

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

Marlen Haß

Johann Heinrich von Thünen-Institut,
Institute of Market Analysis, Braunschweig,
Germany

Correspondence

Marlen Haß, Johann Heinrich von Thünen-
Institut, Institute of Market Analysis,
Braunschweig, Germany.
Email: marlen.hass@thuenen.de

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

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2021 The Authors. *Journal of Agricultural Economics* published by John Wiley & Sons Ltd on behalf of Agricultural Economics Society.

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

MS	VCS 2020		Quantitative limit ^b	Premium	Yield ^c	Premium	Sugar content ^c	Premium
	€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

^aShare of VCS for sugar beet in national ceiling for VCS.

^bAbolished in 2018.

^cAvg. 2014–16, EU-28 yield represents average of MS granting VCS weighted by production quantities.

^dFinland 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.

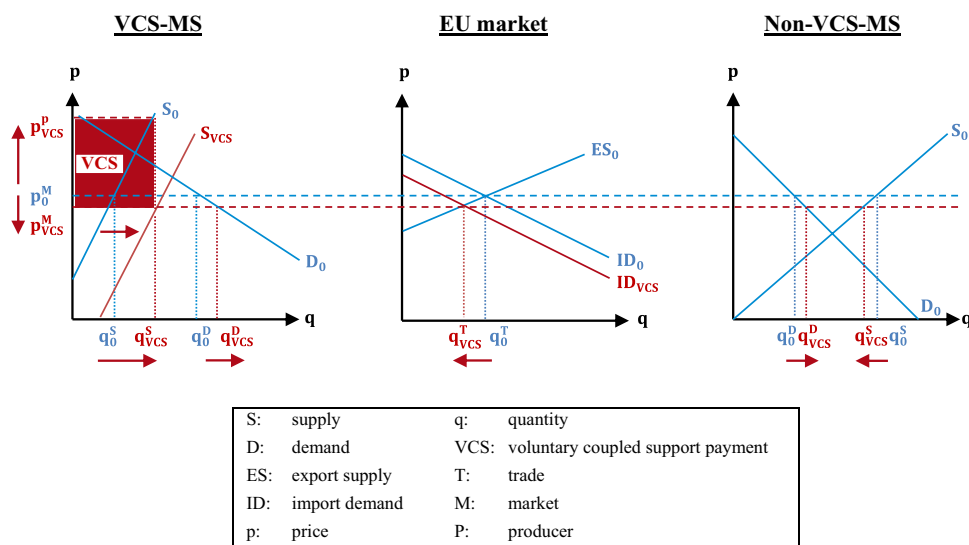


FIGURE 1 Price and quantity effects of VCS payments (reference situation: unregulated market). Source: Own figure [Colour figure can be viewed at wileyonlinelibrary.com]

($S_0 \rightarrow S_{VCS}$) 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

¹Isoglucose (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

²Please 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

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

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

$$\alpha_{su} = (\overline{spr_0_{su}} + (\overline{uod_0_{st}}) * \overline{xtr_0_{su}}) * \left(\frac{PFE_{su} + BPV_{su} - CPO_{su}}{gdpd} \right)^{(-\epsilon_{su})} \quad (2)$$

Thus, Equation (2) implies that a given base quantity—indicated by an overline ($\overline{}$) 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 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 $PFN_{su,FR}$ (price of France), the respective domestic self-sufficiency rate $\left(\frac{SPR_{su}}{UDC_{su}}\right)$ and the domestic market price of the previous year $PFN_{su,t-1}$. The intercept parameter α_{su} as well as all β -coefficients are estimated by linear ordinary least squares regression:

4.1.3 | Sugar price

$$PFN_{su} = \alpha_{su} + \beta_{su}^1 * PFN_{su,FR} - \beta_{su}^2 * \left(\frac{SPR_{su}}{UDC_{su}}\right) \pm \beta_{su}^3 * PFN_{su,t-1} \quad (3)$$

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

$$PFE_{su} = SCF_{su} + CPO_{su} - BPV_{su} \quad (4)$$

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 $EGG_{ws/co/rs}$ 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

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

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

³For 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

⁴It 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.

