]Legumes (peas, beans etc.).
[b]Other crops grown on arable land excluding fodder crops, vegetables and horticulture (mainly potatoes, but also tobacco and cotton).
Source: Own simulation.

higher sugar beet prices. Thus, the cut in the per hectare premium combined with the increase in total production cost explain the otherwise less significant supply response of large sugar producing VCS-MS under the pessimistic yield development.

Under both yield developments in absolute terms mainly Poland contributes to the increase in EU sugar production accounting alone for roughly 60% of the overall increase in sugar production of the 11 VCS-MS. However, in relative terms the increase in sugar production is strongest in Greece, followed by Italy, Romania and Hungary. This reflects the high VCS premiums per hectare granted in these countries resulting in a substantial reduction of production costs.

Compared to VCS-MS the indirect effects in non-VCS-MS are smaller. Given the increase in EU sugar production, market prices at EU-MS level decline between 0.3% and 0.5% in sugar producing countries leading to a decline in production of up to 0.2%. In absolute terms, the large sugar producing EU-MS, namely France, Germany and the Netherlands, are most negatively affected. Together these three countries account for 85% of the total decline in sugar production of non-VCS-MS.

Finally, Table 4 presents the effect of VCS payments for sugar beet on competing crops. Overall, VCS payments for sugar beet lead to an expansion of the sugar beet area in the EU and reduction in the area harvested of competing crops. These effects are stronger under the pessimistic yield development as with lower yield more area is needed for the production of sugar beet. However, because in most EU-MS sugar beets account for less than 5% of the total crop area, effects on competing crops remain limited with relative changes in the area harvested of a specific crop aggregate ranging only between +0.3% and −0.1% at individual MS-level.

As Table 4 shows, providing coupled support for sugar beet results in an expansion of the sugar beet area in VCS-MS at the expense of competing crops, whereas in non-VCS-MS less area is allocated to sugar beet and more area to competing crops. In both groups of countries, the grain sector is most affected, followed by the oilseed sector. In VCS-MS on average about 81% of the additional crop area required to expand sugar beet production is obtained by reducing the grain area and 16% by growing less oilseeds. In non-VCS-MS on average about 60% of the area no longer used for sugar beet production is allocated to grains, and 33% to oilseeds. However, in both groups of countries there are strong variations among countries. Finland, for example, expands sugar beet production almost solely at the expense of grains. Among the non-VCS-MS, Denmark substitutes most of its sugar beet area by oilseeds, while in the Netherlands the oilseed area is not being expanded at all.

5 | CONCLUSION

One of the main objectives of the past CAP reforms was to achieve a stronger market-orientation of agriculture production by gradually abolishing direct market support measures. The 2013 CAP reform reversed this process. The reform expanded the legal scope for coupled support by increasing the national ceilings and extending the list of products eligible for coupled support. A legislative amendment, which came into force at the beginning of 2018, further relaxed the legislative rules for the provision of coupled support by requiring only compliance with the national ceilings, but allowing the hectare limit to be exceeded. Thus, in contrast to the stated intention by the EU legislation, coupled direct payments may potentially give an incentive to increase production, rather than just maintain historical production levels. As part of the 2013 CAP reform the sugar sector was almost completely liberalised by abolishing production quotas and minimum beet prices. However, 11 EU-MS also introduced coupled direct payments for sugar beet. This direct support of sugar beet growing may potentially lead to market distortions within the EU among sugar producing countries and negatively affect the level playing field among crops within a country. Moreover, coupled support to sugar beet growing may increase EU sugar supply with adverse effects for third country sugar producers. Against this background the aim of this paper was to examine the effect of VCS payments on the EU sugar market, focusing in particular on the effect on sugar supply in VCS-MS and non-VCS-MS as well as the effects on the production of competing crops. As sugar beet yields are a key driver for the regional competitiveness of the sugar sector, and at the same time the future yield development is highly uncertain due to the application ban on neonics, which came into force in the EU in 2018, the effects of VCS for sugar beet were investigated under an optimistic and a pessimistic yield development.

Results show that the implementation of VCS schemes for sugar beet leads to an overall increase in EU sugar production and a decline in the market price. Sugar production shifts to less competitive countries, where sugar beet growing is subsidised by coupled support. While the overall effects of VCS for sugar beet are similar under both yield developments, a decline in yields results in a lower level of sugar production under the pessimistic yield development, as the sugar sector becomes less competitive, while the sugar beet area is expanded to source enough sugar beet. With area expansion, some of the large sugar producing VCS-MS need to cut down their hectare premiums due to the budgetary constraints on coupled support. Thus, overall effects of VCS for sugar beet on quantities and prices are slightly lower under pessimistic yield development. Among VCS-MS under both yield developments mainly Poland contributes to the increase in sugar production, whereas in relative terms the increase in production is most significant in countries with the highest per hectare payment rates, namely Greece, Italy, Romania and Hungary. However, most EU-MS granting high per hectare payments are small sugar producing countries. Therefore, the overall market-distorting effect of VCS remains limited. The decline in sugar production in non-VCS-MS does not exceed 0.3% at EU-MS level. Moreover, the effects of coupled support for sugar beet on competing crops remains limited, that is, the relative change in the area harvested of competing crops ranges only between +0.3% and −0.1%. The main reason for the limited effects on competing crops is that in VCS-MS sugar beet account only for a small share in the total crop area.

However, even though the increase in total EU net exports is only 206,000 to 228,000 tonnes of sugar, smaller third country sugar producers may be negatively affected by EU VCS support for sugar beet, as with the increase in EU net exports, producers in third countries are likely to lose an important outlet for their sugar sales.

In general, the results of this paper confirm the findings of previous studies. Results at EU-MS level are in a similar range compared to Smit et al., (2017), who used an EDM model to simulate the market effects of coupled support for sugar beet. At aggregated EU level the relative increase in EU sugar beet production under the optimistic yield development of 1.3% even exactly matches the results presented in this paper. Also the relative supply effects at MS level reported in the CAPRI-based study of Offermann et al., (2015) are in a similar range compared to the results presented here, except for Italy and Romania, where our results suggest a stronger effect of VCS payments on supply. Comparing the effect on prices, results of CAPRI show a 3.9% decline in the sugar beet price and a 0.8% decrease in the price of sugar, which is very close to our findings, while in the study of Smit et al., (2017) VCS payments for sugar beet induce a stronger drop in the EU beet price of 4.5%. However, overall, all three models show similar effects on beet production and prices, despite different approaches to the model supply behaviour of producers. In direct comparison, the supply response of producers in AGMEMOD seems to be less elastic compared to the version of CAPRI applied in the impact assessment on the CAP post-2020 of the EU Commission—as a similar reduction in prices results in a smaller decline in beet production—but more elastic compared to the EDM model—as a similar increase in production leads to a smaller price decrease. In AGMEMOD the supply response is largely driven by the assumed supply elasticities. Changing these assumptions would affect the model outcome as any other change in the model parametrisation. Thus, a sensitivity analysis was performed based on the optimistic yield scenario assuming 50% higher supply elasticities in all EU-MS in order to test the robustness of the results with respect to the supply response.

The detailed results are presented in the Appendix S1 (Tables A2 to A4). Overall, as can be expected, the price and quantity effects resulting from VCS payments for sugar beet tend to be higher with more elastic supply functions, however, the general conclusions that can be drawn from the results do not change. In the sensitivity scenario, VCS payments lead to a 6.9% increase in total sugar production of VCS-MS (compared to 5.7% under the optimistic yield development), resulting in a 1.0% fall in the EU market price of sugar (compared to 0.8%) and a 0.3% decline in total sugar production of non-VCS-MS (compared to 0.2%).

Besides the level of the supply elasticities, both the underlying data as well as the approach applied to derive per unit production costs of sugar processors could have a strong influence on the results. In this paper the approach and data for calculating per unit production costs at EU-MS level is based on LMC (2013), that is, per unit production costs applied to calibrate the model's supply function represent average costs at country level. Using marginal costs at factory level would certainly improve the model outcome. However, more accurate data for production costs would mainly affect the absolute level of production over the projection period, rather than the supply response to a change in policy. Moreover, data on production costs, in particular at the processing stage, is rarely available in literature and LMC (2013) already is one of the most reliable sources.

A further limitation of the current approach is that the AGMEMOD model applied here is a partial equilibrium model based on the assumptions of perfect competitive markets ignoring strategic behaviour and the presence of market power. However, market power might prevail in the sugar market, since the market is highly concentrated, at least at the sugar processing stage of the supply chain. Ignoring market power and strategic behaviour might lead to an underestimation of the effects of coupled support, as during the consolidation process following the abolition of the quota system, companies might tend to close a sugar factory in countries where the government decided against subsidising the sugar beet sector.

Moreover, AGMEMOD allows to analyse the effects on third countries only to a limited extent. This is mainly because the model has a strong focus on the EU-MS, as most other countries are grouped to one ‘Rest of the World’ aggregate and are not modelled explicitly. Also, trade flows are not modelled on a bilateral basis. A more detailed analysis of the effects of VCS for sugar beet on third countries would therefore require a linkage to a global sugar market model covering also bilateral trade flows between the EU and smaller sugar producing countries, as for example the model applied by Nolte et al., (2012).

Nevertheless, the strength of the AGMEMOD model is that it depicts the interlinkages between different crop sectors at EU-MS level, allowing for a detailed analysis of the effects of VCS for sugar beet on the markets of competing crops as well as sugar substitutes on the demand side. Although the CAPRI model, in principle, would also allow for such an analysis, in the impact assessment of the EU Commission results were only published for the sugar beet sector of the EU-28 and Offermann et al., (2015) present results only for selected EU-MS. Furthermore, compared to Smit et al., (2017) a more sophisticated approach is applied to overcome the problem of modelling supply behaviour of sugar producers following the abolition of the quota system by calibrating the supply curves to per unit production costs endogenously calculated within the model. Also, the modelling approach applied ensures that countries do not exceed existing beet slicing capacities as well as the national ceilings for the VCS scheme. Moreover, unlike static approaches such as CAPRI and the EDM model applied by Smit et al., (2017), AGMEMOD as a recursive dynamic model is able to capture adjustments over time and time lags. This is particularly important with respect to the modelling of the EU sugar market, as the sector currently undergoes a dynamic restructuring process, while sugar beets are grown under contracts negotiated about one and a half years before the area is actually harvested. Thus, production decisions are modelled in AGMEMOD based on expected prices and yield, that is, a 3- or 5-year average of the previous years. Also, the dynamic approach of AGMEMOD accounts for adjustments in processing capacities, as for example the closures of sugar beet factories in France, Germany and Poland in the first years of the post-quota period (EC, 2019b).

Even though results suggest that the market-distorting effect of VCS payments for sugar beet are limited, providing coupled support for sugar beet cannot be supported from an economic point of view, since it contradicts the aim of an efficient resource allocation, negatively affects the level playing field and avoids or at least hampers the concentration of sugar production in the most competitive regions following the abolition of the quota system. As a temporary measure, supporting less competitive countries by VCS payments may be politically and economically justifiable in order to give these countries the opportunity to adapt to the new market conditions following the abolition of the sugar quota system. In the long term, however, providing coupled support for sugar beet contradicts one of the main objectives of previous CAP reforms, namely to achieve a stronger market orientation of agriculture production and to reduce market distortions caused by direct support measures.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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Coupled support for sugar beet in the European Union: Does it lead to market distortions?

Marlen Haß

ON-LINE APPENDIX

Table A1. Data used for calibration of sugar supply functions

EU-MS	Sugar production (1000 t)	Sugar beet for ethanol (1000 t)	Extraction rate (%)	Own price supply elasticity (standard)	Own price supply elasticity (sensitivity analysis)
	$\overline{SPR\_0}_{su}$	$\overline{UOD\_0}_{st}$	$\overline{XTR\_0}_{st}$	ε_{su}	ε_{su}
AT	491	-	-	0.25	0.38
BE	766	-	-	0.06	0.09
CZ	550	710	15.0	0.50	0.75
DE	3,894	2,026	15.8	0.22	0.33
DK	438	-	-	0.23	0.35
ES	549	-	-	0.14	0.21
FI	77	-	-	0.23	0.35
FR	4,205	7,211	16.3	0.23	0.34
GR	47	-	-	0.83	1.25
HR	206	-	-	0.50	0.75
HU	116	-	-	0.50	0.75
IT	347	-	-	0.90	1.35
LT	145	-	-	0.23	0.35
NL	992	-	-	0.33	0.50
PL	1,748	-	-	0.50	0.75
RO	100	-	-	0.23	0.35
SE	357	-	-	0.23	0.35
SK	148	-	-	0.23	0.35
UK	1,078	496	15.4	0.11	0.17

Source: AGMEMOD model database.

Table A2. EU sweetener market balance under VCS and VCS-ABOL scenario assuming optimistic yield development and high supply elasticities

	Average 2014-2016[b)]	With VCS 2030	VCS-ABOL 2030	abs diff. 2030	% diff. 2030
Sugar beet					
Area harvested (1000 ha)	1,514	1,446	1,416	30.1	2.1
Beet yield (t/ha)	74	80	81	-0.4	-0.5
Production (1000 t)	112,292	116,373	114,535	1,838.6	1.6
Market price[a)] (€/t)	31	30	31	-1.2	-3.7
Sugar					
Production (1000 t)	15,930	18,199	17,910	289.2	1.6
Consumption (1000 t)	17,334	16,945	16,934	10.4	0.1
Net exports (1000 t)	-1,384	1,252	973	278.8	28.6
Ending stocks (1000 t)	10,366	9,873	9,873	0.0	0.0
Market price[a)] (€/t)	478	396	400	-4.1	-1.0
Isoglucose					
Production (1000 t)	775	1,055	1,055	-0.3	0.0
Consumption (1000 t)	797	897	899	-2.5	-0.3
Net exports (1000 t)	-22	158	156	2.3	1.4
Market price[a)] (€/t dry weight)	460	428	429	-0.6	-0.1

a) Weighted by production quantities, excluding subsidies and taxes, simulated beet prices including transportation costs and late delivery premiums

b) Last three years before end of EU sugar quota system.

Source: own simulation.

Table A3. Change in sugar production, prices and production costs at Member State level assuming optimistic yield development and high supply elasticities, relative to VCS-ABOL, 2030

	Production		Prices		Costs	
Country	**1000 t**	**%**	**€/t**	**%**	**€/t**	**%**
VCS-MS						
PL	193.24	8.2	-17.02	-4.5	-29.29	-9.6
CZ	39.04	6.8	-6.65	-1.7	-19.92	-5.2
HU	17.09	15.4	-5.19	-1.3	-46.16	-11.4
RO	16.22	16.4	-20.19	-4.2	-112.53	-22.3
HR	15.97	7.5	-2.40	-0.6	-21.17	-5.6
IT	15.03	22.7	-2.26	-0.5	-56.12	-8.2
ES	13.63	2.3	-1.86	-0.4	-22.05	-5.4
SK	9.12	5.6	-10.76	-2.5	-38.43	-10.2
GR	7.19	36.4	-5.67	-1.2	-92.49	-14.0
FI	0.57	0.9	-3.27	-0.8	-11.65	-2.3
LT[b)]	0.00	0.0	-2.40	-0.5	-6.22	-1.9
Total[a)]	**327.09**	**6.9**	**-11.52**	**-2.8**	**-28.44**	**-8.0**
Non-VCS-MS						
FR	-18.68	-0.4	-2.00	-0.5	0.00	0.0
DE	-9.66	-0.2	-1.46	-0.4	0.02	0.0
NL	-3.66	-0.3	-1.66	-0.4	0.00	0.0
DK	-1.70	-0.4	-2.43	-0.6	0.00	0.0
AT	-1.68	-0.3	-1.85	-0.5	0.01	0.0
UK	-1.13	-0.1	-1.53	-0.4	0.02	0.0
SE	-0.83	-0.3	-1.81	-0.5	0.00	0.0
BE	-0.55	-0.1	-1.97	-0.5	0.00	0.0
Total[a)]	**-37.91**	**-0.3**	**-1.76**	**-0.4**	**-0.01**	**0.0**
EU-28[a)]	**289.2**	**1.6**	**-4.15**	**-1.0**	**-7.64**	**-2.1**

a) Average prices and costs of aggregates weighted by production quantities.
b) LT is producing at its capacity limit under both scenarios.
Source: own simulation.

Table A4. Change in area harvested in ha assuming optimistic yield development and high supply elasticities, relative to VCS-ABOL scenario, 2030

Country	Grains	Oilseeds	Sugar beet	Protein crops[a)]	Other crops[b)]
VCS-MS					
PL	-15,089	-1,720	16,751	-292	350
CZ	-3,152	-1,086	4,586	-113	-234
RO	-2,013	-608	2,653	-19	-13
HU	-1,260	-717	2,006	–	-29
IT	-1,386	-140	1,719	-29	-163
HR	-1,168	-434	1,671	–	-70
ES	-1,053	-140	1,303	-77	-34
SK	-570	-391	982	–	-21
GR	-820	-112	937	–	-5
FI	-122	-2	134	–	-10
LT	-64	-23	95	-7	-1
Total	**-26,697**	**-5,372**	**32,837**	**-537**	**-232**
Non-VCS-MS					
FR	883	284	-1,341	170	4
DE	433	300	-747	14	0
NL	225	0	-248	0	22
DK	50	79	-126	1	-4
AT	108	12	-122	2	0
UK	-7	93	-84	5	-3
SE	94	-16	-74	2	-5
BE	37	1	-38	0	0
Other	1	11	-2	0	-8
Total	**1,824**	**765**	**-2,783**	**194**	**7**
EU-28	**-24,873**	**-4,607**	**30,054**	**-343**	**-226**

a) Legumes (peas, beans etc.); b) Other crops on arable land excluding fodder crops, vegetables and horticulture (mainly potatoes, but also tobacco and cotton).
Source: own simulation.

Article (5):

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

Marlen Haß

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

Marlen Haß[†]

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:

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

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

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:

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

Supply function of isoglucose:

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

Demand function for sweetener:

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

Ending stocks of sugar:

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

Market clearing:

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

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

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

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

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

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

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:

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

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

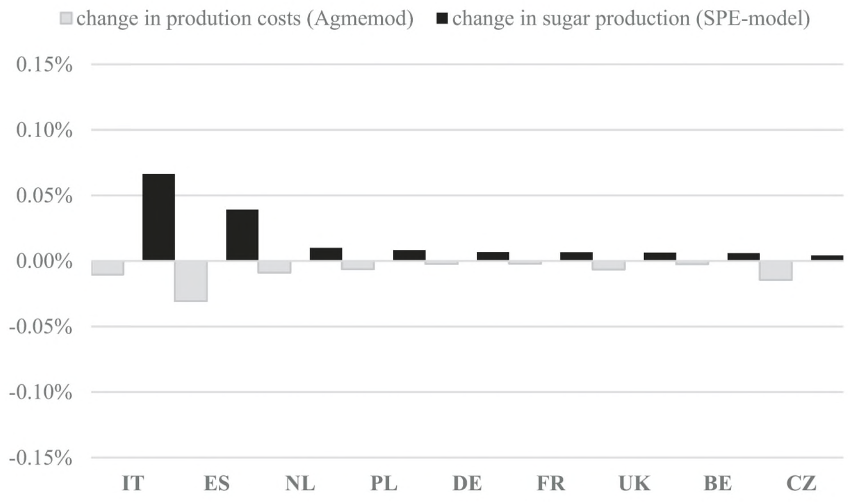

Figure 1 Change in production costs of sugar and sugar production for selected EU MS after 1. iteration in per cent (scenario 'EU MFN_zero', 2030/31). Source: own simulation.

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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3 GENERAL CONCLUSIONS

This section summarises the main findings of this thesis, discusses the major limitations of the applied model approaches and highlights directions for future research. Finally, section 3.3 provides policy recommendations that can be drawn from the findings of the articles included in the thesis.

3.1 Summary of key findings

The overall aim of this thesis is to provide insights into the effects of changes in the EU sugar regime on the EU sweetener market as well as the global sugar market. Specifically, three research questions were identified that have been poorly investigated in previous research. These research questions are addressed in article (2), (4) and (5) by providing own model-based quantitative results. The following paragraphs summarise the key findings of these three articles.

Article (2) investigates the consequences of the abolition of the EU quota system in 2017. Results are simulated for the target year 2020/21 (Oct.-Sep.) assuming three different future developments of the world market prices for sugar, grains, oilseeds and crude oil. Compared to previous studies, the analysis considers bilateral intra-EU trade of sugar and isoglucose and thus captures the price-driven competition between these two close substitutes. This competition is likely to intensify in the post-quota period, since the main reason for the introduction of production quotas for isoglucose was to protect the sugar sector from competition with close substitutes. Moreover, the analysis goes beyond previous model-based impact assessments by simulating the supply behaviour of sugar and isoglucose producers based on empirical data on production costs (raw material costs plus processing costs corrected for by-product values).

Overall the effects presented in article (2) are well in line with the results of other studies (EC 2011; SMIT et al. 2012; BURRELL et al. 2014; NOLTE et al. 2012). Under all simulated world market price scenarios, the most competitive EU MS increase sugar production in response to the abolition of the EU quota system. Moreover, EU sugar producers redirect sales from the global to the EU market substituting quantities imported from preferential high-cost EU trading partner or sugar produced in less competitive EU MS. Thus, EU sugar exports and imports decline (-55% to -100% and -30% to -95%, respectively) and the EU domestic market price drops (-5% to -28%). At high world market prices, the EU switches from a net importer of sugar (2.2 mill. t wse) to a slight net export position (0.4 mill t wse). While total EU isoglucose production increases under all simulated world market price scenarios (+43% to +174%), total EU sugar production substantially increases compared to the quota scenario only at high world market prices (+17%) and even declines if world market prices are assumed to be low (-9%).

However, looking more closely at the results at individual member state level, effects are quite divers. Based on their supply behaviour in response to the abolition of production quotas, article (2) identifies three groups of countries as being most, medium and least competitive. EU MS belonging to the first group are simulated to increase or at least maintain sugar production regardless of the assumed world market price level (0 % to + 31 %). Thus, these countries are identified as the most competitive sugar producing EU MS, where sugar production is likely to concentrate in the post-quota period. This group includes Poland*, the United Kingdom, the Netherlands, Belgium, Croatia*, Hungary* and Lithuania[7]. Compared to other EU MS these countries rank among the sugar producers with the lowest production costs. On the other hand, the model results show a decline in sugar production under all assumed world market price levels in the high-cost sugar producing EU MS (- 2 % to - 59 %). Namely these rather uncompetitive EU MS are Italy, Denmark, Greece and Finland. Finally, sugar producing EU MS that increase sugar production under the quota abolition scenario at high world market prices (up to + 33 %), but decease sugar production, if world market prices are assumed to be low (up to - 44 %) are classified as moderate competitive. Surprisingly, except Poland, also the largest sugar producing EU MS France and Germany belong to this group. On one hand, this can be explained by higher production cost compared to the most competitive sugar producing EU MS. Moreover, France and Germany are already sugar surplus regions under the quota scenario. Consequently, any additional quantities produced under the quota abolition scenario need to be exported. Thus, France and Germany have a cost disadvantage in transportation compared to sugar producers located in sugar deficit regions. This reveals that not only production cost, but also the distance to the major deficit regions inside and outside the EU and corresponding transportation cost are a key factor of competitiveness, partly explaining the moderate competitiveness of France and Germany.

Moreover, the results of article (2) reveal that transportation cost is an important factor determining the competitiveness of sugar relative to isoglucose. This is because isoglucose is more expensive to transport due to its liquid consistency. In the model-based analysis this is taken into account by applying a transport cost premium of ten per cent over sugar, when compared on a dry weight basis[8]. In addition, the model-based analysis of article (1) shows that compared to sugar, production costs of isoglucose are stronger influenced by changes in world market prices. Consequently, the competitive position of sugar relative to isoglucose improves with increasing world market prices and deteriorate with falling world market prices. Thus, sugar is increasingly being substituted by isoglucose at low world market prices reaching an EU market share of up to 10 per cent according to the model simulations. However, simulation results also reveal that isoglucose production could decline in certain EU MS in the post-quota period, in particular under the assumption of high world market prices. Namely, these EU MS are Italy, Germany and Belgium. While Italy ranks among the high-cost producers in the EU, Germany and Belgium are sugar surplus regions and do thus have a transportation

[7] Countries marked with an asterisk (*) grant coupled payments for sugar beet, which increases their competitiveness. Please also note that coupled payments for sugar beet granted in Lithuania were not considered in the analysis, as these were first introduced in 2017, i. e. after the publication of article (1). Also, at the time of writing article (2) the UK was still a member of the EU.