⁵Neonics 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.

⁶Since 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)							

(Continues)

TABLE 2 (Continued)

	Base year Avg. 2014–2016 ^b	Optimistic yield development			Pessimistic yield development		
		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)

^aWeighted by production quantities, excluding subsidies and taxes, simulated beet prices including transportation costs and late delivery premiums.
^bAverage 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; Zaitogui 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

⁷AGMEMOD 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.

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
VCS-MS						
PL*	154.35 (7.07)	-13.70 (-3.44)	-31.83 (-10.40)	136.86 (6.59)	-12.21 (-2.98)	-33.57 (-10.07)
CZ*	29.13 (5.16)	-5.17 (-1.29)	-20.44 (-5.32)	25.64 (4.79)	-4.62 (-1.13)	-21.00 (-5.12)
IT	17.18 (4.87)	-1.99 (-0.46)	-56.12 (-8.25)	16.33 (15.48)	-1.83 (-0.42)	-65.31 (-8.95)
HU*	12.00 (10.63)	-3.85 (-0.99)	-47.13 (-11.60)	10.36 (9.67)	-3.39 (-0.86)	-48.97 (-11.19)
RO	11.05 (11.12)	-14.09 (-2.91)	-112.54 (-22.26)	11.07 (11.42)	-13.94 (-2.84)	-130.81 (-23.94)
HR	10.26 (5.02)	-1.95 (-0.46)	-21.18 (-5.59)	9.96 (5.18)	-1.77 (-0.41)	-24.78 (-6.05)
ES*	9.33 (1.59)	-1.49 (-0.35)	-22.92 (-5.58)	8.09 (1.40)	-1.34 (-0.32)	-22.99 (-5.26)
SK	6.26 (3.97)	-7.67 (-1.76)	-38.42 (-10.20)	6.36 (4.13)	-7.61 (-1.72)	-45.00 (-11.06)
GR	6.20 (23.39)	-4.81 (-1.05)	-92.50 (-14.00)	5.75 (24.05)	-4.43 (-0.95)	-108.38 (-15.03)
LT	1.45 (0.85)	-2.37 (-0.51)	-6.22 (-1.95)	1.47 (0.88)	-2.19 (-0.47)	-7.08 (-2.10)

(Continues)

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

(Continues)

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 (-0.16)	-1.53 (-0.38)	0.00 (-0.00)	-18.58 (-0.14)	-1.39 (-0.34)	0.00 (0.00)
EU-28 ^a	236.37 (1.34)	-3.22 (-0.79)	-7.86 (-2.15)	213.83 (1.25)	-2.83 (-0.69)	-8.16 (-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 sale⁸ 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

⁸In 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).

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

Country	Optimistic yield development					Pessimistic yield development				
	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

^aLegumes (peas, beans etc.).
^bOther 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.

ACKNOWLEDGEMENTS

The author is grateful for the helpful suggestions from two anonymous reviewers.