[8] When comparing the competitiveness of isoglucose relative to sugar, transportation and production costs need to be compared on a dry weight basis, i. e. transportations and production costs of isoglucose need to be converted from commercial (wet) weight into dry weight, because only then do both products have a similar sweetness and can be substituted one-by-one.

cost-disadvantage compared to isoglucose producers located in or close to the sugar deficit regions of the EU, such as Spain, Portugal, Bulgaria and Hungary.

Article (4) assesses the market-distorting effects of coupled support payments for sugar beet under two different assumption regarding the future development of sugar beet yields. Coupled support payments for sugar beet were introduced on a voluntary basis as part of the 2013 CAP reform and have been applied by 11 of 19 sugar beet producing EU MS (so-called voluntary coupled support, VCS). Against this background, article (4) provides a model-based policy impact assessment at EU MS level. The analysis quantifies the change in production cost caused by VCS payments for sugar beet and the resulting changes in sugar production, sugar prices and changes in land allocation. Results are presented for the target year 2030. Methodologically, this article adds to the literature by modelling the supply response of EU MS based on empirical data on production costs drawing on the approach developed in article (2). Moreover, VCS payments are calculated endogenously from the available budget thus ensuring compliance with the national ceilings. In particular, the analysis goes beyond previous studies for two reasons: First, the effects of coupled support to sugar beet are investigated under two different yield scenarios (optimistic: no change in yield growth; pessimistic: 15 per cent lower yield growth) to account for yield uncertainties arising from the application ban on certain insecticides that came into force in the EU in 2018. Second, previous studies have been limited to the sugar beet or sugar sector, while article (4) also quantifies the effects on other arable crops competing with sugar beet.

The results show that the implementation of VCS schemes for sugar beet leads to an overall increase in EU sugar production of about 1.3 per cent and a decline in the market price of nearly 1 per cent. Sugar production shifts to the EU MS, where sugar beet growing is subsidised by coupled support (hereafter VCS-MS). These principal effects can be observed under both yield scenarios. However, when assuming a decline in yield growth of about 15 per cent, the EU sugar sector becomes less competitive and sugar production decreases compared to the optimistic yield scenario, while the sugar beet area needs to expand to source enough sugar beet. As a consequence of the area expansion, some of the large sugar producing VCS-MS need to cut-down their hectare premiums to ensure compliance with the budgetary constraints on coupled support. Thus, the overall price and quantity effects of coupled payments are slightly lower under the pessimistic yield scenario. In the optimistic yield scenario sugar production increases on average by 5.67 per cent in VCS-MS (compared to 5.36 in the pessimistic yield scenario), while the average market price falls by 2.14 (compared to 1.87). In non-VCS MS the decline in the average market price equals 0.38 per cent in the optimistic yield scenario (compared to 0.34 in the pessimistic yield scenario) leading to an average decrease in sugar production of 0.16 per cent (compared to 0.14 per cent).

Under both yield scenarios mainly Poland contributes to the increase in sugar production of VCS-MS, whereas in relative terms the increase in production is most significant in countries granting the highest per hectare payment rates, namely Greece, Italy, Romania and Hungary. In these countries VCS payments lead to an increase in sugar production between 9.67 and 24.06 per cent. However, the EU MS paying high per hectare payments are small sugar producing countries. This explains the overall limited market-distorting effect of VCS payments on sugar production.

Also, the effects of coupled support for sugar beet on competing crops are only minor. The relative change in the area harvested of competing crops ranges only between +0.3 and -0.1 per cent. The main reason for these limited effects on competing crops is the rather small share of sugar beet in the total crop area not exceeding 3.5 per cent most EU MS (exceptions are the Netherlands: 8.1% and Belgium: 6.8%, avg. 2018-20) (EUROSTAT 2022).

In general, the results of article (4) confirm the findings of previous studies that report price and quantity effects in a similar range (OFFERMANN et al. 2015; EC 2018; SMIT et al. 2017). Moreover, a sensitivity analysis was performed in order to test the robustness of the results with respect to the supply response. Assuming 50 per cent higher supply elasticities across all EU MS, VCS payments lead to a 6.86 per cent increase in total sugar production of VCS-MS (compared to 5.67 per cent under the optimistic yield development), resulting in a 1.04 per cent fall in the EU market price of sugar (compared to 0.79 per cent) and a 0.38 per cent decline in total sugar production of non-VCS-MS (compared to 0.16 per cent). Hence, as can be expected, the price and quantity effects resulting from VCS payments for sugar beet tend to be higher with more elastic supply functions. However, the general conclusions that can be drawn from the results do not change.

Article (5) examine the consequences of changes in the EU sugar regime on non-EU countries. Since the simulated scenarios show a quite dynamic development over the simulation period, results are presented not only for the target year 2030, but also for the average of the period 2024-26. Compared to article (2) and (4) a broader range of policy scenarios is modelled assuming a gradual phasing-out of all domestic support and border protection measures. Thus, the scenarios are partly hypothetical, as so far EU tariffs on sugar have only been reduced under regional trade agreements which provide tariff preferences to a limited number of countries. Moreover, the EU recently decided that VCS payments for sugar beet will remain in place during the next financial period of the CAP (Regulation (EU) 2021/2115, Article 33).

In the existing literature, only few studies have addressed the trade-distorting effects of changes in the EU sugar regime (CHAPLIN et al. 2006; VAN BERKUM et al. 2005; ELBEHRI et al. 2008; MATTHEWS 2008; CALÌ et al. 2013; KOPP et al. 2016; NOLTE et al. 2012). One reason might be that only few models have a sufficiently detailed country coverage including also those small countries that are important preferential sugar exporters, but of minor importance in total agricultural trade. Moreover, only few models are able to sufficiently capture the complex global tariff regulation for sugar, under which quantities important at a reduced preferential tariff rate are often limited by tariff-rate-quotas. However, the SPE model applied in article (2) allows for such an analysis. Thus, this model is linked to the Agmemod model developed in article (3) and (4), whose key strength is to determine the EU supply response in the post-quota period based on empirical data on production costs taking into account the competitive position of sugar beet in the crop rotation.

Overall, results of article (5) show that sugar production of most third countries declines as a consequence of a progressive full liberalisation of the EU sugar market. This decrease in production is mainly the result of the abolition of the EU quota system, which leads to an increase in EU production, a drop in the EU sugar price and thus erosion of the preference margin for third countries resulting in a decrease in EU imports. An elimination of EU MFN tariffs can partly, fully or even over-compensate for the negative effect on sugar production of third countries. However, an over-compensation, i.e., increase in sugar production remains limited to selected countries and periods of low global sugar prices. During these periods EU imports from Brazil increase significantly, creating export opportunities for other sugar exporters to markets previously supplied by Brazil. Moreover, trade diversions can lead to less competition on the domestic market of net importing countries, such as the US and China, allowing domestic sugar producers to increase their sugar production.

The third countries found to be most negatively affected from a liberalisation of the EU sugar regime are small preferential sugar exporters that face high trade barriers (tariffs, transportation cost) to other markets thus exporting 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 that export 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. Sugar production of these countries declines up to 23.1 per cent.

Fiji and Papua New Guinea belong to the group of LDC-ACP countries, which have been in the past traditional preferential sugar exporters accounting for more than 50 per cent in total EU imports. The results of article (5) reveal, however, that LDC-ACP countries are the first group of countries being squeezed out of the EU market as a consequence of any liberalisation of the EU sugar regime. In particular, LDC-ACP countries lose market shares due to increasing imports under regional trade agreements concluded in recent years. Thus, most LDC-ACP countries are less affected by further liberalisation steps, such as the abolition of the EU quota system. Fiji and Papua New Guinea are exceptions in this respect, because both countries are not well integrated into the global sugar market and do therefore fail to re-direct sugar exports to alternative outlets.

3.2 Limitation and future research

The quantitative analyses included in this thesis are subject to limitations with respect to the method and scope that need to be pointed out. In detail, these limitations have already been discussed in the respective articles. The following paragraphs summarise again the most relevant aspects that may also provide a starting point for further research.

First, the quantitative analyses build on two partial equilibrium models that were both extended to the isoglucose sector. In contrast to previous model-based studies, this extension allows to capture the price- and cost-driven competition between sugar and isoglucose at EU MS level that is likely to intensify in the post-quota period. However, while most sugar processors can increase sugar production by lengthening the sugar processing campaign, existing isoglucose processing capacities are limit. A substantial increase in isoglucose production does therefore require investments in new factories. In partial equilibrium model these strategic investment decisions can only be captured in a simplified way by applying exogenous shifters to the supply functions. Moreover, the supply functions need to be calibrated to observed base data making it difficult to model the supply of countries that did not produce isoglucose under the quota system, but could enter the market in the post-quota period. In principal this also applies for the sugar sector, however, prior to the abolition of the quota system, investments in new processing capacity were expected to occur in particular in isoglucose sector. This is because production quotas for isoglucose (and inulin) have only been introduced to protect the sugar sector from competition with low-cost substitutes. Hence, in particular the simulated expansion of the isoglucose sector relies to some extent on expert knowledge and plausible assumptions regarding the magnitude of applied shifters and the selections of countries that are likely to enter the isoglucose market. The observed development in the first years of the post-quota period showed that, contrary to expectations in the run-up to the quota abolition, only few EU MS have increased isoglucose production with the Netherlands and Austria entering the isoglucose market, while total EU production even declined (EC various years). These observed market developments in the post-quota period were taken into account in article (4) and (5), as these two articles were published after the abolition of the quota system, while article (2) represents an ex-ante policy impact assessment carried out before any actual market developments could be observed. Given the above-mentioned limitations, it will be important for future research to carefully monitor the (dynamic) development of the EU isoglucose market and to continuously update the model databases and parameters to the most recent statistics and (expert) expectations.

Second, the quantitative analyses are based on empirical data on production costs used to calibrate the supply functions for sugar and isoglucose of EU MS. The data was obtained from LMC (2013) and includes cost components that are corrected for changes in input prices. These corrections, however, are not applied to all cost components in the data set. Examples of endogenous cost components being corrected for changes in input prices are raw material cost (sugar beet, wheat, corn price), by-product values[9] and energy costs of sugar and isoglucose processing. Constant cost components include in particular fixed processing costs comprising permanent labour, fixed cost component of repairs and maintenance, depreciation and return on capital. Compared to the actual average costs in 2010/11 to 2012/13, the cost used in the analyses were adjusted for expected efficiency gains resulting from lengthening the processing campaign to the maximum possible limit. In the last few years, however,

9 By-product values are derived based on fixed extraction rates, but variable prices (see Appendix A for details).

most large sugar processing companies have made substantial investments to further reduce their processing and logistic costs. This might not be adequately reflected in data. Moreover, structural changes, i. e., factory closures observed since 2017, are only taken into account by reducing the processing capacity limit of a country. This neglects that sugar processors will most likely close factory with above-average processing cost resulting in a decline in the average processing cost per country.

Moreover, another limitation related to the representation of production costs in the model is that derived beet prices, i. e. raw material cost of sugar production, do not exactly represent beet prices paid by sugar processors. By deriving the beet price from the gross margin of the most competitive alternative crop the approach ensures that sugar beet growing remains economically attractive for farmers in the post-quota period. In principal, sugar processors calculate beet prices offered to beet growers in a similar way, however, across the EU a wide variety of sugar beet contracts exists. Most sugar processors offer several contracts from which sugar beet growers can choose their preferred option. Moreover, in most contracts the so-called 'basic price' is corrected for various premiums paid for, e.g., late or early delivery, a sugar content deviating from the standard of 16 per cent or for beet pulp. In addition, some sugar processors even pay loyalty premiums to beet growers who consistently deliver the contracted beet quantity for at least two consecutive years. Moreover, in most contracts the basic beet price depends on the sugar revenue of sugar processors. Reflecting all these individual contract specifications in the model would most probably lead to changes in beet cost affecting the relative competitiveness among EU MS. Since beet cost account for a large proportion of total net-production costs (50 % to 70 %)[10], the change in competitiveness could be substantial depending on how large the differences between the beet price derived from the expected gross margin of the most competitive alternative crop and the beet price actually paid by sugar processors according to the current beet contract are. Thus, representing different beet contracts in the model would further improve the approach and could be a topic for future research. However, publicly available data on the exact contract specifications as well as the percentage of sugar beet area grown under a specific contract is currently lacking. Moreover, contracts usually have a duration of one to three years and are likely to be adjusted afterwards.

Finally, it needs to be mentioned that derived production costs for sugar and isoglucose represent average cost rather than marginal cost. As well-known from economic theory, the marginal cost curve – representing the supply curve in its upward sloping part – crosses the average cost curve in its minimum. Thus, the approach indirectly assumes that all sugar processors produce the base quantity at minimum average cost. If this is not the case, the derived average costs used to calibrate the supply function would need to be corrected shifting the supply curve upwards. However, data on production cost is scarce and the empirical data of LMC (2013) used in the analysis is already one of the most reliable sources. Nevertheless, more research is needed to estimate the correct position and slope of sugar and isoglucose supply functions.

[10] According to LMC (2013).

While the abolition of the quota system poses exceptional methodological challenges, some other uncertainties regarding the model specification and parametrisation need to be mentioned that are not specific to this analysis. Any model-based simulation relies on numerous assumptions regarding the assumed functional forms, level of supply and demand elasticities, shifters and other exogenous drivers. Changing one of these assumptions will affect the entire model outcome. This should be kept in mind when interpreting the results. To a certain extend uncertainties regarding the model parametrisation can be addressed in a sensitivity analysis by varying selected assumptions that are expected to have a strong influence on the results. In the quantitative analysis of article (2), for example, the consequences of the abolition of the quota system were simulated under three different assumptions regarding the future development of world market prices. Also, the model-based impact assessment on the effects of VCS for sugar beet, presented in article (4), accounts for yield uncertainties by assuming two different future developments of sugar beet yields. Moreover, the level of supply elasticities was systematically increased to test the robustness of the results. Nevertheless, improving the model parametrisation and updating the databases of the applied models to the most recent market developments remains an important task for future work and is an ongoing, never-ending exercise.

Looking forward, further research should focus on improving the representation of sugar consumption and policy measures affecting the demand side in economic models. The research conducted in this thesis assesses mainly the effects of policy changes on the supply of sugar. In recent years, however, policy measures aimed at reducing sugar consumption have received increasing attention from policymakers and the public. This is mainly because high levels of sugar intake are associated with health concerns, in particular obesity and its accompanying diseases, such as diabetes and high blood pressure. Thus, many countries around the globe have introduced policy measures during the last couple of years in order to reduce per capita consumptions of sugar (GFRP 2021c, 2021a, 2021b). Most popular measures are taxes on high sugary drinks, but there are also other policy instruments, such as voluntary or mandatory agreements between the food industry and government to reduce the sugar content of certain products or within certain commodity groups (so-called ‘reformulation strategies’). Other measures are voluntary or mandatory food labelling systems (e.g., traffic light, nutri-score) or advertising bans for high sugary products targeted at children.

All these measures aimed at reducing sugar consumption are currently not implemented in the two models applied in this thesis, despite a growing need for ex-ante policy impact assessment in this field to quantify the actual market effect of consumption related policy measures. Over past decades, however, agricultural policy measures focused almost exclusively on regulating the supply and trade of agricultural products. Thus, it is not surprising that in the development of agricultural models more emphasis has been put on the supply side. As a consequence, the models’ demand systems need to be carefully revised, before any reliable policy impact assessments of the above-mentioned consumption related policy instruments can be carried out, in particular with respect to the demand elasticities, as these will be crucial in determining the demand response of consumers to any price-driven policy change. Moreover, as described above, most policy measures aimed at reducing sugar consumption do not target sugar consumption in general, but only selected high sugary products or products primary sold to highly vulnerable social groups, e.g. children. Therefore, a more realistic and detailed representation of these policy measures requires a further disaggregation of the demand system of most economic models in order to capture the demand for different processed products and ideally also the demand of different social groups. While this is certainly an interesting topic for future research, the biggest challenge is in the data availability. This is because detailed statistics on consumption are lacking. Moreover, existing statistics are often of poor quality, since consumption figures are mostly not directly reported, but derived as residual from reported trade flows and production figures.

A second major topic for future research related to the demand of sugar is a better representation of the use of sugar for non-food purposes in economic models. Mostly due to data constrains and the rather small shares of non-food sugar in total sugar use, demand for non-food purposes other than ethanol is currently represented in a very aggregated way in most economic models. In recent years, however, the global public has become increasingly concerned about environmental issues and is putting more pressure on policymakers to set and achieve ambitions environmental target. With its 'Bioeconomy Strategy' launched already in 2012 and 'Circular Economy Proposal' published in 2015, the EU, for example, aims to strengthen and scale up the bio-based sectors with the overall goal of moving form a linear economy based on the extensive use of fossil and mineral resources to a circular bio-based economy. In light of these developments the use of sugar for non-food purposes, such as bio-plastics, could gain significant market share supported by policy measures targeting growth of the bioeconomy. which are likely to be introduced in the coming years. Thus, the need for ex-ante policy impact assessments can be expected to increase in this field in order to identify the most effective and efficient ways to transform the economy from a linear to a circular system.

However, despite the need for model-based quantitative research in this field, at this point it also has to be mentioned again that innovations and very dynamic market developments can only be captured to a limited extend in equilibrium models. Similar to the assessment of the future development of the isoglucose market included in this thesis, any analysis of the potential evolution of new bio-economy sectors relies to a large extent on assumptions regarding strategic investment decisions in processing capacities as well as changes in consumer preferences that can only be captured by exogenous shifters. Moreover, cross- and own-price elasticities are hardly available for innovative products in the existing literature and long-data series that could be used for own estimations are lacking. Despite these methodological challenges, however, the implementation of new bio-economy sectors will be an important topic for future research. In particular, economic models could provide a corridor of quantitative results representing different possible pathways. Moreover, the quality and availability of data can be expected to improve over time.

Regarding the representation of bilateral trade flows, the current version of the SPE model could be further improved by extending the SPE model to the sugar refining sector. Although the representation of trade polices has been further improved compared to the first published version of the SPE model by including multi-regional tariff-rate quotas, all sugar is still modelled in white sugar equivalent. As already pointed out by NOLTE (2008), this misspecification of real world relationships partly explains why simulated bilateral trade flows can substantially deviate from observed trade figures. Moreover, differentiating between raw and refined sugar would allow for an even more sophisticated representation of trade policies, since most countries apply different tariff rates for raw and refined sugar. Also, preferential imports under tariff rate quotas are often limited to raw sugar. However, while international trade and world market price statistics distinguish between raw and refined sugar, statistics on production and consumption are currently only available in raw or white sugar equivalent or tel quel[11]. Therefore, modelling raw and white sugar as two distinct products remains a topic for future research that highly depends on improved data availability.

3.3 Policy recommendations

With the decision to abolish the EU quota system in 2017, the EU sugar market has been ultimately fully integrated into the systematic liberalisation process of the EU's Common Agricultural Policy, started in 1992. Apart from voluntary coupled support payments, which were introduced in 2015 to maintain sugar production in less competitive EU MS in the aftermath of the abolition of the quota system, today the EU domestic sugar market is completely liberalised. However, prohibitive MFN import tariffs are still in place, although the number of countries with preferential market access to the EU under regional trade agreements has increased over the last years. As well-known from classical micro-economic theory, market liberalisation leads to the most efficient allocation of resources and maximisation of social welfare. Hence, from a pure economic perspective, the abolition of the quota system is clearly a step in the right direction. Compared to an unregulated market, production quotas do not only result in a welfare loss, they also involve administration cost and hamper structural change as well as innovations and technical progress resulting in an overall loss in competitiveness of the EU sugar sector. However, classical micro-economic theory does not account for environmental and social aspects, such as crop diversity and maintenance of jobs in rural areas etc. These aspects, however, are of high importance for policy decisions.

Against this background, the following policy recommendations can be drawn:

As the results of article (2) show, the abolition of the quota system may cause some EU MS to completely cease sugar production, despite voluntary coupled support introduced in less competitive regions. In particular, model results suggest that EU MS, such as Greece, Italy, Finland and Denmark, are likely to end beet sugar production during periods of low world market prices[12]. While in a model-based analysis these countries would return to production, if world market prices are assumed to re-

[11] tel quel: sugar as such, not converted into white or raw sugar equivalent.

[12] Please note that some of these countries (IT, GR) have a large refining sector and may continue to import raw sugar for processing into white sugar. However, since the two models applied in the analysis do not cover the refining sector with all sugar modelled in white sugar equivalent, no conclusions can be drawn regarding the maintenance of the refining sector.

cover, practically, once existing sugar factories have been closed and deconstructed, it seems unlikely that these countries will rebuild production capacities. Rural regions would thus permanently lose employment in the sugar industry. Nevertheless, introducing coupled subsidies or even increasing per hectare payments cannot be recommended from a scientific point of view. Rather than trying to maintain sugar production in uncompetitive regions, policy measures should target at helping the EU sugar sector to faster adapt to the new market environment. This could be achieved by extensive restructuring programmes, as they were already part of the 2006 EU sugar reform. By offering financial incentives, less competitive sugar processors could be encouraged to leave the industry accelerating the shift in production from high- to low-cost sugar producing regions. Moreover, supporting regions that cease sugar production by programmes that stimulate investments in innovations and growth of alternative, more competitive sectors would be a better option than paying coupled subsidies.

Moreover, the quantitative modelling results of article (2) and (5) highlight that with increasing market liberalisation the EU sugar market becomes more dependent on the world market and thus more volatile. This finding is also confirmed by the market development observed since the end of the 2006 sugar market reform. As outlined in article (1), despite maintaining the EU quota system, even a reduction in production quotas and the intervention price resulted in higher fluctuations of the EU sugar price caused by a stronger variation in the quantity of sugar available at the EU market. With the complete abolition of the quota system the volatility of the EU sugar price can be expected to further increase. For sugar beet growers and sugar processors this means that they have to deal with higher uncertainties and market risks. Thus, as for any other liberalised (agriculture) market, risk management instruments will become more important for the EU sugar sector. For those risk management instruments that are fully or partly subsidised, the EU Common Agricultural Policy could set the legal framework. Under the CAP, risk management schemes were first introduced as part of the 2008 Health Check reform. Since then, risk management instruments have become more important. Examples of such instruments are subsidies for insurances premiums and co-financing of mutual funds, so-called income stabilisation tools (IST). However, so fare the uptake of these measures has been limited (EC 2017).

With the increasing number of extreme weather events in recent years, however, risk management strategies have received growing public attention (OFFERMANN et al.). Besides subsidies for insurances premiums and co-financing of mutual funds, other risk management instruments that are partly or fully subsidised by the government are government aid for unexpected events (droughts, floods etc.), government guarantees for loans to bridge liquidity shortages, tax reserves or reserves of direct payments (OFFERMANN et al.; HIRSCHAUER et al. 2018). Dealing with risks is, however, inherent in all economic activities and not specific to agriculture. Thus, market interventions can only be justified in case of market failures. In general, preference should be given to those instruments where the risk is not fully taken over by the government to ensure that risks are still adequately taken into account in economic decisions (HIRSCHAUER et al. 2018). Moreover, instruments that fully compensate for any risk related to agriculture production, like government aid for unexpected events, entail the hazard that those farms are maintained that are high-cost producers and/or poorly managed leading to an inefficient allocation of resources (BRÜMMER 2018).

For the sugar sector, especially the sugar processing stage, diversification and price hedging on commodity futures exchanges can be considered as the most promising risk management strategies. The first years after the end of the EU quota regime have shown that, for example, the Südzucker company was able to compensate losses in the sugar segment with profits in other divisions (special products, bioethanol, fruit products), while highly specialised sugar processors, such as the Nordzucker company, which exclusively processes sugar beet into sugar and ethanol, suffered high losses (SÜDZUCKER AG 2021; NORDZUCKER AG 2021).

Besides diversification, price hedging could help sugar processors to better manage price risks in a volatile market environment. This would also benefit sugar beet growers, as beet prices often directly dependent on the sugar revenue of sugar processors. The main problem with price hedging is, however, that sugar is currently only traded on international commodity futures exchanges, while a commodity future exchange for EU sugar does not exist. Establishing a commodity futures contract for sugar traded within the EU could therefore help the sector to mitigate price risks, in particular, as long as high EU MFN import tariffs secure a significant price difference between the EU and the world market price in times of low global sugar prices. Such a contract was already announced by the pan-European exchange Euronext in 2016, but has not yet been introduced (REUTERS MEDIA 2016; KOCH et al. 2017). On the EU market, sugar is therefore primarily traded under long-term supply contracts in order to reduce price risks. One major downside of these long-term supply contracts is, however, that the contracting parties need to agree on the price, which can be difficult in times of volatile markets, while a commodity futures exchange allows sellers and buyers to hedge the price individually, both in terms of time and level (KOCH et al. 2017). Moreover, long-term supply contracts have the drawback that price signals only become visible in the official EU price statistic with a significant delay making it difficult for policymakers and the industry to react timely and adequately to market signals.