REFERENCES

- Agreste. (2019). *Sucres et produits sucrés. Campagnes 1993-1994 à 2016-2017*. Available at: <http://agreste.agriculture.sg-ppd.maaf.ate.info/enquetes/bilans-d-approvisionnement/sucres-et-produits-sucres/> (last accessed 28 July 2020)
- Audran, X. (2020) France's Sugar Beet Crop Devastated by Disease - Sugar Industry's Viability Threatened. GAIN Report FR2020-0021. Available at: https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=France%27s%20Sugar%20Beet%20Crop%20Devastated%20by%20Disease%20-%20Sugar%20Industry%27s%20Viability%20Threatened_Paris_France_08-11-2020 (last accessed 4 February 2021)
- Binfield, J., Westhoff, P.C. and Young, R. (2003) Reforming the CAP: A Partial Equilibrium Analysis of the MTR Proposals. Contributed paper selected for presentation at the 25th International Conference of Agricultural Economists. Available at: <http://ageconsearch.umn.edu/record/25856/files/cp03bi01.pdf> (last accessed 28 July 2020)
- Boulanger, P. and Philippidis, G. (2015) The EU budget battle. Assessing the trade and welfare impacts of CAP budgetary reform, *Food Policy*, 51, 119–130. <http://dx.doi.org/10.1016/j.foodpol.2015.01.004>
- CEFS. (2017) *CEFS Sugar statistics 2016*, Brussels.
- Chantreuil, F., Hanrahan, K. and van Leeuwen, M. (2012) *The future of EU agricultural markets by AGMEMOD*, Dordrecht: Springer Science+Business Media B.V.
- Croatian Bureau of Statistics. (2018). *Table 4. Sugar Balance Sheet, in '000 Tonnes, Republic of Croatia*. Available at: https://www.dzs.hr/default_e.htm (accessed 28 July 2020)
- Dwivedi, D.N. (2012) *Microeconomics*, New Delhi, India: Pearson Education/Dorling Kindersley.
- EC. (2017a). *Agricultural outlook for the agricultural markets and income 2017-2030*. Brussels, Belgium: European Commission, DG Agriculture and Rural Development. Available at: https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/outlook/medium-term_en (last accessed 28 July 2020)
- EC. (2017a) Voluntary coupled support. Notification of the revised decisions taken by Member States by 1 August 2016 ('the review'). Available at: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/voluntary-coupled-support-note-revised-aug2016_en.pdf (last accessed 28 July 2020)
- EC. (2018a) EU Agricultural outlook for the markets and income 2018-2030, Brussels: European Commission, DG Agriculture and Rural Development. Available at: https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/outlook/medium-term_en (last accessed 28 July 2020)
- EC. (2018b) Impact Assessment Accompanying the Commission's Legislative Package on the Common Agricultural Policy Post 2020. Commission staff Working Document SWD (2018) 301 final. Available at: https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-cap-swd-part3_en.pdf (last accessed 28 July 2020)
- EC. (2019a) Balance sheet. update 26 September 2019. Available at: https://ec.europa.eu/agriculture/market-observatory/sugar/balance-sheets_en (last accessed 28 July 2020)
- EC. (2019b) EU Agricultural Outlook for markets and income. 2019-2030, European Commission, DG Agriculture and Rural Development, Brussels. Available at: https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/outlook/medium-term_en (last accessed 28 July 2020)
- EC. (2019c) Report of the High-Level Group on Sugar. Available at: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/plants_and_plant_products/documents/final-report-high-level-group-meeting-sugar.pdf (last accessed 28 July 2020)