Besides the consequences of an increasing market liberalisation for the EU sugar sector discussed in article (2) and (4), the results of article (5) highlight that third countries that have traditionally been preferential sugar exporters to the EU are likely to be adversely affected by a liberalisation of the EU sugar regime. There are two main reasons for this: First, the EU sugar price moves closer to the world market price with increasing market liberalisation leading to an erosion of the value of the preference margin of preferential sugar exporters. Second, more competitive sugar producing countries will gain market shares and displace traditional preferential sugar exporters from the EU market.

As outlined in article (5) LDC-ACP countries are the first group of countries being squeezed out of the EU market as a consequence of a liberalisation of the EU sugar regime. Even without any further liberalisation of the EU sugar market, these countries lose market share due to increasing imports under regional trade agreements concluded in recent years with other more competitive sugar producing third countries, such as Central American countries. Hence, the liberalisation of the EU sugar market reduces the financial support for LDC-ACP countries that has been established under the Everything-But-Arms Agreement by granting LDC countries non-reciprocal preferential market access to the well protected and thus highly profitable EU sugar market. This loss in financial support is currently not compensated by other development aid. Thus, the liberalisation of the EU sugar market may lead to a decline in the gross domestic product and contribute to economic instability, particularly in those countries where the sugar sector represents an important part of the national economy. In order to mitigate the risk for economic destabilisation in these countries, the EU could initiate development programmes that help these countries to diversify their economies.

In general, as already discussed in article (5), various strategies are applicable in order to support domestic sugar production of those countries that are likely to be negatively affected form a liberalisation of the EU sugar regime. 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 programmes 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, 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 programmes could be launched to both create alternative employment opportunities in rural areas and encourage uncompetitive sugar processors to exit the market.

Finally, the global outbreak of the corona pandemic in 2020 as well as the war between Russia and Ukraine has reminded policymakers and the public of one of the traditional key aims of the CAP: ensuring a stable supply of affordable food. Model results of article (5) highlight that with a complete liberalisation of the EU sugar market including the elimination of MFN tariffs EU sugar production may come under threat at world market price below 400 €/t resulting in net-import needs of about 2 to 3 million tonnes of sugar. Whereas in times of functioning global supply chains this import demand can be easily met from the world market, food security could be at risk in times of global crises. Although policymakers and the general public are currently aiming at reducing per capita consumption of caloric-sweeteners, sugar is likely to remain an important ingredient in a wide variety of products that cannot be replaced overnight. Thus, shortages in sugar supply due to global crises could temporary threaten one of the key aims of the CAP. This should be considered in future policy decisions on a complete liberalisation of the EU sugar sector and weighed against the pure economic goal of achieving the most efficient allocation of resources.

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APPENDICES

Appendix A: Documentation of the Agmemod sweetener module

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1 THE AGMEMOD SWEETENER MODULE

In March 2013, the European Union agriculture ministers agreed to remove the EU quota system for sugar and isoglucose by the end of the sugar marketing year 2016/17. At that time, the sugar sector was represented in a simplified way in the basic model version of Agmemod with supply quantities of sugar being fixed to the quota level while the isoglucose sector was not modelled at all. Therefore, a new sweetener module was developed for Agmemod as part of a wider project funded by the European Commission[1]. This new sweetener module covers not only sugar and sugar beet but also isoglucose, a liquid sweetener produced from corn or wheat starch. Since its first implementation in 2018, the module database as well as parameters have annually been updated. The following sections describe the model approach as well as the most important data sources.

1.1 Approach

Modelling supply behaviour of beet growers and sugar processors in the post-quota period poses methodological challenges. This is because with binding production quotas in place, i. e., until the marketing year 2016/17, market prices reported in statistics incorporate the quota rent and do thus not represent marginal cost of production. As a consequence, either estimates of the quota rent or production costs are needed to properly calibrate the supply functions of economic models. In the revised sweetener module of Agmemod the second approach is applied, i. e., supply functions for sugar and isoglucose are calibrated to average per unit production costs. These production costs are endogenously calculated within the Agmemod model building on the approach developed by LMC (2013). To align this approach with the overall concept of Agmemod, where supply quantities are determined based on expected values, production costs are derived from expected prices and yields, which are a weighted or simple average of previous years. However, in contrast to other crop sectors represented in Agmemod, the revised Agmemod sweetener module applies Cobb-Douglas functions which are calibrated to a given base year instead of linear functions, which were estimated by Ordinary Least Squares (OLS) regression from the model database. Moreover, the functions for selected other variables, such as isoglucose demand as well as imports and exports of sugar and isoglucose are also specified by calibrated Cobb-Douglas functions. For most other variables, however, such as the yield of sugar beet, per capita consumption of sweetener as well as sugar and isoglucose prices linear functions are applied which have been estimated from the model database by OLS regression.

The following equations describe the revised sweetener module of Agmemod[2]:

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[1] Specific contract ‚Support for AGMEMOD model, baseline and database updates 2017/2018‘, funded under Framework contract ‚Economic modelling of agri policies in Europe (AgEconEurope)‘ 154208-2014-A08-NL.

[2] Please note that endogenous variables are written in capital letters, exogenous variables in lowercase letters.

1.1.1 Supply

Sugar beet

Production of sugar beet equals the quantity of beet required for sugar processing plus the quantity of sugar beet processed into ethanol and quantities used for feeding:

$$SPR_{st,c,t} = \frac{SPR_{su,c,t}}{XTR_{su,c,t}} + UOD_{st,c,t} + UFE_{st,c,t} \tag{1}$$

Where:

SPR:	production	st:	sugar beet
UOD:	beet quantity required for ethanol production	su:	sugar
UFE:	beet quantity used for feeding	t:	time
c:	country		

The **sugar extraction rate** used in equation (1) equals the sugar content of beets less two per cent factory losses[3]. The **sugar content** is modelled by a linear function depending on a trend over time to account for biological technical progress:

$$XTR_{su,c,t} = YCO_{st,c,t} - 0.02 \tag{2}$$

$$YCO_{st,c,t} = \alpha_{st,c} + \beta_{st,c} * trend_t \tag{3}$$

Where:

XTR:	extraction rate	α:	intercept
YCO:	sugar content of beets	β:	coefficient/slope parameter

The **sugar beet area harvested** is derived by dividing the production of sugar beet by the sugar beet yield. The **sugar beet yield** is modelled by a linear function depending on the real sugar beet price and a linear trend representing biological technical progress:

$$AHA_{st,c,t} = \frac{SPR_{st,c,t}}{YHA_{st,c,t}} \tag{4}$$

$$YHA_{st,c,t} = \alpha_{st,c} + \beta_{st,c} * \frac{PFN_{st,c,t}}{gdpd_{c,t}} + \beta_{st,c} * trend_t \tag{5}$$

[3] Unlike the EU legislation, which assumes 3 per cent factory losses, the extraction loss was set to 2 per cent as, according to market experts, this is closer to the real extraction losses of most EU factories.

Where:

AHA:	area harvested	PFN:	domestic market price
SPR:	production	gdpd:	GDP deflator
YHA:	yield		

Sugar

In contrast to most other behavioural equations in Agmemod, which are estimated by linear ordinary least squares regression, **sugar supply** is modelled by a calibrated Cobb-Douglas function. In this function the supply of sugar depends on the market price of sugar corrected for the processing costs and the by-product value of sugar processing. This specification of the supply function ensures that sugar processors will cease production if the market price falls below the net-processing cost. The quantity of sugar beets required for ethanol production (converted into white sugar equivalent, wse) is deducted from the total beet supply, effectively reducing the quantity of beets available for processing into sugar. As a result, changes in ethanol production shift the sugar supply function. Furthermore, sugar supply is limited to the existing beet slicing capacity not used for the processing of sugar beet into ethanol:

$$\mathrm{SPR}_{su,c,t} = \mathrm{Min}\left\{ \left(\mathrm{bsc}_{st,c} * \mathrm{loc}_{st,c,t} - \mathrm{UOD}_{st,c,t}\right) * \mathrm{XTR}_{su,c,t}, \; \mathrm{Max}\left\{0, \; \alpha_{su,c,t} * \left(\frac{\mathrm{PFN}_{su,c,t} + \mathrm{BPV}_{su,c,t} - \mathrm{CPO}_{su,c,t}}{\mathrm{gdpd}_{c,t}}\right)^{\varepsilon_{su,c}} - \mathrm{UOD}_{st,c,t} * \mathrm{XTR}_{su,c,t}\right\}\right\} \quad (6)$$

Where:

bsc:	daily beet slicing capacity	BPV:	by-product value
loc:	max. length of the campaign (days)	CPO:	processing costs
XTR:	extraction rate	gdpd	GDP deflator
UDO:	beet quantity used for ethanol production	α:	intercept
PFN:	domestic market price	ε:	slope parameter

As already mentioned at the beginning of the chapter, the sugar supply function is calibrated to per unit production costs calculated endogenously during the model run:

$$\alpha_{su,c,t} = \left(\overline{spr\_0_{su,c}} + \overline{uod\_0_{st,c}} * \overline{xtr\_0_{su,c}}\right) * \left(\frac{PFE_{su,c,t} + BPV_{su,c,t} - CPO_{su,c,t}}{gdpd_{c,t}}\right)^{(-\varepsilon_{su,c})} \quad (7)$$

Where:

α: intercept
spr_0: production quantity in base year
uod_0: beet quantity used for ethanol production in the base year
xtr_0: extraction rate in base year
PFE: production costs/supply price ex mill
BPV: by-product value
CPO: processing costs
gdpd: GDP deflator
ε: slope parameter

As a result, sugar production will start to decline (increase) compared to the level of the base year if the simulated market price of sugar falls below (exceeds) the estimated production cost per tonne of sugar.

Per unit production costs are calculated following the approach of LMC (2013):

Total production costs per tonne of sugar are the sum of raw material costs and processing costs less by-product values:

$$PFE_{su,c,t} = SCF_{su,c,t} + CPO_{su,c,t} - BPV_{su,c,t} \quad (8)$$

Where:

PFE: total production costs/supply price ex mill
SCF: sugar equivalent beet costs
CPO: processing costs
BPV: by-product value

Since, along with the quota system, the minimum price for sugar beet was also abolished, raw material costs of sugar production, i. e. beet prices, are calculated from the gross margin of the most competitive alternative crop to sugar beet (wheat, maize, rapeseeds), corrected for the amount of voluntary coupled support[4], growing costs for sugar beet, costs for beet haulage and a late delivery premium paid by the sugar industry to compensate farmers for a lower sugar content at the end of the campaign due to a late harvest or storage losses. In doing so, the calculated beet price ensures that sugar beets achieve a gross margin that is at least as high as the gross margin of the most competitive alternative crop. Thus, the calculated beet price reflects the fact that in the post-quota period sugar processors are aiming to reduce beet costs to the lowest level possible to be competitive while at the same time needing to ensure that farmers include sugar beets in their crop rotation. From the calculated beet price **sugar equivalent beet costs** per tonne of sugar are obtained by dividing the calculated beet price by the expected sugar extraction rate:

$$\mathrm{SCF}_{su,c,t} = \left(\frac{\mathrm{Max}\{\mathrm{EGG}_{ws,c,t}, \mathrm{EGG}_{co,c,t}, \mathrm{EGG}_{rs,c,t}\} + \mathrm{gco}_{st,c,t} - \mathrm{SUB}_{st,c,t}}{\mathrm{YHT}_{st,c,t}}\right) * \mathrm{XRE}_{su,c,t}{}^{-1} + \frac{\mathrm{bhg}_c + \mathrm{ldp}_c}{\mathrm{XRE}_{su,c,t}} \tag{9}$$

Where:

SCF: sugar equivalent beet costs
EGG: expected gross margin (3- or 5-year average of previous years)
gco: growing costs
SUB: subsidy
YHT: trend yield (3-year average of the previous years)
XRE: expected sugar extraction rate (3-year average of the previous years)
bhg: costs for beet haulage
ldp: late delivery premium
ws: wheat
co: corn
rs: rapeseed

In Agmemod the expected gross market return is calculated as the expected price which is a weighted 3-year average of the previous years multiplied with the expected yield which is a 3- or 5-year average of the previous years. To obtain the expected gross margin, growing costs are subtracted from the expected gross market return. Growing costs are not inflated, but kept constant over time in nominal term, effectively assuming that inflation and mechanical technological progress offset each other.