- EC. (2019d) Short-term outlook for EU agricultural markets in 2018 and 2019. Spring 2019, Released: 4 April 2019 (based on data available until 18 February 2019), European Commission, DG Agriculture and Rural Development, Brussels. Available at: https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/outlook/short-term_en (accessed 28 July 2020)
- EC. (2020) Crop monitoring in Europe. *JRC MARS Bulletin*, 28, 1–15. <https://ec.europa.eu/jrc/en/mars/bulletins>
- Erjavec, E., Chantreuil, F., Hanrahan, K., Donnellan, T., Salputra, G., Kožar, M. and et al (2011) Policy assessment of an EU wide flat area CAP payments system. *Economic Modelling*, 28, 1550–1558. <https://doi.org/10.1016/j.econmod.2011.02.007>
- Eurostat. (2018) Selling prices of crop products (absolute prices) - annual price (from 2000 onwards) [apri_ap_crpouta]. Last update: 26 April 2018. Available at: <https://ec.europa.eu/eurostat/data/database> (last accessed 28 July 2020)
- Eurostat. (2019a) Crop production in EU standard humidity [apro_cpsh1]. Last update: 02 April 2019. Available at: <https://ec.europa.eu/eurostat/data/database> (last accessed 28 July 2020)
- Eurostat. (2019b) EU trade since 1988 by CN8 [DS-016890]. Last updated: 17 December 2019. 2019b. Available at: <https://ec.europa.eu/eurostat/data/database> (last accessed 28 July 2020)
- F.O. Licht. (2018) World sugar balances 2004/05 - 2018/19. *F.O. Licht's International Sugar and Sweetener Report*, 145-150, 1–35.
- FAOSTAT (2018) *Food Balance Sheets. Extracted: 31.07.2018* (Rome). Available at: <http://www.fao.org/faostat/en/#-data/FBS> (last accessed 28 July 2020)
- Frandsen, S.E., Jensen, H.G., Yu, W. and Walter-Jørgensen, A. (2003) Reform of EU sugar policy. Price cuts versus quota reductions. *European Review of Agricultural Economics*, 30, 1–26. <https://doi.org/10.1093/erae/30.1.1>
- Gandolfo, G. (2013) *International economics*, Berlin: Springer.
- Gohin, A. and Bureau, J.-C. (2006) Modelling the EU sugar supply to assess sectoral policy reforms. *European Review of Agricultural Economics*, 33, 223–247. <https://doi.org/10.1093/erae/jbl006>
- Haß, M., Banse, M., Deblitz, C., Freund, F., Geible, I., Gocht, A., Kreins, P., Laquai, V., Offermann, F., Oserburg, B., Pelikan, J., Rieger, J., Rösemann, C., Salamon, P., Zinnbauer, M. and Zirngibl, M.-E. (2020) Thünen-Baseline 2020 - 2030. Agrarökonomische Projektionen für Deutschland. Thünen Report 82. 2020. Available at: https://www.thuenen.de/media/publikationen/thuenen-report/Thuenen_Report_82.pdf (last accessed 1 February 2021)
- Hill, B. (2014) *An introduction to economics. Concepts for students of agriculture and the rural sector*, Oxfordshire: CABI.
- Jensen, H.G. and Pohl Nielsen, C. (2004) EU dairy policy analysis: Assessing the importance of quota rent estimates. Paper prepared for the 7th Annual Conference on Global Economic Analysis, June 17-19, 2004. 2004. Available at: <https://www.gtap.agecon.purdue.edu/resources/download/1732.pdf> (last accessed 28 July 2020)
- Jongeneel, R. and Tonini, A. (2009) The impact of quota rent and supply elasticity estimates for EU dairy policy evaluation: a comparative analysis. *German Journal of Agricultural Economics*, 58, 269–278.
- LMC. (2019) EU sugar & sweeteners market, the outlook after quotas, Main Report.
- Maier, K., Baron, O. and Bruhns, J. (2018) *Sugar Economy Europe 2018*, 64th edition, Berlin: Dr. Alert Bartens KG.
- Matthews, A. (2015) *Two steps forward, one step back: coupled payments in the CAP*. Available at: <http://capreform.eu/two-steps-forward-one-step-back-coupled-payments-in-the-cap/> (last accessed 28 July 2020)
- Matthews, A. (2018) The EU's Common Agricultural Policy Post 2020: Directions of Change and Potential Trade and Market Effects. Available at: https://www.wita.org/wp-content/uploads/2018/11/ictsd_-_the_potential_trade_and_market_effects_of_the_eu_cap_post_2020_-_alan_matthews.pdf (last accessed 28 July 2020)
- Miao, Z., Beghin, J.C. and Jensen, H.H. (2010) Taxing sweets. Sweetener input tax or final consumption tax?, *Economics Working Papers* (2002–2016). 122. Available at: http://lib.dr.iastate.edu/econ_las_workingpapers/122 (last accessed 19 April 2021).
- Nolte, S., Buysse, J. and van Huylenbroeck, G. (2012) Modelling the effects of an abolition of the EU sugar quota on internal prices, production and imports. *European Review of Agricultural Economics*, 39, 75–94. <https://doi.org/10.1093/erae/jbr043>
- Offermann, F., Banse, M., Deblitz, C., Gocht, A., Gonzalez-Mellado, A., Kreins, P., Marquardt, S., Oserburg, B., Pelikan, J., Rösemann, C., Salamon, P. and Sanders, J. (2015) Thünen-Baseline 2015 – 2025: Agrarökonomische Projektionen für Deutschland. Thünen Report 40. 2015. Available at: https://literatur.thuenen.de/digbib_externdn056473.pdf (accessed 28 July 2020)
- Offermann, F., Banse, M., Freund, F., Haß, M., Kreins, P., Laquai, V., Oserburg, B., Pelikan, J., Rösemann, C. and Salamon, P. (2018) Thünen-Baseline 2017 – 2027: Agrarökonomische Projektionen für Deutschland. Thünen Report 56. 2018. Available at: https://literatur.thuenen.de/digbib_externdn059667.pdf (last accessed 28 July 2020)
- Poonyth, D., Westhoff, P., Womack, A. and Adams, G. (2000) Impacts of WTO restrictions on subsidized EU sugar exports. *Agricultural Economics*, 22, 233–245. [https://doi.org/10.1016/S0169-5150\(99\)00055-9](https://doi.org/10.1016/S0169-5150(99)00055-9)