[4] Voluntary coupled support subsidies equal a fixed hectare premium as long as the total amount of premiums does not exceed the total budget available to support the sugar beet sector. If the total amount of premiums exceeds the budget, hectare premiums are reduced, i. e. the hectare premium is calculated as the total available budget divided by the beet area harvested in the previous year.

$$EGG_{p,c,t} = \left(0.5 * PFN_{p,c,t-1} + 0.3 * PFN_{p,c,t-2} + 0.2 * PFN_{p,c,t-3}\right) * \frac{YHA_{p,c,t-1} + YHA_{p,c,t-2} + YHA_{p,c,t-3}}{3} - gco_{p,c,} \tag{10}$$

Where:

EGG:	expected gross margin	gco:	growing costs
PFN:	domestic market price	p:	competing product (wheat, corn, rapeseeds)
YHA:	yield		

Processing costs per tonne of sugar are the sum of fixed costs, variable costs and administration costs. Fixed costs include cash costs (permanent labour, fixed cost component of repairs and maintenance) and non-cash costs (depreciation, return on capital) and are constant during simulation while variable costs depend on the crude oil price. Administration costs are a proportion of total net processing costs:

$$CPO_{su,c,t} = cfx_{su,c} + CVA_{su,c,t} + CAD_{su,c,t} \tag{11}$$

$$CVA_{su,c,t} = cne_{su,c} + \overline{cen\_0_{su,c}} * \delta_c * \left(\frac{0.5 * pmd_{eo,eu,t-1} + 0.3 * pmd_{eo,eu,t-2} + 0.2 * pmd_{eo,eu,t-3}}{\overline{pmd\_0_{eo,eu}}}\right) \tag{12}$$

$$CAD_{su,c,t} = \left(CPO_{su,c,t} - BPV_{su,c,t}\right) * csh_{su} \tag{13}$$

Where:

CPO:	total processing costs	CAD:	administration costs
cfx:	fixed costs	cne:	variable costs (non-energy)
CVA:	variable costs	cen_0:	energy costs in base year
pmd:	word market price in US Dollar	eo:	crude oil
pmd_0:	market price in US Dollar in base year	δ:	energy coefficient
csh:	share of administration costs in total net processing costs		

The energy coefficient δ in equation (12) is a weighted average of the β coefficients of three regression functions estimating the relationship between the crude oil price and the gas, coal or fuel oil price. The β coefficients are weighted by the share of the fuel type in total energy use.

Processing sugar beet into sugar yields two by-products, namely beet pulp and molasses. Thus, the total **by-product value** per tonne of sugar is calculated as the sum of by-product credits from beet pulp and molasses. The value of the individual by-product is obtained by multiplying the respective by-product price with the respective by-product yield. By-product yields are fixed technical conversion factors while by-product prices depend on the prices of close substitutes. The main outlet for beet pulp is the feed market where beet pulp competes against fodder cereals. Therefore, the beet pulp price is derived from the domestic wheat price assuming a parallel movement of both feed prices. The domestic price of molasses depends on the world market price of raw sugar and has been estimated by linear ordinary least squares regression with the beet molasses price (c.i.f. Amsterdam) as the dependent and the world raw sugar price as the independent variable. Finally, the resulting molasses price is adjusted by a regional price differential and transportation costs:

$$BPV_{su,c,t} = PFN_{bp,c,t} * YHA_{bp,c} + PFN_{mo,c,t} * yha_{mo,c} \quad (14)$$

$$PFN_{bp,c,t} = \rho_{bp} * \left(0.5 * PFN_{ws,c,t-1} + 0.3 * PFN_{ws,c,t-2} + 0.2 * PFN_{ws,c,t-3}\right) \quad (15)$$

$$PFN_{mo,c,t} = \alpha_{mo} + \beta_{mo} * \left(0.5 * pmd_{su,ww,t-1} * exrd_{t-1} + 0.3 * pmd_{su,ww,t-2} * exrd_{t-2} + 0.2 * pmd_{su,ww,t-3} exrd_{t-3}\right) - tpc_{mo,c} + rdp_{mo,c,NL} \quad (16)$$

Where:

BPV:	by-product value	bp:	beet pulp
PFN:	domestic market price	mo:	molasses
yha:	yield	ws:	wheat
pmd:	world market price in US dollar	ww:	world
exrd:	exchange rate (Euro/US dollar)	NL:	the Netherlands
tpc:	transportation costs		
rdp:	regional price differential		
ρ	ratio of the domestic beet pulp to the domestic wheat price in base year		

Isoglucose

In principal **isoglucose supply** is modelled in the same way as the supply of sugar. The supply of isoglucose is a function of the market price corrected for processing costs and the value of by-products. This function is calibrated to per unit cost of isoglucose production which are endogenously determined during the model run. Similar to the specification of the sugar supply function, isoglucose producers are assumed to leave the market if the market price does not cover net-processing cost. In addition, a shift parameter was introduced to model a potential expansion of isoglucose production capacities after the abolition of the EU quota system:

$$SPR_{is,c,t} = \theta_{is,c} * \alpha_{is,c,t} * \left(\frac{PFN_{is,c,t} + BPV_{is,c,t} - CPO_{is,c,t}}{gdpd_{c,t}}\right)^{\varepsilon_{is,c}} \qquad (17)$$

$$\alpha_{is,c,t} = \overline{spr\_0_{is,c,}} * \left(\frac{PFW_{is,c,t} + BPV_{is,c,t} - CPO_{is,c,t}}{gdpd_{c,t}}\right)^{(-\varepsilon_{is,c})} \qquad (18)$$

Where:

SPR	production in current year	θ:	shifter
spr_0	production in base year	α:	intercept
PFN:	domestic market price	ε:	slope parameter
PFW:	sugar equivalent cost	is:	isoglucose
BPV:	by-product value		
CPO:	processing costs		
gdpd:	GDP deflator		

Similar to the production costs of sugar production, **total production costs** of isoglucose are calculated as the sum of raw material costs and processing costs, corrected for the value of by-products. In order to be able to compare the production costs of isoglucose to the costs of sugar processing, isoglucose production costs are calculated on a dry weight basis rather than on commercial weight[5]. In addition, production costs of isoglucose are converted into sugar equivalent costs by adding the additional amount of isoglucose that is required to compensate for the hydrolysis effect on sugar in low acid solutions[6]:

$$PFW_{is,c,t} = \left(\frac{NRC_{is,c,t} + CPO_{is,c,t}}{dmc_{is}}\right) * (1 + hye_{is}) \qquad (19)$$

Where:

PFW:	sugar equivalent cost
NRC:	net raw material costs
CPO:	processing costs
dmc:	dry matter content of isoglucose
hye:	technical coefficient for hydrolysis effect

[5] Sugar and isoglucose have the same sweetness when compared in solutions with the same dry matter content.

[6] Isoglucose producers have to sell 5 per cent more product to compensate for the hydrolysis effect when sucrose breaks down into its component mono-saccharides in low acid solutions (e.g. beverages).

In the EU, isoglucose is produced either from wheat or corn. While the end product is identical, the production process and therefore the production costs involved in the production of isoglucose differ depending on the raw material base. Therefore, in Agmemod production costs of isoglucose are calculated for both raw materials and the isoglucose supply function is calibrated to the costs of the prevailing raw material base in a country.

Net raw material costs of isoglucose production are calculated from the expected raw material price, which is a weighted 3-year average of the previous years, by subtracting all by-product values and adding the costs of transporting the grain to the factory. The resulting net raw material costs per tonne of grain are then divided by the respective isoglucose yield to obtain the net-raw material costs per tonne of isoglucose:

$$\mathrm{NRC}_{\mathrm{is,c,t}} = \frac{0.5 * \mathrm{PFN}_{\mathrm{ws/co,c,t-1}} + 0.3 * \mathrm{PFN}_{\mathrm{ws/co,c,t-2}} + 0.2 * \mathrm{PFN}_{\mathrm{ws/co,c,t-3}}}{\mathrm{yha}_{\mathrm{is}}} - \frac{\mathrm{BPV}_{\mathrm{is,c,t}} + \mathrm{tpc}_{\mathrm{ws/co,c,t}}}{\mathrm{yha}_{\mathrm{is}}} \tag{20}$$

Where:

NRC:	net raw material costs	yha:	yield (technical coefficient)
PFN:	domestic market price	tpc:	transportation costs
BPV:	by-product value		

The first step in the production process of isoglucose is the conversion of wheat or corn into starch. The processing of starch yields a number of high value by-products. In case of wheat based isoglucose production the main by-products are bran and vital wheat gluten; whereas the production from corn yields the by-products corn gluten feed, corn gluten meal and corn oil[7].

Similar to the approach of calculating the **by-product value** of sugar processing, the by-product credits of isoglucose production are calculated by applying the respective by-product yield which is a simple technical coefficient to the respective by-product price. The sum over the individual by-product credits divided by a technical coefficient for the isoglucose yield from corn or wheat starch gives the total by-product value per tonne of isoglucose:

$$\mathrm{BPV}_{\mathrm{is,c,t}} = \frac{\mathrm{PFN}_{\mathrm{nb,c,t}} * \mathrm{yha}_{\mathrm{nb}} + \mathrm{PFN}_{\mathrm{vw,c,t}} * \mathrm{yha}_{\mathrm{vw,}}}{\mathrm{yha}_{\mathrm{is}}} \tag{21}$$

[7] In the EU, only large factories crush the germ to manufacture oil. Small plants sell the dried germ to corn oil refineries. However, for simplification purposes, it is assumed that all isoglucose producers crush the germ and sell corn oil.

$$BPV_{is,c,t} = \frac{PFN_{gf,c,t} * yha_{gf} + PFN_{mm,c,t} * yha_{mm} + PFN_{ci,c,t} * yha_{ci}}{yha_{is}} \quad (22)$$

Where:

BPV:	by-product value	vw:	vital wheat gluten
PFN:	domestic market price	gf:	corn gluten feed
yha:	yield	mm:	corn gluten meal
nb:	bran	ci:	corn oil

By-product prices of high fibre by-products (wheat bran and corn gluten feed) follow the price development of their underlying raw materials, whereas the prices of protein rich by-products (vital wheat gluten and corn gluten meal) are mainly driven by the price development of other protein rich feed products, i. e. oilseed meals. The price of corn oil is linked to the prices of other vegetable oils as well as the price of biodiesel. However, in the approach of LMC (2013), which is applied here, all by-product prices depend on either wheat or corn prices. This is a simplification of reality and could be improved in subsequent research. The prices of high fibre by-products are calculated as a percentage of the domestic raw material price. For protein rich by-products and corn oil a slightly different approach is applied. First a key price is calculated which is then adjusted by a regional price differential. The key price itself is, in turn, a percentage of the domestic raw material price (wheat/corn) in a key country. For vital wheat gluten France is chosen as the key country while domestic prices of corn gluten meal and corn oil are derived from the by-product price of Hungary:

$$PFN_{nb,c,t} = \rho^{2}_{nb,c} * \left(0.5 * PFN_{ws,c,t-1} + 0.3 * PFN_{ws,c,t-2} + 0.2 * PFN_{ws,c,t-3}\right) \quad (23)$$

$$PFN_{vw,c,t} = \rho^{3}_{vw} * \left(0.5 * PFN_{ws,FR,t-1} + 0.3 * PFN_{ws,-FR,t-2} + 0.2 * PFN_{ws,FR,t-3}\right) + rpd_{vw,c,FR} \quad (24)$$

$$PFN_{gf,c,t} = \rho^{4}_{gf,c} * \left(0.5 * PFN_{co,c,t-1} + 0.3 * PFN_{co,c,t-2} + 0.2 * PFN_{co,c,t-3}\right) \quad (25)$$

$$PFN_{mm,c,t} = \rho^{5}_{mm} * \left(0.5 * PFN_{co,HU,t-1} + 0.3 * PFN_{co,HU,t-2} + 0.2 * PFN_{co,HU,t-3}\right) + rpd_{mm,c,HU} \quad (26)$$

$$PFN_{ci,c,t} = \rho^{6}_{ci} * \left(0.5 * PFN_{co,HU,t-1} + 0.3 * PFN_{co,HU,t-2} + 0.2 * PFN_{co,HU,t-3}\right) + rpd_{ci,c,HU} \quad (27)$$