- Salputra, G., Chantreuil, F., Hanrahan, K., Donnellan, T., van Leeuwen, M. and Erjavec, E. (2011) Policy harmonized approach for the EU agricultural sector modelling. *Agricultural and Food Science*, 20, 119. <https://doi.org/10.2137/145960611797215655>
- Salputra, G., Salamon, P., Jongeneel, R., van Leeuwen, M. and Banse, M. (eds.) (2017) *Unveiling diversity in agricultural markets projections: from EU to Member States. A medium-term outlook with the AGMEMOD model*, JRC Technical Report. 29025 EUR Luxembourg, Publications Office of the European Union. <https://doi.org/10.2760/363389>
- SI-STAT. (2018) 3. *Supply balance sheet for sugar (1000 t), market year, Slovenia, annually*. Available at: https://pxweb.stat.si/SiStatDb/pxweb/en/30_Okolje/30_Okolje__15_kmetijstvo_ribistvo__12_prehranske_bilance__01_15634_trzne_bilance/?tablelist=true (accessed 28 July 2020)
- Smit, A.B., Jongeneel, R., Prins, H., Jager, J. and Hennen, W.H.G.J. (2017) Impact of coupled EU support for sugar beet growing: More production, lower prices. Wageningen Economic Research, Report 2017-114. <https://doi.org/10.18174/430039>
- Tanyeri-Abur, A., McCarl, B.A., Chang, C.-C., Knutson, R.D., Wesley, E., Peterson, F. and et al (1993) 'An analysis of possible U.S. sugar import policy revisions', *Applied Economic Perspectives and Policy*, 15, 255–268. <https://doi.org/10.2307/1349446>
- Uri, N.D. (1994) 'Estimating the U.S. demand for sugar in the presence of measurement error in the data', *Journal of Agricultural Economics Research*, 45, 17–30.
- USDA (2019) PS&D: Production, Supply and Distribution. Extracted: 18.11.2019. 2019. Available at: <https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery> (last accessed 28 July 2020)
- Uthes, S., Piorr, A., Zander, P., Biełkowski, J., Ungaro, F., Dalgaard, T. et al (2011) 'Regional impacts of abolishing direct payments. An integrated analysis in four European regions', *Agricultural Systems*, 104, 110–121. <https://doi.org/10.1016/j.agsy.2010.07.003>
- Weinmann, B., Schroers, J.O. and Sheridan, P. (2006) Simulating the effects of decoupled transfer payments using the land use model ProLand. *German Journal of Agricultural Economics*, 55, 248–256.
- World Bank. (2018) Thinking CAP. Supporting Agricultural Jobs and Income in the EU. EU Regular Economic Report 4. Available at: <https://issuu.com/world.bank.europe.central.asia/docs/123443-repl-public> (Accessed 28 July 2020)
- Zaitegui Perez, D. (2018) Macro Data. Email received: 10 August 2018. 2018.

SUPPORTING INFORMATION

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

How to cite this article: Haß M. (2022) Coupled support for sugar beet in the European Union: Does it lead to market distortions?. *Journal of Agricultural Economics*, 73, 86–111. <https://doi.org/10.1111/1477-9552.12435>