Where:

PFN:	domestic market price
rpd	regional price differential to the key price (France/Hungary)
ρ2:	ratio of the domestic wheat bran price to the domestic wheat price in base period
ρ3:	ratio of the French vital wheat gluten price to the French wheat price in base period
ρ4:	ratio of the domestic corn gluten feed price to the domestic corn price in base period
ρ5:	ratio of the Hungarian corn gluten meal price to the Hungarian corn price in base period
ρ6:	ratio of the Hungarian corn oil price to the Hungarian corn price in base period
FR, HU:	France, Hungary

Processing costs per tonne of isoglucose are the sum of fixed (labour, repairs and maintenance, depreciation, return on capital employed) and variable costs (energy, chemicals/enzymes, water, effluent treatment etc.) with variable costs depending on the crude oil price. Fix costs are assumed to be constant during simulation:

$$\mathrm{CPO}_{is,c,t} = \mathrm{cfx}_{is,c} + \mathrm{CVA}_{is,c,t} \tag{28}$$

$$\mathrm{CVA}_{is,c,t} = \mathrm{cne}_{is,c} + \overline{\mathrm{cen\_0}_{is,c}} * \delta_c * \left(\frac{0.5 * \mathrm{pmd}_{eo,eu,t-1} + 0.3 * \mathrm{pmd}_{eo,eu,t-2}\ 0.2 * \mathrm{pmd}_{eo,eu,t-3}}{\overline{\mathrm{pmd\_0}_{eo,eu}}}\right) \tag{29}$$

Where:

CPO:	total processing costs	CVA:	variable costs
cfx:	fixed costs	cne:	variable costs (non-energy)
eo:	crude oil	cen_0:	energy costs in base year
pmd:	world market price in US Dollar	δ:	energy coefficient
pmd_0:	world market price in US Dollar in base year		

1.1.2 Demand

In Agmemod the equation for total domestic **demand of sugar beet** is used to ensure market clearing, i. e. total domestic use equals production plus net imports. Total beet demand is broken down into four categories: beet use for processing into sugar for food purposes, beet use for processing into industrial sugar (chemical and pharmaceutical industry), beet use for processing into ethanol and sugar beet used as feed. Sugar beet use for processing into ethanol is not modelled price dependent but can be shifted by an exogenous parameter. Also feed use is modelled in a simplified way and either fixed to the last observed value or to an average of the previous three or five years:

$$\mathrm{UDC}_{st,c,t} = \mathrm{SPR}_{st,c,t} + \mathrm{SMT}_{st,c,t} - \mathrm{UXT}_{st,c,t} \tag{30}$$

$$\mathrm{UOD}_{st,c,t} = \beta_{c,t} * \mathrm{UOD}_{st,c,t-1} \tag{31}$$

$$\mathrm{UFE}_{st,c,t} = \left(\frac{\mathrm{UFE}_{st,c,t-1} + \mathrm{UFE}_{st,c,t-2} + \mathrm{UFE}_{st,c,t-3}}{3}\right) \tag{32}$$

$$\mathrm{UFA}_{st,c,t} = \frac{\mathrm{UFA}_{su,c,t}}{\mathrm{XTR}_{su,c,t}} \tag{33}$$

$$\mathrm{UFD}_{st,c,t} = \frac{\mathrm{UFD}_{su,c,t}}{\mathrm{XTR}_{su,c,t}} \tag{34}$$

Where:

UDC: domestic use

UOD: ethanol use

UFE: feed use

UFA: beets processed into industrial sugar

UFD: beets processed into sugar used for food purposes

Domestic use of sugar is the sum of industrial sugar and sugar used for human consumption. Whereas industrial use of sugar is not modelled endogenously, food consumption of sugar is a share in **total sweetener use for human consumption**. Total sweetener demand for food use is calculated as per capita human consumption multiplied by the total population. Per capita human consumption of sweetener is specified as a linear function depending on the real GDP per capita, a trend over time and the domestic real sweetener price which is a weighted average of the sugar and isoglucose price using the respective share in sweetener consumption as weights:

$$\mathrm{UDC}_{su,c,t} = \mathrm{UFD}_{su,c,t} + \mathrm{UFA}_{su,c,t} \tag{35}$$

$$\mathrm{UFA}_{su,c,t} = \mathrm{UFA}_{su,c,t-1} \tag{36}$$

$$\mathrm{UFD}_{su,c,t} = \mathrm{UFA}_{se,c,t} * \mathrm{ASH}_{su,c,t} \tag{37}$$

$$\mathrm{UFA}_{se,c,t} = \mathrm{UPC}_{se,c,t} * \mathrm{pop}_{c,t} \tag{38}$$

$$\mathrm{UPC}_{se,c,t} = \alpha_{se,c} - \beta^{1}_{se,c} * \frac{\mathrm{PFN}_{su,c,t} * \mathrm{ASH}_{su,c,t} + \mathrm{PFN}_{is,c,t} * \mathrm{ASH}_{is,c,t}}{\mathrm{gdpd}_{c,t}} + \beta^{2}_{se,c} * \frac{\mathrm{rgdp}_{c,t}}{\mathrm{pop}_{c,t}} \pm \beta^{3}_{se,c} * \mathrm{trend}_{t} \tag{39}$$

$$\mathrm{ASH}_{su,c,t} = 1 - \mathrm{ASH}_{is,c,t} \tag{40}$$

$$\mathrm{ASH}_{is,c,t} = \frac{\mathrm{UDC}_{is,c,t}}{\mathrm{UFA}_{se,c,t}} \tag{41}$$

Where:

UDC:	domestic use	rgdp:	real GDP
UFD:	food use	pop:	population
UFA:	industrial use	ASH:	share in sweetener food consumption
UPC:	per capita food consumption	α:	intercept
PFN:	domestic market price	β:	coefficient/slope parameter
gdpd:	GDP deflator		

Unlike domestic use of sugar, **consumption of isoglucose** is not broken down into subcategories. The demand of isoglucose is modelled by a calibrated Cobb-Douglas function where consumption of isoglucose depends on the real market prices of isoglucose and its main substitute, i. e. sugar. Since isoglucose is usually not transported over long distances and therefore mainly consumed domestically, a certain share of the change in isoglucose production in the previous year compared to the base year is added to the domestic demand of isoglucose. In addition, a second shifter was introduced to allocate – based on observed historical trade flows – a certain share of the change in isoglucose production of neighbouring producers to a country’s domestic demand:

$$\mathrm{UDC}_{is,c,t} = \alpha_{is,c} * \left(\frac{\mathrm{PFN}_{is,c,t}}{\mathrm{gdpd}_{c,t}}\right)^{(-\varepsilon^{1}_{is,c})} * \left(\frac{\mathrm{PFN}_{su,c,t}}{\mathrm{gdpd}_{c,t}}\right)^{(\varepsilon^{2}_{is,c})} + \theta_{is,c} * \left(\mathrm{SPR}_{is,c,t-1} - \overline{\mathrm{spr\_0}_{is,c}}\right) + \theta_{is,cc} * \left(\mathrm{SPR}_{is,cc,t-1} - \overline{\mathrm{spr\_0}_{is,c}}\right) \tag{42}$$

Where:

UDC:	domestic use	α:	intercept
SPR:	production in current year	ε^1:	own price elasticity
spr_0:	production in base year	ε^2:	cross price elasticity
PFN:	domestic market price	cc:	country of origin
gdpd	GDP deflator	θ:	shifter (share of production sold domestically or imported from country cc)

Equation (42) is only applied if a maximum share of isoglucose in total sweetener consumption is not exceeded. This is because sugar can only be substituted by isoglucose in liquid applications. Thus, the maximum share of isoglucose in total domestic consumption of sweetener equals the size of the liquid sweetener market in a country. If a country exceeds its maximum market share of isoglucose in one year, in the next year isoglucose consumption is set to the level of the previous year corrected by the percentage change in sugar consumption.

1.1.3 Trade

Trade in Agmemod is modelled in a simplified way. Trade flows are not depicted on a bilateral basis and the approach does also not distinguish between extra-EU and intra-EU trade. Therefore, total imports and exports of sugar and isoglucose are modelled by one calibrated equation depending on the price ratio of the word market price or the average EU price to the domestic price. Since isoglucose is traded almost exclusively within the EU, isoglucose imports and exports react only on the price ratio of the average EU price to the domestic price. Moreover, a behavioural equation is only specified for one trade flow as the other is defined as model closure. The equation chosen to clear the market varies depending on the country and commodity:

Calibrated equations:

$$\mathrm{SMT}_{su,c,t} = \alpha_{su,c} * \left(\frac{\mathrm{pmd}_{su,ww,t} * \mathrm{exrd}_t}{\mathrm{PFN}_{su,c,t}}\right)^{(-\varepsilon_1)} * \left(\frac{\mathrm{peu}_{su,eu,t}}{\mathrm{PFN}_{su,c,t}}\right)^{(-\varepsilon_2)} \quad (43)$$

$$\mathrm{SMT}_{is,c,t} = \alpha_{is,c} * \left(\frac{\mathrm{peu}_{is,eu,t}}{\mathrm{PFN}_{is,c,t}}\right)^{(-\varepsilon_1)} \quad (44)$$

$$\mathrm{UXT}_{su,c,t} = \alpha_{su,c} * \left(\frac{\mathrm{pmd}_{su,ww,t} * \mathrm{exrd}_t}{\mathrm{PFN}_{su,c,t}}\right)^{(\varepsilon_1)} * \left(\frac{\mathrm{peu}_{su,eu,t}}{\mathrm{PFN}_{su,c,t}}\right)^{(\varepsilon_2)} \quad (45)$$

$$UXT_{is,c,t} = \alpha_{is,c} \ * \ \left(\frac{peu_{is,eu,t}}{PFN_{is,c,t}}\right)^{(-\varepsilon_1)} \qquad (46)$$

Market clearing:

$$SMT_{p,c,t} = -\ SPR_{p,c,t} - UXT_{p,c,t} + UDC_{p,c,t} - CCT_{p,c,t-1} + CCT_{p,c,t} \qquad (47)$$

$$UXT_{p,c,t} = SPR_{p,c,t} + SMT_{p,c,t} - UDC_{p,c,t} + CCT_{p,c,t-1} - CCT_{p,c,t} \qquad (48)$$

Where:

SMT:	imports	α:	intercept
UXT:	exports	ε:	elasticity/slope parameter
pmd:	world market price in US dollar	p:	product
exrd:	exchange rate (euro/US dollar)	eu:	European Union
peu:	EU market price	ww:	world
PFN:	domestic market price		

1.1.4 Stocks

Stock demand is only modelled for sugar and depends on the price ratio of the current price to the price of the previous year:

$$CCT_{su,c,t} = \alpha_{su,c} \ * \ \left(\frac{PFN_{su,c,t}}{PFN_{su,c,t-1}}\right)^{(-\varepsilon_1)} \qquad (49)$$

Where:

CCT:	ending stocks	α:	intercept
PFN:	domestic market price	ε:	elasticity/slope parameter

1.1.5 Prices

Domestic **prices of sugar and isoglucose** are represented by a linear function depending on a key price, the domestic self-sufficiency rate and the price of the previous year. All parameters are estimated by linear ordinary least squares regression. For the sugar market, France was chosen as the key price country whereas the Hungarian isoglucose price determines the price development on the isoglucose market as these two countries are the largest producers of the respective product within the EU. The key prices have a similar functional form as other domestic prices but instead of the key price the

EU price is used as a predictor. The EU price enters the model as exogenous information[8]. In all countries the domestic price is not allowed to fall below the reference threshold of 404.4 €/t set by legislation. Thus, the price support by private storage aid is not modelled explicitly:

$$PFN_{su,c,t} = \text{Max}\left\{pin_{su,eu,t},\ \alpha_{su,c} + \beta^{1}_{su,c} * PFN_{su,FR,t} - \beta^{2}_{su,c} * \left(\frac{SPR_{su,c,t}}{UDC_{su,c,t}}\right) \pm \beta^{3}_{su,c} * PFN_{su,c,t-1}\right\} \tag{50}$$

$$PFN_{is,c,t} = \alpha_{is,c} + \beta^{1}_{is,c} * PFN_{is,HU,t} - \beta^{2}_{is,c} * \left(\frac{SPR_{is,c,t}}{UDC_{is,c,t}}\right) \pm \beta^{3}_{is,c} * PFN_{is,c,t-1} \tag{51}$$

Where:

PFN: domestic market price
pin: intervention price/reference threshold
SPR: production
UDC: domestic use
α: intercept
β: coefficient

The domestic **price of sugar beets** equals the sugar equivalent beet costs at factory level (Eq. 9) multiplied by the expected sugar extraction rate:

$$PFN_{st,c,t} = SCF_{su,c,t} * XRE_{su,c,t} \tag{52}$$

Where:

PFN: domestic market price
SCF: sugar equivalent beet costs
XRE: extraction rate

1.1.6 Linkages between sectors

As a partial equilibrium model covering the entire agricultural sector Agmemod allows to link the sweetener module to other agricultural commodity markets. One important linkage has already been described in section 1.1.1: Supply functions of sugar and isoglucose are calibrated to per unit production costs endogenously calculated based on the expected gross margin of competing crops (wheat, corn and rapeseed) or prices of raw materials (wheat, corn). As a result, changes in the wheat, corn and rapeseed market directly affect the supply of sugar and isoglucose. In turn, it is also important to mod-

[8] According to the 'standard approach' of Agmemod key prices are estimated depending on the world market price. However, for the sweetener market this approach cannot be applied as in the past there was no relationship between the EU and world market due to the quota system and high import tariffs.

el the effect of changes in the sugar and isoglucose market on other crop markets. Therefore, two additional sectoral linkages were implemented:

The first linkage concerns the land allocation in the model. In the original model approach land is allocated by a top-down approach, i. e., the share of a crop aggregate in the total crop area is modelled by a linear function depending on the ratio of the expected gross market return for the respective crop aggregate (e.g., oilseeds) to the expected gross market return of competing crops (grains, protein crops, other crops). A balanced land allocation is ensured by specifying one crop share as the residual. As the sugar beet sector is modelled by a different approach, the sugar beet area is integrated into the existing land allocation structure by adding an adjustment term to the equations for the share of a crop aggregate in total crop area. This adjustment term corrects the share of a crop aggregate in total crop area for the change in sugar beet area compared to the base year (last observed value in the database). The adjustment term applied to the respective crop share equals the absolute change in beet area multiplied by a share defining how much of the total change in beet area is allocated to the respective crop aggregate divided by the total crop area of a country. In most countries, the share that allocates the absolute change in sugar beet area to the individual crop aggregate is set to the value of the function that is used to distribute a change in the total crop area to the grain, oilseed, protein crop and other crop area. Consequently, a change in sugar beet area compared to the base year is allocated in the same way as a change in total crop area. Finally, the share of industrial crops (sugar beets and potatoes) in total crop area is corrected by the change in sugar beet area:

$$\mathrm{ASH\_AD}_{os,c,t} = \mathrm{ASH}_{os,c,t} - \left(\frac{\left(\mathrm{AHA}_{st,c,t} - \overline{\mathrm{aha\_0}_{st,c}}\right) * \mathrm{ASH}_{os,c,t}}{\mathrm{AHA}_{cr,c,t}}\right) \tag{53}$$

$$\mathrm{ASH\_AD}_{pc,c,t} = \mathrm{ASH}_{pc,c,t} - \left(\frac{\left(\mathrm{AHA}_{st,c,t} - \overline{\mathrm{aha\_0}_{st,c}}\right) * \mathrm{ASH}_{pc,c,t}}{\mathrm{AHA}_{cr,c,t}}\right) \tag{54}$$

$$\mathrm{ASH\_AD}_{oc,c,t} = \mathrm{ASH}_{oc,c,t} - \left(\frac{\left(\mathrm{AHA}_{st,c,t} - \overline{\mathrm{aha\_0}_{st,c}}\right) * \mathrm{ASH}_{oc,c,t}}{\mathrm{AHA}_{cr,c,t}}\right) \tag{55}$$

$$\mathrm{ASH\_AD}_{ic,c,t} = \mathrm{ASH}_{ic.c.t} - \left(\frac{\overline{\mathrm{aha\_0}_{ic,c,t}} + \left(\mathrm{AHA}_{st,c,t} - \overline{\mathrm{aha\_0}_{st,c}}\right)}{\mathrm{AHA}_{cr,c,t}}\right) \tag{56}$$

$$\mathrm{ASH\_AD}_{gr,c,t} = 1 - \mathrm{ASH\_AD}_{os,c,t} - \mathrm{ASH\_AD}_{pc,c,t} - \mathrm{ASH\_AD}_{oc,c,t} - \mathrm{ASH\_AD}_{ic,c,t} \tag{57}$$

Where:

ASH_AD:	adjusted share of a crop aggregate in total crop area	pc:	protein crops
ASH:	estimated share of a crop aggregate in total crop area	oc:	other crops
AHA:	area harvested in the current year	ic:	industrial crops
aha_0:	area harvested in base year	gr:	grain
os:	oilseeds		

The second linkage accounts for the additional demand for grain resulting from a change in isoglucose production compared to the base year. This additional demand is added to the food demand of corn or wheat, depending on which grain is used as the raw material for isoglucose production in a country[9]. As a result, changes in isoglucose production affect the self-sufficiency rate of the respective cereal and thus the domestic market price, which, in turn, affects the costs of producing isoglucose:

$$UFD_{ws/co,c,t} = UPC_{ws/co,c,t} * pop_{c,t} + \frac{SPR_{is,c,t} - \overline{spr\_0_{is,c}}}{dnc_{is}} * yha_{is}^{-1} \tag{58}$$

Where:

UFD:	food use	dnc:	dry matter content of isoglucose
UPC:	per capita consumption	yha:	yield (t isoglucose per t grain)
SPR:	production in the current year	pop:	population
spr_0:	production in base year		

1.1.7 Scaling and re-calculations after scaling

One regular application of Agmemod is to disaggregate the market projections of the Aglink-Cosimo model for the two country blocks EU-15 and EU-13 to the individual member state level (EC 2015, 2016, 2017, 2018, 2019c, 2020, 2021). The model approach of Agmemod, however, does not allow to calibrate the original model outcome to a given data set such as the projections obtained from Aglink-Cosimo. Instead, production and consumption figures of EU MS are scaled with a uniform scaling factor after the model run in order to ensure that the aggregated results of Agmemod exactly meet the projections of Aglink-Cosimo for the two country blocks EU-15 and EU-13. This is done in a two-step approach: First, uniform scaling factors are derived for the EU-15 and EU-13 MS, respectively. These scaling factors represent the relative difference between the cumulative model outcome of Agmemod over all EU MS belonging to the EU-15 or EU-13 and the production and consumption quantities projected by the Aglink-Cosimo model for the respective country block. Second, production and consumption quantities of all EU MS are corrected for deviations between Agmemod and Aglink-Cosimo by multiplying the original model outcome of Agmemod by the respective scaling factor. As an example, Equations 59 to 60 illustrate the scaling of sugar production in Germany:

[9] This assumes that quantities required for isoglucose production are included in the category 'food demand' in the statistics used to build the model database.

$$SF_{EU15_{su,SPR,t}} = 1 + \frac{SPR_{Aglink_{su,\mathbf{EU15},t}} - \sum_{EU15MS} SPR_{Agmemod_{su,c,t}}}{\sum_{EU15MS} SPR_{Agmemod_{su,c,t}}} \quad (59)$$

$$SPR_{su,\mathbf{DE},t} = SPR\_Agmemod_{su,\mathbf{DE},t} * SF\_EU15_{su,SPR,t} \quad (60)$$

Where:

SF:	scaling factor
SPR:	production
EU15MS:	MS belonging to the EU15
EU15:	EU-15 country block

After scaling production and consumption quantities, other variables need to be re-calculated to ensure market clearing and consistency between variables. Equation 61 to 65 show the re-calculation of selected variables that are usually presented in a market balance sheet:

Sugar beet:

$$AHA_{st,c,t} = \frac{SPR_{st,c,t}}{YHA_{st,c,t}} \quad (61)$$

$$UXN_{st,c,t} = SPR_{st,c,t} - UDC_{st,c,t} \quad (62)$$

Sugar:

$$SMT_{su,c,t} = UDC_{su,c,t} - SPR_{su,c,t} + UXT_{su,c,t} + CHT_{su,c,t} \quad (63)$$

$$UXN_{su,c,t} = UXT_{su,c,t} - SMT_{su,c,t} \quad (64)$$

Isoglucose:

$$UXN_{is,c,t} = SPR_{is,c,t} - UDC_{is,c,t} \quad (65)$$

Where:

AHA:	area harvested	UXT:	exports
SPR:	production	SMT:	exports
YHA:	yield	UXN:	net exports
UDC:	domestic use	CHT:	stock change

1.2 Database

1.2.1 Prices

Wherever possible, consistent EU statistics available for all EU countries are used to build and update the database of the sweetener module in Agmemod. The following sections describe the main data sources for prices, market balances, production costs and other parameters[10].

Observed **world market prices of raw and white sugar** are taken from USDA (2019) and USDA (2019) while historical price series of the **EU sugar price** are obtained from (EC 2019a). The **world market price of curd oil** is sourced from EIA (2020) for observed periods. World and EU price projections that enter the baseline run as exogenous parameters are taken from the EU medium-term outlook (EC 2019b).

Domestic prices of sugar beet are directly extracted from Eurostat, whereas domestic prices of sugar and isoglucose are calculated as import or export unit values based on monthly intra-EU trade flows extracted from Eurostat (EUROSTAT 2019, 2020).

1.2.2 Market balances

Sugar beets: Most variables included in the market balance for sugar beet are derived from the sugar market balance to ensure consistency between both sectors. Sugar beet use for sugar processing is derived by dividing sugar production by the sugar extraction rate. Ethanol use and feed use are obtained from national statistics. Domestic use of sugar beet is the sum of all subcategories. Trade figures are extracted from EUROSTAT (2019) and when needed adjusted to replicate the figures from the EU short-term outlook for production and yields. Sugar beet production is calculated as domestic use plus net exports. Also, beet yields are derived by dividing sugar beet production by the area harvested. Data on the area harvested is taken from the EU short-term outlook (STO) (EC 2019d) while the sugar content of beets is based on (CEFS 2016).

Sugar: Data on production, consumption, trade and stocks are taken from F.O. LICHT (2019). Since the F.O. Licht statistics do not differentiate between different subcategories for domestic use, national sources are used for industrial sugar use while food use is calculated as the residual of total domestic use and industrial use.

Isoglucose: Data on production is obtained from the sugar balance sheets published by the European Commission (EC 2019a). Data on monthly trade flows is extracted from EUROSTAT (2019), converted from commercial weight into white sugar equivalent (dry basis) by applying conversion factors and aggregated to the marketing year (Oct.-Sep.). Domestic use is calculated as the difference between isoglucose production and net imports to close the market balance.

[10] The Agmemod database is continuously updated to the most recent data. The exact version of the indicated data sources does therefore vary depending on the applied model version.

1.2.3 Production costs

Fixed and variable processing costs as well as all data and technical coefficients required to derive total production costs per tonne of sugar or isoglucose, as described in section 1.1.1 (e.g. growing, costs, by-product yields, ratio of by-product prices to wheat, corn), are obtained from LMC (2013).

1.2.4 Other parameters

Elasticities applied to calibrate the functions of the model that are not estimated by linear ordinary least squares regression are either literature based or set by assumption in a plausible range. Supply elasticities of sugar and sugar beets reported in literature for EU Member States vary between 0.1 and 1.8 (GOHIN 2006; GRETHE 2012; SMIT et al. 2017). Depending on the model version the long-term supply elasticities estimated by POONYTH (2000) or SMIT et al. (2012) are applied. As the first source doesn't provide data for all EU sugar producing countries, supply elasticities in countries that are not covered are set to the average value over all available countries (0.58). Elasticities used to calibrate imports and exports as well as ending stocks are assumed to be in a similar range as the supply elasticities. For the calibration of the isoglucose demand function an own price elasticity of 0.48 and a cross-price elasticity of 0.27 is applied as reported by MIAO et al. (2010) for the U.S. market[11].

Processing capacities for sugar per country and year are calculated based on (CEFS 2016). The CEFS statistics provide data on the number of factories by country categorized by the daily beet slicing capacity. From these data, the maximum beet slicing capacity is calculated by multiplying the number of factories by the upper limit of the respective category. The sum over all categories gives the total beet slicing capacity per day.

[11] Since cross-price elasticities are reported by Miao et al. (2010) for different sectors (e.g. soft drink, processed fruits and vegetables, milk etc.), the average over all sectors was used.

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Appendix B: Further publications

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